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Author(s): Paul Doty
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The Community of Science and the Search for Peace

Paul Doty

To speak of the community of science and the search for peace at this moment of history may seem anachronistic, if not actually pretentious. To many people, external suspicions and internal doubts seem to have robbed science of the self-confidence and sense of purpose that have given it the coherence of a community. To all who have for years striven to end the Vietnam war, the suggestion that peace requires only a search may seem empty and superficial. In fact, when the national anxiety disposes us to look for scapegoats, isn't it possible that science is more connected with war than with peace?

To contest these points and give substance to this title requires our stepping back into a larger frame of time and freeing ourselves from some of these moods of the moment. Let me sketch some of the complex ways in which science and peace seem to be related.

Science is understanding, primarily of the physical and biological worlds, but also, to the extent that it is possible, of the more complex domain of human behavior. Peace is more than the absence of war: it is the restraint of aggression, the sense of security among nations, and the functioning of domestic order and economy at a level sufficient for meeting the deeply felt needs of the citizenry. While the requirements of such a peace are many and complex, it seems likely that an adequately functioning and responsive technology is an unavoidable necessity.

Technology is simply the multiplicity of ways in which human groups go about satisfying their physical needs. The first technology was agriculture. When it had evolved to the point of sustaining social units larger than isolated villages, civilization began—about 6000 years ago. With technology evolving only slowly, the 4000 years from that time until the time of Christ saw the world's population grow slowly to about 100 million. It was 400 million by 1500, and it reached a billion by 1825. By then, the infusion of science into technology was under way, and denser populations could be supported. A few decades later, a new medical technology supported by revolutionary public health measures was established, and death rates plummeted. By 1930, the population had doubled again to 2 billion. Another billion was added by 1960, and another billion will be with us by 1975. Two more billion, the total population of the world only 40 years ago, are expected to be added in the 30 years after 1975.

The author is professor of biochemistry, Harvard University, Cambridge, Massachusetts 02138. This article is adapted from the Robertson Memorial Lecture given on 26 April 1971 to the National Academy of Sciences.

The Trend toward Peace

Perhaps the most striking transformation of our era has been the quadrupling of the world's population in this century. The strains that this explosive growth produces are more likely to promote war than peace. By having served as the catalyst of the technological revolutions that made this explosive growth possible, science is inevitably linked to the threats to international order that this condition creates.

In part, world wars of this century were the realization of these threats. In addition, the greatly increased lethality of these wars was only possible because of an advancing technology. Nearly half of the deaths directly due to warfare in recorded history occurred in the two world wars. These wars took place when, for the first time, it was technically possible to bring together so many soldiers and so much firepower.

More than 25 years have now passed without a recurrence of this kind of intense warfare. While war casualties have numbered 1 to 2 million per decade during this period, the carnage of the earlier decades of this century has been stopped. To put it another way, death rates in war have dropped by a factor of 10 during the last quarter century, a period when 1 billion people were being added to the earth's population. Indeed, if one takes as an index of peace the fraction of the world's population that is killed in war per decade, it is likely that the last two decades have been the most peaceful for centuries.

Of course, this view runs counter to the popular conception of turmoil and war, which is made more real by its daily transmission on television. Communications technology has vastly altered the perception of war and, perhaps, has thereby contributed to restraining it by making its reality much more widely felt. On the other hand, the constant visualization of the horrors of wars, even small ones, can have a brutalizing effect as well, and this may indeed contribute to the worldwide increase in domestic violence. However, we will not know which effect will be the dominant one for a long time.

By contrast, we can be rather certain that the relatively peaceful condition of the world in the last two decades is, in large measure, due to the mutual deterrence of American and Soviet nuclear weapons. Without this nuclear deterrence, the continuation of world wars would seemingly have been inevitable. The collision of expanding power centers, growing populations intent on securing a better share of dwindling resources, or simple, unrestrained aggression would have maintained and probably quickened the cycle of wars on the immense scale that technology now makes possible. Mutual deterrence has been effective not only between the Soviet Union and ourselves, but between either of these nations and any other potential adversary. This has radically changed the military picture throughout the world. The great standing armies of Western Europe were not rebuilt. The major losers of World War II have become leading industrial nations, in large part because the umbrella of deterrence allowed them to forego rearming.

