Chemistry and the World of Tomorrow

Linus C. Pauling

This article is based on the Priestley Medal Address presented by Linus C. Pauling on April 9, during the ACS spring meeting in St. Louis. Still active at 83, Pauling is director of the Linus Pauling Institute of Science & Medicine, Palo Alto, Calif., where he continues his scientific research. Much of his work has dealt with the nature of the chemical bond. The Priestley Medal, ACS's highest award, recognizes his contributions in this and other areas, and is the latest in a long list of honors and awards Pauling has received, including the 1954 Nobel Prize in Chemistry and the 1962 Nobel Peace Prize.

Thirty-five years ago I gave a talk at the national meeting of the American Chemical Society with the title "Chemistry and the World of Today." This was my presidential address to ACS. I began by asking "What can I say under the title 'Chemistry and the World of Today'? My answer to this question is that I can say anything, discuss any feature of modern life, because every aspect of the world today—even politics and international relations—is affected by chemistry."

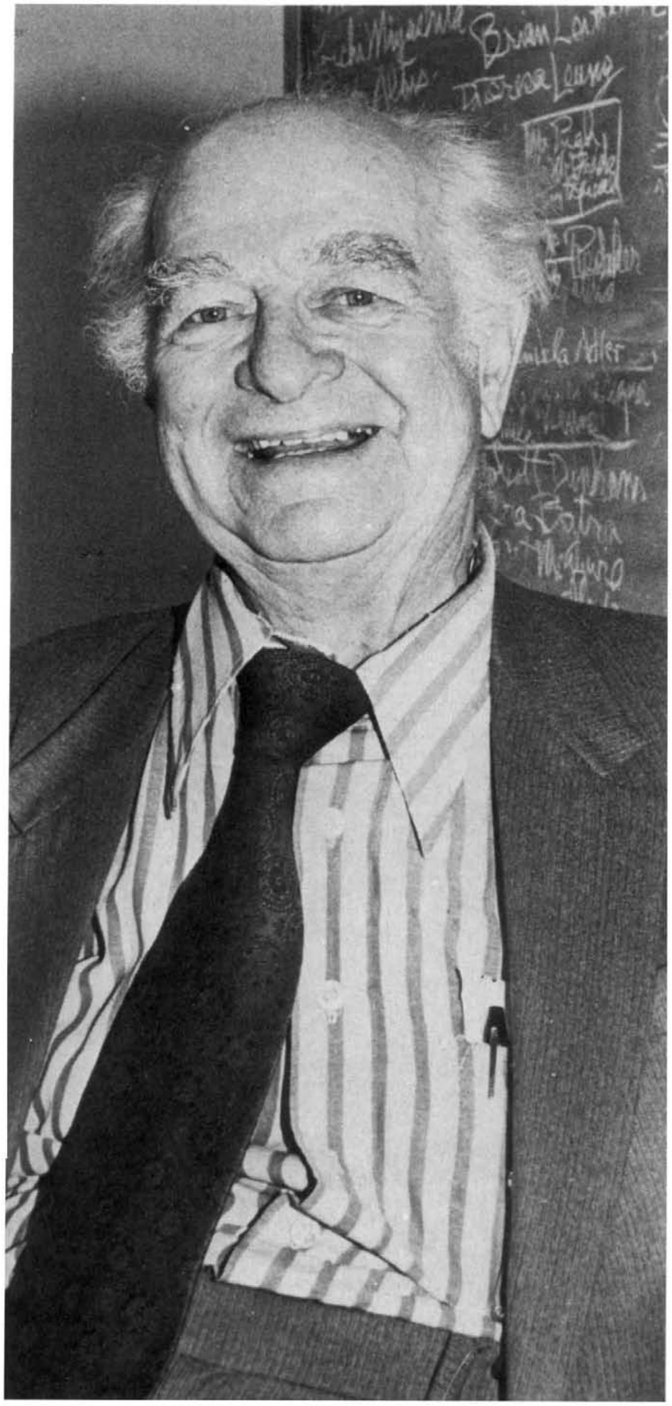
In my address I pointed out that during the years of World War II we began using up in practical applications our backlog of new basic discoveries, and it became clear that, although all scientists make their contributions to scientific progress, modern life is really based on fundamental science, on pure research, and that the nature of the world today has been determined, and the nature of the world of the future will be determined, by the work, and especially the ideas, the imagination, of a small number of people—the "impractical scientists," mainly university professors, who strive to add to our body of knowledge in every way, rather than to solve certain practical problems that obviously need solution. I said that I was not minimizing the importance of developmental research and of industrial application of new discoveries, but was instead pointing out that the direction in which progress occurs is in fact determined by the basic discoveries that are made, and that accordingly it is the progress of pure science that determines what the nature of the world will be a generation later.

It had been proposed in 1945 by the committees that prepared the Bush Report that there be set up a National Science Foundation, and that federal funds reaching $250 million per year in a few years be appropriated for the support of basic scientific research. More than two years had gone by without action on this proposal, and I urged that Congress act by setting up NSF and giving it a suitable appropriation. I also urged that a counterbalancing fund to support basic research be set up by the industries of the U.S., so that the field of research would not be dominated by the federal government. NSF came into existence shortly thereafter, but it was not found possible for the American Chemical Society to achieve the result of organizing the foundation by the great industrial corporations of a comparable fund for support of basic science, and the consequence has been that the federal government is now the dominating force in the support of scientific research.

