Lecture in Lyons: Science and Freedom

Andrei Sakharov
Introduction by Elena Bonner
Translated by Matvei E. Yankelevich

[Editor's Note: Andrei Sakharov, renowned Soviet physicist and activist, returned from exile on 23 December 1986. He gave this talk in Russian in Lyons, France, on 27 September 1989. Just over a month later, on 9 November 1989, the Berlin Wall fell. One month after that, on 14 December 1989, Andrei Dmitrievich Sakharov died. For more on Sakharov, see the August 1990 issue of PHYSICS TODAY*, which was a special issue devoted to him.*

This is the first English publication of the Lyons lecture. Though recorded in Russian, it was first published in French, in Andrei Sakharov: Science et Liberté *(Les Éditions de Physique, 1990). The only Russian publication was in the May 1991 issue of* Ogonyok*, with the following introduction by Elena Bonner.]*

Upon receiving an honorary degree from Claude Bernard University, Andrei Sakharov delivered the following Lyons lecture at a joint session of the university and the Société Française de Physique on 27 September 1989.

The speech was unwritten, which worried the French interpreter at that time. But Sakharov said that, since the lecture was to be given to a friendly audience of scientists, his colleagues, he wanted to talk freely rather than reading a text written in advance. Perhaps this desire was a direct psychological consequence of the aggressive reaction and obstruction that Sakharov had encountered when appearing at the First Congress of People's Deputies of the USSR, earlier in 1989.

Elena Bonner

In a little more than ten years, this century will come to a close and we must try to come up with a name for it and identify its most prominent trait. However, there is no single answer to this question.

Ours has been a century of two world wars, and many little wars, that took many lives. It has been a century of genocide such as history has not seen. A few weeks ago, I stood together with 5000 of my fellow countrymen by an open grave meant for the reburial of victims of Stalin's terror. Representatives of three faiths stood by, conducting the funeral service. There were Russian Orthodox priests, Jewish rabbis, and Muslim mullahs. The hundreds and thousands of innocent victims buried there included members of every nation and every religion.

And still, when we think of the 20th century, there is one trait that seems to me incredibly important: The 20th century was a century of science, when science took its greatest step forward. In the development of science during the 20th century, we saw vividly science's three key goals wrapped up in its three key qualities.

First, we saw science for its own sake, for the sake of knowledge. Science for science's sake—a reflection of the human mind's great quest for knowledge. This is one of the fields of human activity that justifies our existence on Earth.

ELENA BONNER, *a human rights activist and retired physician, has been the chairman of the Andrei Sakharov Foundation since its creation in 1991.* MATVEI YANKELEVICH *is a writer and translator, living in New York City.*

Second, we saw the practical significance of science. It was precisely during the 20th century that we saw science become, to a much greater degree than ever before, the basis for material production. And in our production, in our total combined output, perhaps the greater part is made up of the results of scientific inquiry. That is what we mean when we speak of science as a materially productive force.

And finally, we saw the third goal of science: to reach some kind of wholeness that binds humanity together.

These three goals—each independent of the others—are tightly interwoven.

Most likely our apelike ancestor was a very curious creature. He overturned and lifted the rocks under his feet; he did so because of his instinct of curiosity. But under those rocks he found bugs and worms that served as food. From curiosity came practical benefits, as so often happens unexpectedly. So it is with fundamental science.

Science is based on common laws, on common terms; this is the foundation for its internationality. Although, like any living thing, science contradicts itself—its discoveries often have good and bad consequences simultaneously—its ability to be all-encompassing is science's most important characteristic. The general laws of nature, and those laws of society that arise from fundamental science, are the most universal, and therefore they draw us closer together.