It is, of course, the possibility of failure in this stabilization by deterrence that is terrifying. Failure would

probably mean the annihilation of most of the developed world. The losses in the first hour could far exceed the casualties of all wars in history combined. The long-term effects would probably destroy the remaining social and economic fabric of the northern hemisphere. The suffering that the survivors would endure cannot be imagined.

Thus it is that our generation is the first to have felt the real surge of the population explosion and the first to have lived with the constant threat of nuclear annihilation. It could not have been otherwise—only the timing could have been a little different. Given the steady progress in scientific understanding and the increasingly dynamic technology of the previous 100 years, it was inevitable that the conditions making possible both rapid population growth and the development of strategic nuclear weapons would come into being somewhere near the middle of the 20th century. For quite different reasons, World War II accelerated both. At the end of that war, only two nations had both the capability and the incentives to undertake the large-scale development of nuclear weapons and delivery systems. Admittedly they were nations with little experience in world affairs, with intense suspicions of each other, and with ambitions to extend or protect their political system in other parts of the world. That we and the Soviet Union have remained at peace during the first quarter century of the nuclear age is no small accomplishment. Indeed, taken together with the absence of large-scale conventional wars, this is a remarkable achievement. It is even more remarkable when it is remembered that an additional 1 billion people have populated the earth during this same period and have been nurtured no less well than those that preceded them.

That these accomplishments are not celebrated and that most people seem to take an increasingly dim view of their condition, are perhaps more a consequence of unfulfilled expectations than of comparisons with other historical crises.

In short, man has survived the difficult passage of the early years of this new age. He has bought time and a little self-confidence with which to measure the dimensions of two towering, global problems—the prevention of nuclear war (and, with it, large-scale conventional war) and the control of population growth to the point that its attendant problems of hunger, malnutrition, unemployment, and disease can be systematically reduced. These are negative goals, but their attainment is the necessary condition for the social, economic, and political health of all societies.

Thus, science has been both parent and midwife of the technology that has made possible the population explosion and nuclear weaponry. The management and control of the revolutions these developments have produced are the decisive challenges we confront. The two nations that have pioneered in the development of strategic nuclear weapons also lead the world in production of goods and energy. These two nations have, therefore, the leading role to play in meeting these challenges. It is the response to these challenges that constitutes the search for peace, and it is the part that the community of scientists can play that I stress. The perspective I wish to convey is one of decades, not years. Therefore, the task requires a tenacity that will outlive individuals, and its continuity calls for some support in institutions. Because the Soviet Union and the United States have such unique responsibilities, the relations among their scientists have a special significance. In concentrating on this, I must put aside the much more extensive and synergistic relations we have with the scientific communities of many other nations and the promising partnerships we have with many developing countries.

Soviet-American Scientific Exchange

The Atoms-for-Peace Conference in Geneva in 1955 marked the beginning of significant contacts between Soviet and American scientists and the declassification of many interesting developments in nuclear physics. Although there was obviously a desire to broaden these contacts to include visits and collaboration in research, it soon became evident that the differences in social systems and the degree of governmental control was too great to allow the long-established patterns of individual scientists' making their own arrangements and proceeding to other countries. Therefore, in 1958 the Academy of Sciences in Moscow and the National Academy of Sciences negotiated an agreement to make the necessary arrangements for the exchange visits. In 1961, nine American scientists went to the Soviet Union for a total of 13 months, and eight Soviet scientists came here for a total of 20 months. This operation, carried out in the office of the foreign secretary and supported by the National Science Foundation, has grown to the point where last year approximately 28 scientists were exchanged each way, for totals of about 91 months in each country, a threefold to fourfold increase in a decade.