Just as the nature of the world of 1945 had in large part been determined by the discoveries made by chemists and other scientists, we can see clearly that the changes in the nature of the world that have occurred in the past 35 years have been similarly determined by scientific discoveries and their application to practical problems. The nature of the world of tomorrow will depend upon what we do—what we do as chemists, and what we and our fellow citizens do as human beings. The two factors that will determine the nature of the world of the future are the knowledge that we possess and the decisions that we make about how to use that knowledge.

Now I am glad to have the opportunity of expressing my pleasure at being able to give this Priestley lecture. It is a source of satisfaction to me to know that the three chemists who nominated me for the medal said that I have some similarity to Priestley, in that the interests of both Priestley and me have included not only science but also morality. I may point out, however, that there is a difference between us. With me, it was science that came first; I then, several decades ago, formulated a basic ethical principle through what I have contended is essentially a scientific derivation. With Priestley, it was morality that came first.

Although Priestley is remembered now mainly as a scientist, his life was in fact devoted for the most part to social, political, religious, and philosophical analysis, writing, and education. He felt that questions in these fields could be attacked with increased effectiveness by obtaining additional knowledge about the nature of the world. When in 1758, at age 25, he moved to Nantwich, England, where he was minister to a congenial nonconformist congregation, he opened a school. From the Encyclopaedia Britannica, 9th edition, 1885, I quote the following statement: "Always bringing his best intelli-



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gence to bear on everything he undertook, he varied his elementary lessons with instruction in natural philosophy, illustrated by experiments, for which he could now afford the needful instruments."

His studies up to this time had been entirely literary, philosophical, and theological. In them, however, he had displayed the fundamental characteristics of the scientist—honesty, rationality, and freedom from bias and dogma. These characteristics seem to have been inborn in him, and they were fostered by his having entered a nonconformist academy at age 19. At age 17 he had been strictly orthodox, and he "anxiously endeavored to realize the experiences he supposed to be necessary to religious conversion. His chief trouble was that he could not repent of Adam's transgression, a difficulty he never overcame. The pressure of this impossibility forced his candid mind to the conclusion that there must be a mistake somewhere, and he began to doubt whether he was so much entangled in Adam's guilt as he had been taught."

In his scientific work Priestley exploited a new technique, which opened up a new field of chemistry—the technique of handling gases by collecting them over water or mercury in a pneumatic trough. This innovation might be compared to the 20th-century introduction of x-ray crystallography into structural chemistry or of chromatography into analytical chemistry. By use of this technique Priestley was able to discover 10 new gases and to contribute significantly to the development of modern chemistry. One of Priestley's biographers, Gibbs, has asked, "How was it that, in this difficult and obscure field [of the existence and nature of different kinds of gases] he was able to make advances that had eluded so many men of science? He himself put it down to his habit of searching into dark and mysterious corners, and of following a scent wherever it might lead, without any preconceived ideas. Almost alone among scientists then living, he was honest enough to credit part, at least, of his success to enthusiasm and a sense of adventure. If he was looking at a piece of mint standing in an upturned jar over a bowl of water, or at a mouse in an inverted beer glass, great issues were at stake. He was watching carefully for any hint that might lead to means for enhancing the welfare and happiness of mankind. And behind it all he was convinced that the rapid progress of knowledge would 'be the means, under God, of putting an end to all undue and usurped authority in the business of religion, as well as of science.' "

We ourselves have seen the rapid progress of science during recent decades. Right now the organometallic compounds, especially of the transition metals, have been the subject of great interest on the part of many chemists, and it is likely that the discoveries that are being made will have a pronounced effect on the nature of the world of the future. A few decades ago a new science, molecular biology, was developed as a result of the interest of structural chemists in the question of the nature of living organisms. The consequences of this development can be seen about us now, in the effort that is being spent on genetic engineering and related fields.

Most important of all, with respect to science and the world of the future, is the existence of nuclear weapons, based upon the processes of nuclear fission and nuclear fusion that were discovered by physicists and chemists half a century ago. The greatest of all questions now is whether or not the world will have a future—whether there will be a tomorrow. It is with respect to this question that chemists have their primary obligation as citizens.

Many of us remember an outstanding physical chemist, George Kistiakowsky, who died a year and a half ago at age 82. He had been an officer in the White Russian army at age 21 and a manual laborer in the Balkans, and then he studied chemistry in Berlin and came to the U.S. I worked with him in the explosives division of the National Defense Research Committee, and in 1944 he became head of the explosives division at Los Alamos. From 1959 to 1961 he was science adviser to President Eisenhower. During the last 12 years of his life he devoted himself to working for world peace. His last article, published Dec. 2, 1982, in the *Bulletin of the Atomic Scientists*, was on world peace. In it he described the development of nuclear weapons, and wrote, "The Soviets, of course, kept up with us in most respects. And so here we are, possessers of some 50,000 nuclear warheads: more than enough to produce a holocaust that will not only destroy industrial civilization but is likely to spread over the earth environmental effects from which recovery is by no means certain.

"As one who has tried to change these trends, working both through official channels and, for the last dozen years, from outside, I tell you, as my parting words, *forget the channels!*

"There is simply not time enough before the world explodes.

"Concentrate instead on organizing a mass movement for peace such as there has not been before.

"The threat of annihilation is unprecedented."

And so, Kisty said, we must now take unprecedented action to save the world.

We, as chemists, can contribute to developing a better world. Our primary duty now is to work to help educate our fellow citizens. We are facing the unprecedented threat of extinction of the human race in a nuclear war, and we must all join in taking unprecedented actions to prevent this annihilation and to achieve the goal of the abolition of war. We must do our part to see to it that there is a world of tomorrow. □