

Science and Revolutions

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I. THE SECOND RUSSIAN REVOLUTION —
IS THIS THE LAST?

I spent quite a number of years doing space research so I would like to start with the reference to *Sputnik I*, and its launch thirty-five years ago. For many of us, it signified the beginning of a new era of scientific discoveries. We compared the forthcoming future with the epoch of the great geographical discoveries. We thought: so this is what is going to happen on the scale of the solar system and the universe !

However, thirty-five years later, during the year called “International Space Year” by the United Nations, we have to confess that we were bad prophets. Instead of living in the epoch of great geographic discoveries, we, former Soviets, now realize that we are living in the epoch of great *historical* discoveries: those of our own past. The old paradigm we had for many years is best expressed in a joke. We used to say: “The past unpredictable, the future is bright.” Now that is obsolete.

I would like to invite you to make a brief historic excursion to that period, then proclaimed “the grand historic experiment,” which was launched in October 1917. At the time of the “Great October Revolution,” the Bolsheviki in Russia were only a minority. The first multiparty elections in Russian history, held two weeks after the October Revolution, brought the Bolshevik party only 25% of the votes. But it didn’t stop them from implementing their rule. Lenin declared that this 25% of the populace represented the most conscious avant-garde of the working class, mostly in St. Petersburg, in Moscow, and in industrialized central Russia.

This grand historic experiment followed the wisdom suggested by Marx and Engels that theory and practice must be unified — the theory based on what Bolsheviki thought to be the ultimate

science: Marxism. At that particular junction of history, there were people who predicted that the experiment would fail, that in order to be successful it had to satisfy necessary preconditions. Those people who were quite skeptical were called “social traitors” by Lenin and the Bolsheviks. In fact they were followers of Marx and Engels and the leaders of contemporary European social democracy. They had quite a few followers inside Soviet Russia too.

The principal Marxist prerequisite for the success of the socialist revolution was the proper external environment, in which the developed capitalist Western nations would be ready to embark on the socialist experiment. In other words, they suggested that the Russian experiment could succeed only if this external environment was already on its way to socialism.

Although Lenin rejected this argument, he too feared his revolution could not succeed alone. All of his hopes were for a worldwide proletarian revolution. Nevertheless, this revolution did not come about, even though there were some very brief sparks in Germany and in a few other countries. In fact the only place where the Bolshevik revolution was able to establish itself, at least for a few months, was in Hungary.

On Stalin’s accession to power he soon changed Lenin’s formula. With no “worldwide revolution” forthcoming he developed a modification of the Marxist theory. For many years — from early childhood — we were taught Stalin’s theory about the possibility of the construction of socialism in a single isolated country, surrounded by the capitalist environment. External conditions, or prerequisites, according to Stalin, could be replaced by a state of utmost mobilization or readiness to fight. That was how we lived for seventy years — in a state of alert.

In 1940, the Soviet Union added to its empire the Baltic states. The final composition of the USSR, at that time, totaled sixteen republics. Despite the hardships and losses in World War II, that heroic period created a lot of illusions inside the country. There was a feeling, based on the international solidarity of the allies

and on the revival of genuine national patriotism, that the regime would change the conditions of its experiment. But it was only delusion. Very quickly, beginning with the end of World War II, Stalin again came back to his original posture, his totalitarian behavior.

During 1944 and 1945, based on the results of World War II, Bolsheviks were capable of taking over Eastern Europe, which led to the formation of what we called for several decades the socialist camp. In an ironic way, Marx's warning against a premature attempt to build socialism was right.

The first recognition that the experiment was not doing well came in 1956, with the famous pronouncement from Khrushchev at the Twentieth Party Congress. At that time, the failure of the Communist experiment was attributed to the specifics of Stalin's personality and to the fashion in which the country was run —the idea of a "personality cult." Khrushchev attempted to implement small changes and modifications in the rigid Stalinist model. However, the next few decades indicated that a simple mending of the wrong systemic concept could not be successful. The last attempt to modernize, to revise the ongoing experiment, was launched by Gorbachev, after several decades of the stagnation of the regime.

Gorbachev developed a scenario that now probably would be regarded as a new utopia. It was based on the assumption that the Communist system could provide "friendly, nice governments" with a "human face," with a big Gorbachev ruling from the Kremlin, loved by everyone, and small "Gorbachevs" everywhere from Berlin to Prague. Perhaps he thought that this was the way the system could repair itself. It is not accidental that at that very same time he was talking about "new thinking" and universal human values.

Those most important values proclaimed by the great French Revolution —*liberté, égalité, and fraternité* —were implanted in Soviet reality in a very peculiar way. I don't think we, at that time, were familiar with the notion of democratic "freedom" at all. The

notion of *égalité* was transformed into a kind of egalitarianism, which is now backfiring, in our attempt to move to a market economy. The only achievement of which we all were indeed proud, even those who were critical of the socialist experiment, was the *fraternité* among the different nationalities and ethnic groups, united in one Soviet Union. But what is happening now in this respect has revealed that we were living with the wrong notion of *fraternité*—one that had to be imposed from above. With liberalization of control it immediately exploded in a multitude of interethnic conflicts and even bloodshed, as we see now.

However, in one particular aspect, Gorbachev succeeded tremendously. It was in the implementation of *glasnost* and openness in our country. In 1989, the Soviet Union had competitive political elections for the first time. If not completely multiparty, they were at least based on a competitive electoral process. When the nation elected the Congress of People's Deputies I had my own chance too, for a brief period—before this congress was eliminated—to enjoy being a part of this distinguished group of people, together with the late academician Andrei Sakharov.