In order to allow the interests of the receiving nation more expression, the National Academy eventually reached an agreement with the Soviet Academy whereby invitations could be extended for special visits or conferences. This is now beginning to work: at the request of interested American scientists, we extended invitations to 45 Soviet scientists last year. Unfortunately, only four of them came. The Soviet Academy prefers to extend invitations to Americans for 2-week visits outside the exchange agreement, but we have no way of knowing how many of these invitations have been received and accepted. Moreover, the Soviet Academy has often been very cooperative in helping to arrange professional contacts for American scientists traveling privately to the Soviet Union. Consequently, the American contact with Soviet science is somewhat greater than that provided for in the agreement. Although both sides benefit, the Americans benefit more because they attend many more international scientific meetings held in the Soviet Union than vice versa.

Scientific exchanges with the Soviet Union also take place through other agencies, particularly the National Institutes of Health, the National Aeronautics and Space Administration, and the Atomic Energy Commission. But the exchange of academic scientists is concentrated largely within the Academy program. How then can the first decade of experience with the interacademy exchange be assessed? In terms of facilitating the travel of American scientists to the Soviet Union, we are doing rather well, at a level of about 100 man-months per year. About 90 percent of those we recommend actually complete their visits. The visits are becoming longer, and the quality of applicants has steadily improved. We now have three times as many qualified applicants as we can accommodate. What is not very satisfactory from the standpoint of American scientists is

the inability to have the Soviet scientists of their choice visit here. Moreover, the Soviet scientists who come on the exchange program are heavily concentrated in physics and engineering; therefore, many important areas of science are scarcely covered.

The exchange program has clearly broken the ice and has, by now, introduced nearly 200 scientists of each country into the scientific life of the other country. This means that realism replaces ignorance on both sides, a widening perspective of each other's science is conveyed, and a basis for future developments has been laid, assuming that more intimate scientific contacts become possible in the future. In addition, some very good research has been carried out in collaboration, and the program has served as the forerunner of similar exchange programs with Eastern Europe. Thanks to Harrison Brown's initiative, such exchanges are now under way with all countries of Eastern Europe except Albania—usually at the level of 40 man-months per year. That such programs continue and gradually expand seems clearly to be a mutual goal. For example, the president of the Soviet Academy has suggested a 10 percent expansion, and the president of the Czechoslovak Academy has suggested a 50 percent expansion for the next 2 years. It is hoped that the increased funding needed can be obtained. Having mentioned funding, it is appropriate to point out that a substantial contribution is made by each of the American universities that receives Soviet or Eastern European scientists. The universities provide office and laboratory space and find the means by which the visiting scientists' research is supported.

Given this positive assessment, it must nevertheless be acknowledged that this form of exchange falls short of international collaboration as we know it—where one investigator is so interested in doing research with someone in another country that he invites him here or is invited there. I do not see this easy, informal exchange taking place for a long time—especially not until Soviet citizens are more free to travel abroad. Until that time, we will have to forego the pleasures of individually initiated collaboration, which is often very productive.

However, truly collaborative work of this kind *is* becoming possible in groups, especially in the field of nuclear physics. An American team is working successfully at the new accelerator at Serpukhov in the Soviet Union. Instruments from the United States and the European Center for Nuclear Research are being taken in and out easily. Even teletype links have been established between some Soviet nuclear laboratories and California. What is still missing is the arrival of the Soviet team to work at the Stanford Linear Accelerator Center. But with things going so well and the timing of experiments being so important, there are clear grounds for optimism (*1*). Moreover, there has now been established an informal annual meeting of the directors of accelerator laboratories in the United States, the Soviet Union, and Western Europe. This group, having been established for 3 years, is very effective in joint planning of experiments and now will begin to plan for a superaccelerator.

It seems likely that the most important extension of Soviet-American scientific cooperation will take place by means of planning groups such as these in areas where both nations have high competence and special interest. The areas of meteorology, plasma physics, deep drilling and fusion power (where, curiously, both countries have had research cutbacks), oceanography, and certain areas of medicine are obvious candidates.