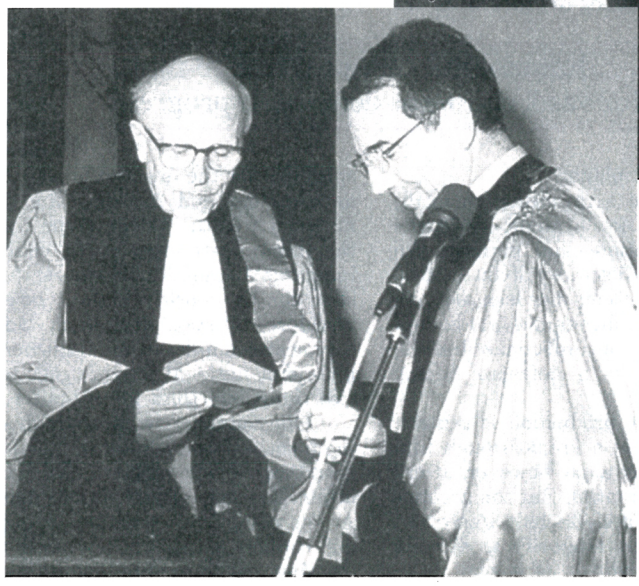
Science for its own sake

At the end of the previous century, it seemed that the main laws of physics were already set in stone and all that was left was to somehow apply them mathematically. There were just a few tiny clouds on the clear horizon—or so it seemed. We know now that from those tiny clouds grew storms of revolutionary change in fundamental science, in our understanding of nature. We found out that our image of the world, which goes back to Galileo and Newton, was only a superficial slice of reality. More fundamental laws are deeper and more abstract while, at the same time, they are uniquely beautiful in their mathematical simplicity. Einstein doubted that God was tossing dice, but now the majority of physicists are convinced that, in reality, the laws of nature have a probabilistic character. This is not because we're not exactly sure about something or we can't calculate some things exactly. Rather, it is because the idea of probability is inherent in the very nature of things.

We now know that space and time are united in a single geometrical structure. This is one of the first breakthroughs into new physics, attached to names like Lorenz, Poincaré, Einstein, and many others. But, and this is not accidental, Einstein became in a sense the embodiment of the spirit of the new science and, likewise, the new attitude of science toward society. In Einstein's talks, in his letters, one can find the following parallel very often: God and nature. This is a reflection of his thought and the thought of many others in science. During the Renaissance and the 18th and 19th centuries, religious and scientific thought were seen as contrary to each other, as if they were mutually exclusive.

That juxtaposition was justified historically; it reflected a particular period in the development of society. But my feeling is that, in the next stage in the development of human consciousness, there will be some deep, versatile resolution of the perceived discord between religion and science. My deep sense (not even conviction—the word "conviction" wouldn't be right here) is that some kind of inner meaning exists in nature, in nature as a whole. (I am speaking here of things intimate and deep, which is absolutely necessary when it comes to taking a final count, when it comes to deciding what you want to communicate to people.) This sense of things is nourished by—perhaps more than anything else—the image of the world revealed to us during the 20th century.

We now understand that the world is more immense than we could have ever thought before, and much more diverse. And the world is not static. It changes and develops with time. Even Einstein accepted the possibility that the universe as a whole is a dynamic system, though he believed that this contradicts the law of the conservation of energy. But in fact this conservation law, applied to the universe as a whole, is simply meaningless, and we must widen the scope and categories of our thought.



ANDREI SAKHAROV IN LYONS. Sakharov with Elena Bonner (above), and receiving his honorary degree (left) from Jean Zech, the president of Claude Bernard University, on 27 September 1989. (Photos used with permission of Les Éditions de Physique.)

Only a theory of an expanding universe matches up both with the equations of Einstein's theory of relativity and with the current findings of astronomers. This picture of the world has brought us to ask two questions of enormous importance: What happened in the beginning and where are we going—what is our forecast? Neither of these questions has yet been granted an exhaustive answer, but just posing such questions displays a new cosmological way of thought that sets human consciousness one-on-one with the cosmos.

Immanuel Kant once said that there are two miracles in the world: the starry sky above us and the instinct of the moral imperative within us. Now we are repeating the same idea, except the starry sky is no longer that unchanging collection of glowing points that it was in Kant's time. Now we can envision the universe on a much vaster scale and, although the picture is unfinished, we can see that it is grander and more complex than we could ever have imagined.

During these last decades, so packed with scientific events, we have seen other breakthroughs in our quest to understand the world. Now we think it highly probable that space is not made up of only three dimensions, as we were taught in geometry textbooks, but many more. The extra dimensions exist on a very small scale, but they do exist. In fact, they determine the fundamental laws of nature. The complex geometric structure of the additional space, closed in on itself, defines the symmetry of the physical laws of elementary particles.

We deem it possible that, in addition to those bodies that interact with us by way of electromagnetic or atomic forces, there is another form of matter with which we interact only in a gravitational scheme. This is the so-called looking-glass world. We are also almost certain that a large part of our everyday world is likewise concentrated in a form of hidden mass, invisible to us. We are looking into the fantastic possibility that regions of space separated from each other by billions of light-years are, at the same time, connected to each other with the help of additional parallel entrances, often called "wormholes." In other words, we do not exclude the possibility of a miracle: the instantaneous crossing from one region of space to another. The elapsed time would be so short that we would appear in the new place quite unexpectedly or, vice versa, someone would suddenly appear next to us.

I talk of such things in order to show what kinds of questions are being raised and discussed at the cutting edge of science. Perhaps much of what I have said, especially having to do with wormholes, is a misconception, but it makes clear what courageous thinking is going on among physicists and astronomers. This is evidence of the curiosity that overturns stones, the curiosity so characteristic of modern science.