To complete this summary of where we stand after 10 years of experimenting with cooperation between the two scientific communities, I should mention the slowly maturing plans for a multinational Institute of Applied Systems Analysis. Eight nations are participating thus far. The National Academy has been deeply involved in these arrangements, and an agreement has already been reached to have an American director and a Soviet chairman of the institute. To be located in Western Europe, the institute will, it is hoped, become a center for sharing experience and research in such problems as industrial planning, optimization of man-machine systems, ecological planning, and rapid, large-scale medical diagnosis. The long gestation period of this project has seemed frustrating to many people, but it is probably unavoidable. The highly centralized but very slow decision-making process in the Soviet Union, and the divergent, keep-your-options-open attitudes of western countries involved in collective planning do not compensate for each other's shortcomings.

The Role of Pugwash

Another multinational arena, in which relations among American and Soviet scientists have been growing for 15 years, is Pugwash. Pugwash has become many things since the first conference was held in a pleasant fishing village in Nova Scotia. It has become a series of 20 conferences, held since 1957, on science and world affairs. These conferences were initiated in response to an Einstein-Russell statement of 1955, and with the initial benefaction of Cyrus Eaton. They have taken place all over the world, as well as twice here and twice in the Soviet Union, and have been attended by many leading scientists, scholars, and diplomats, in addition to representatives of the entire spectrum of the scientific and diplomatic communities. The most common themes at the conferences have been arms control and aspects of development and scientific cooperation.

Pugwash is a group of autonomous national committees that select participants to conferences, instruct the continuing committee members on how to run the conferences, raise funds, and often become active national centers for the discussion of science, science policy, and world affairs.

Pugwash is, more recently, a series of symposia in which substantially higher standards for contributed papers are in evidence and discussion is much more focused than at the Pugwash conferences. One of the most recent, the tenth in this series, was held last June in Racine, Wisconsin. Its title was "Impact of New Technologies on the Arms Race," and it has already been published. The symposium brought a number of experts together for the first time, and the book presents a whole array of unclassified material that has never before been assembled or analyzed in this way. The meeting was enlivened by the presence of four Soviet scientists of considerable experience who had not participated previously. Thus, the circle of acquaintances grows, and the analyses needed for rational decisions in arms control are discussed long before policy decisions are made. From time to time at Pugwash conferences, bilateral discussions of arms control problems between Soviets and Americans have had important consequences.

Pugwash is a commitment to the rational discussion of the more difficult problems in arms control and disarma-

ment. For example, the control and elimination of chemical and biological warfare has been on the Pugwash agenda for a long time. The discussions there have certainly helped keep this issue in view. President Nixon's move to end an American capability in bacteriological warfare was a long step toward cutting off in its infancy a new dimension of warfare, one for which there was no military need and which, if pushed to prominence, would distort and divide a whole sector of biological science. For more than a year, the Soviet Union maintained its position that chemical and bacteriological weapons should be banned together. Finally, last March, the Soviet Union reversed its position, thus ending an East-West stalemate. It is quite possible that by the end of the year we shall have a convention, accepted by most of the world, which not only outlaws disease as a weapon of war, but commits world powers to the destruction of these weapons as they now exist. We do not know what weight Pugwash discussions carried in these two decisions, but, at the very least, it is gratifying to have been applying pressure when the change came.

Attention is now focused sharply on the U.S. Senate's debate on the ratification of the Geneva Protocol of 1925, which prohibits gas and germ warfare. The positive effects of the President's submitting this treaty to the Senate can be compromised by his insisting that it does not apply to the use of herbicides and riot gas in war, whereas the view of virtually all signatories to the treaty is the opposite. Anticipating this kind of conflict many participants in the Pugwash discussions have urged that the matter be submitted through the U.N. General Assembly to the International Court of Justice for an advisory opinion.

Pugwash is a mood that tries to go beyond the Cold War. For some, it is an uncritical affirmation that goodwill is sufficient for solving intractable problems. For others, it is an entrée to more realistic discussions of serious international problems than is possible anywhere else. For five of the first six conferences, scientists from the People's Republic of China participated. Every effort is being made to bring them back at the next conference in Rumania in September.

Most particularly, Pugwash is the unending patience and dedication of the members of the Continuing Committee and of Executive Secretary Joseph Rotblat, all of whom hold it together (*2*).

At 15 years, Pugwash is already middle-aged for informal consortia of this kind. In many ways it needs rejuvenation, and the 1972 Conference at Oxford is the deadline for whatever transfusion or transplantation can be agreed upon. Indeed, such changes are already under way in the actions being taken by the new president, Hannes Alfvén, a foreign associate of the National Academy of Sciences.

My own prescription begins with a judgment that Pugwash, like the United Nations, would have to be invented if it didn't exist, and that this will become more evident with time. It shares, on a microscale, many of the weaknesses of the United Nations. But, as in the United Nations, these weaknesses could, in large measure, be overcome if the leading nations were more involved. What is particularly missing is a sufficiently high level of participation from West Germany and France, as well as the real involvement of Chinese and Japanese scientists. In the United States, the National Academy has offered increasingly strong support, although the operation remains centered in the American Academy in Boston. Greater participation by these other leading nations might best be encouraged by the National Academy's playing a greater role. In that case, the equivalent academies in these other countries could not easily remain aloof.

To take this next step, the National Academy might seek to join equally with the American Academy in sponsoring the American operation. However, I do not mean to recommend simply an organizational change. Rather, I suggest joint sponsorship only if the National Academy finds its worldwide concerns would benefit from using, and thereby helping shape, a forum for informal discussion of international scientific problems. It is when such problems are in a formative stage, before national positions are taken, that useful illumination from many points of view can be most helpful. Moreover, the National Academy may want a more heterogeneous arena in which to explore initiatives and be made aware of the range of response these initiatives may elicit. It is in this sense that more active participation in Pugwash would be of mutual benefit to Pugwash and the National Academy.

The other problem that besets Pugwash is its uncertainty as to how it can help science deal effectively with the second challenge I have emphasized—the problems triggered by the rapid growth of population: development, food production, employment, and health in the developing countries. It is not surprising that attempts have, thus far, not been particularly fruitful. There is no agreement among experts on the proper mix of activities that produces obviously desirable results. The more the developed world becomes aware of the burden that its own lifestyle is putting on world resources, the less it can serve as a model of how other nations should develop. Indeed, developing nations cannot go our way, and we ourselves may soon have to evolve into less consumptive economies. At issue are very complex systems problems in which scientists should find a definite, but limited, role. However, until such complex systems are better understood, one can expect uncertainty, ambivalence, and mismatches to be in evidence.

Two recent developments give considerable promise in this area. The first is the expanding and successful efforts to help developing countries set up their own science advisory systems. This is being carried out by the Board on Science and Technology for International Development in the foreign secretary's office. The second is the restructuring, now under way, of the Agency for International Development. If present plans hold, research and development in this area will constitute a separate organization, the International Development Institute. This will become a focus for the science-based, research-oriented end of the aid spectrum and should greatly facilitate a rational use of science in this area.

When these developments have gone further, what scientists can do to help will become much clearer, and more effective international action in Pugwash and elsewhere can be expected. At the last Pugwash conference, a very effective symposium on population problems was presented. Similarly, the green revolution will be a main symposium topic at this year's conference.

This recital of the state of informal scientific contacts in two particular areas has intended to show where we stand. A comparable review of the more extensive, more organized Soviet-American contacts that occur within the International Council of Scientific Unions and Unesco would have fur-

ther supported the view that, in retrospect, the improvement in Soviet-American relations within the last 10 to 15 years has been enormous. But, in comparison with what is to be done, the bridge of understanding that is being erected is still extremely fragile. Only a start has been made in effective international scientific discussion of either of the challenges I have emphasized—dealing with rapid population growth and its attendant consequences, and controlling the arms race.