Technological developments

Our century has seen the creation of new means of doing research. In particular, the electron microscope and chemical and biochemical methods of analysis have revolutionized our knowledge of the foundations of life. We have

reached an extraordinary understanding of the biochemical mechanisms of life and heredity. At the same time, we have come to realize that what we don't know exceeds what we do know. We have found out that life is the most complex reflection of nature's possibilities, and that to understand these processes in their immeasurable complexity, we need new methods of research and new methods of analyzing what is going on. As if on cue, new research methods have emerged, and among them the development of computer technology takes first place. In it we have a bridge, one of the innumerable bridges between fundamental science and applied science that has appeared in our century.

Developments in biology, genetics, and the life sciences in general made the green revolution possible. Although the problem of providing food continues to concern us, we now realize that the possibilities are endless and that the most serious obstacles to conquering world hunger are really socioeconomic—the imbalance of cultural and economic development on our planet.

. . . humankind cannot refuse to move forward, it cannot deny itself progress.

Applied science brought about a revolution in medicine, in health services, in creating new hygienic conditions for life on earth. One manifestation—and perhaps the symbol of this revolution—was the discovery of antibiotics, which marked the victory over infectious diseases. As with the green revolution, the victory is incomplete. As before, millions of people are still dying from infectious disease, but we already know that this is a defeated enemy engaging in rearguard battles.

For technical progress, energy production is central. In this field, science has also made a breakthrough into the future. We still have a long way to go, however, before our progress can realize its full potential. But the groundwork has been laid, and that is tremendously important because, as we now know, human longevity is directly dependent on the per capita expenditure of energy.

When you talk and think about practical applied science, you realize that humankind cannot refuse to move forward, it cannot deny itself progress. Humankind can only develop progressively; there can be no return to the past. A return to a primitive natural farming economy is impossible. Still, we must keep the negative aspects of progress from getting the upper hand, so that progress does not threaten humankind. The worst threat is self-destruction in a world war. At the same time, we must overcome the enormous ecological and environmental dangers that pose a threat to our existence. A complete solution to these problems is very hard to find; there are no final or easy answers. But one thing is certain: Dividing humankind into two opposing camps is the greatest source of danger, turning global problems into an immediate threat to our existence on Earth. The most dangerous division has historically been between socialism and capitalism. I am convinced that only by bridging the chasm that separates these systems, only by putting an end to their mutual opposition, can we find the key to solving the global problems of humankind.

Science as unifier

Finally, we arrive at science as a unifying force. Science is more objective than art and has less to do with ambition than sports. Although we often come upon negative human qualities in the field of science, such displays still seem less dangerous to me in science than in other areas of human activity. In the modern world, we can already spot the integrating function of science, even in our individual fates, which are such small points in time and space. But even more—a million times more—important is the unbiased, sober-minded, and amicable attention displayed by people, including people in the sciences, to what is going on in the world.

Right now, our country [the Soviet Union] is going through a critical period in its history. The process that began a few years ago has reached a point at which the people, having understood the depth of their country's crisis, are asking themselves and their government: When will words be followed by actions? We have figured out that, in the course of 70 years, our society has displayed its unsound economy and inability to make any real progress, technological progress included. Its economic system, created by Stalinism, is in reality Stalinism today. This implies the unlimited power of the [Communist] Party and state monopolies embodied in two parallel structures: that of state agencies and the pervasive structures of Party management. This system is responsible for the absurd zigzags of the country's economic development and the resulting destruction of enormous material wealth. At the same time, it is responsible for the tragic destruction of the country's ecology on an unimaginable scale. Furthermore, this system is also responsible for the world's highest level of exploitation of the workforce by state capitalism. On this last point, here is a typical example, using plain numbers: 35% of our country's joint national product goes to paying workers, about two times less than in any other developed country.

Our country now faces the historic challenge of building a society that combines social justice with an effective economy. At the moment, we have neither one nor the other. The fate of our people depends on these changes. At the same time, whether or not we can end the threat our country poses to the rest of the world also depends on what we do in this historic moment.

Simultaneously, there are grandiose processes going on in other countries, such as China, and in developing countries. The savage treatment of the students in Tiananmen Square this past June was a demarcation line in China's history, when its development toward democracy and transformation was halted. No pragmatic explanations can justify what happened in China.

In the very same way, no short-term pragmatic considerations, no narrowly nationalistic views can justify employing the politics of appeasement toward the Soviet Union. All of the West's interaction with the USSR, China, and other socialist countries where the fight is raging for the freedom to choose the right path, ought to be built on one and only one principle: helping the move toward pluralism and keeping the road closed to the conservation of stagnation and the reinforcement of Stalinism. I mention all this in a general way because specific examples demand individual examination. I have no doubt, however, about the general principle on which we must proceed.

Within this entire worldwide complex of questions, the role of science and of scientists is wholly unique. Finding yourself surrounded by an audience of scientists, you experience a feeling of optimism. You feel that you are among friends who are not apathetic about what goes on beyond the boundaries of their field, nor about what they can do for the common good with the help of their profession. When it comes to our country, that means facilitating pluralistic development. And pluralistic development is part of the process of convergence, which I consider the cardinal path for human development. ■