Arms Control and Disarmament

It is impossible to give a simple, affirmative answer to the question of whether we are making progress in controlling the arms race and reducing the risk of nuclear war. However, some important beginnings have been made. The Soviet-American dialogue in arms control is much more intense than ever before. While defenses in the form of antiballistic missile (ABM) systems are slowly increasing, there is widening acceptance of the belief that extensive defensive measures—whether potentially effective or not—are incompatible with deterrence. On balance, I think this incompatibility is becoming more widely understood on both sides. In addition, the futility of continuing the nuclear arms race is being shared by wider audiences on both sides. The state of parity has been reached, and this may well have been a prerequisite for serious negotiation. Finally, note the political importance seen in the issue of arms control by all of the Democratic contenders for the presidential nomination and the enormous amount of time devoted by this Administration to the Strategic Arms Limitation Talks (SALT).

There is no public evidence that SALT is likely to lead to important agreements soon. However, such pessimism about a nuclear test ban would have been justified at this point in 1963, and by late summer there was an agreement. Nevertheless, the high expectations that many people had for this round of SALT have been diminished by the lack of evidence that the Soviet Union is prepared to negotiate a comprehensive agreement. The alternative, therefore, would seem to be a much more limited agreement, and public discussion is pointing to an agreement to limit ABM systems. This is a matter that many of us have discussed for years with our Soviet colleagues. We were gratified that a common assessment began to emerge in 1967. By early 1968, there were indications at Soviet and U.S. governmental levels that ABM limitations might be possible, along with a limit on offensive missiles. These hopes were dashed when, on the eve of President Johnson's visit to open such negotiations, Soviet troops moved into Czechoslovakia.

It has taken a long time to recover from this reversal of hopes, and, in the meanwhile, much has happened to make future agreements more difficult. In my own view, the greatest difficulty lies in the apparent erosion—on both sides—of the doctrine of deterrence. While approximate parity has been reached, it is evident that the level of weapons far exceeds that required for deterrence. In this state of nuclear plenty, new doctrines are required to justify the weaponry. For a while, "damage limitation" sufficed. The extra weapons would be used to take out the enemy's unlaunched missiles, should an exchange begin. But now it would seem that the momentum on each side—our MIRV's (multiple independently targetable reentry vehicles) and their continuing deployment of very large missiles—is largely maintained to satisfy those planners on both sides who think of fighting a nuclear war to the finish, not of deterring such a war.

If this assessment is correct, we confront a massive block to serious disarmament measures. Everyone concerned, along with new recruits, will have to address this relatively unexamined aspect of the problem, both in public and in international discussions. Until there is a common and manageable conception of the role of nuclear weapons, their control cannot be honestly confronted.

If this view is correct, then our expectations at SALT must be lowered. An agreement that severely limits ABM, or, preferably, bans such systems, would clearly be a great step forward. If a freeze or limitation on all offensive missiles is not possible, then a freeze on land-based missiles and the completion of the nuclear test ban treaty by banning underground testing would be an attractive alternative.

I have tried to present here enough of the picture to indicate that our progress in meaningful scientific contacts is only a means that may be helpful, even essential, in dealing with the two challenges I have focused on. But the magnitude of these challenges dwarfs our present efforts in dealing with them. Let me give a final statistic that unites the two world problems I have been discussing. It is estimated that military budgets consume 7 percent of the total of the world's gross national product. This number takes on more meaning when it is noted that half of the world's population lives on 7 percent of the world's gross national product. I think it will be increasingly difficult for us—as a part of the scientific community—to accept this ironic balance.

Notes

1. Indeed, since this lecture was delivered, the first Soviet scientists have arrived to work at the National Accelerator Laboratory, Batavia, Ill.
2. The American group is Bernard Feld, Franklin Long, and Eugene Rabinowitch. Former members were Bentley Glass and Harrison Brown. The Soviets are Mikhail Millionshchikov, first vice president of the Academy of Sciences, and Aleksandr Topchiev, who preceded him.