In 1990, this very congress ended the one-party monopoly of the Bolsheviks. It was a very important event, the advent of a multiparty system. I remember how slowly we approached this moment. In 1987 and 1988, I myself was quite skeptical about the possibility of a quick implementation of a multiparty system. Of course, to some extent, we shared the wisdom of “Radio Yerevan,” the legendary and inexhaustible source of political anecdotes. Once it joked: “A multiparty system is utopia for the Soviet Union. The poor country is barely capable of feeding even one party!”

In August 1991, we witnessed an abortive coup, which essentially formally ended the CPSU. From that very moment the CPSU became only an illegal underground party, just as it was in tsarist Russia. But this time it happened with the support of the majority of the population. The next outstanding step, which came at the end of 1991, was the abolition of the Soviet Union and the forma-

tion of fifteen independent states. (I still have difficulty calling it the Commonwealth of Independent States. I am waiting for someone to suggest a better formula. My only satisfaction comes from the fact that Sovietologists themselves have to look for a new name.)

This profound political transformation was intertwined with economic evolution and changes in the country. In historic retrospect, going back to the beginning of the “grand historic experiment,” the economic dimension of the whole picture started with a “war communism economy,” from 1917 to 1922. This is a period when the economy of the country was ruined, when all normal incentives and interregional and industrial ties were broken. It was a time when the functioning of the economy was implemented only with terror or, as the Communists would say, “with iron discipline.” The economy of war communism, after some period of temporary stability, eventually gave rise to an economic experiment which Lenin called “the New Economic Policy” —from 1923 to approximately 1929. In 1929, Stalin decided to abolish this particular subprogram and launched massive collectivization of land use, accompanied with what he called the “Great Socialist Industrialization of the Country.” In such a framework, after surviving the bloody conflict of World War II, the country reached the Cold War in 1945–46, which led to the creation and buildup of a tremendous military machine. We now finally admit that it was a period when we were building our own military-industrial complex, comparable only to the Americans’. This of course was an unbearable burden for the national economy. Some analysts consider that the military-industrial development, which led to an unduly high fraction of military expenditures of the national budget, was probably one of the principal reasons for the failure of the “grand experiment.”

The first signs of failure were detected in 1962. In order to feed people, Khrushchev launched the import of grain. For a moment we thought it was a brief retreat, but bringing grain from

abroad revealed a very well defined illness of the system. After 1962, there was only a continuous escalation of grain imports. These massive imports of grain were done on the basis of oil exports, generating Soviet-style petro-dollars to pay for the grain imports. And not only that: they also paid for the prolongation of the “grand historic experiment.” Some of my colleagues, among contemporary members of the Congress of People’s Deputies, were calling these grain imports the giant conspiracy with the United States of America —as the biggest exporter of grain. Although the grain sales may have benefited both governments, the result was to continue the agony of the Bolshevik regime, and a system that couldn’t feed its people.

By late 1970, it was very clear that oil exports alone were unable to support a decent standard of living. In the atmosphere of political and economic stagnation the leaders of the country — not for general consumption, but at least for internal consumption inside the politburo — launched another slogan. Marshall Ustinov, the minister of defense in the 1970s and 1980s (he was the second man in the state and many people thought that since Brezhnev was almost completely debilitated Ustinov was number 1 in the hierarchy), even suggested: “The Soviet people are very patient. They need only two things. Bread and defense.”

By 1985, when Gorbachev took power in the Kremlin, the direct military expenses in the Soviet Union contributed up to 20–25% of the total budget. In many ways Gorbachev’s revolution, as the first part or the beginning of the Second Russian Revolution, was driven by an understanding of the ridiculousness of such overinflated military expenditures. Probably the very first move he made with extreme boldness was an attempt to bring this budget down. He did not want to do it on unilateral basis versus the United States, the main rival. Probably if he had tried to do it unilaterally, he would have encountered fervent resistance from the Soviet military-industrial complex. So this is why he entered into far-reaching arms control and eventually arms reduction dia-

logue with the Western world, first of all with the United States.

The very first signs of success in arms control allowed Gorbachev to launch economic reforms, which he thought would completely change but assure the framework of the “grand historic experiment” of communism. He launched the first cooperatives, the first laws on economic independence of enterprises, even if they were still state-owned, and so on. But instead of the expected success, *perestroika*'s dividends, these reforms very quickly led to the complete collapse of the national economy.

There are different explanations for such an unexpected outcome for the economy, which deteriorated in only two years. One particular explanation, which I would consider farfetched, came from the political proponents of SDI. They say that it was SDI that finally ruined the Soviet economy. Even some of the current Soviet politicians and analysts share that view.

I was, from the very beginning, very close to the focal point in the debates over SDI. And I think it was one of the most important and impressive achievements of Gorbachev that he did not accept the challenge posed by Reagan's SDI program. Instead he eventually adopted what was then called an “asymmetric response.” In fact the “asymmetric response,” even as vaguely as it was formulated, prevented huge Soviet expenditures in the area of antiballistic missile defense. If the race with SDI had developed further, Gorbachev and his advisers had in mind a cheaper approach based on a different technique to counter SDI developed by the American side. But in historic retrospect, in the evolution of relations between superpowers, the SDI dialogue played a very important role. I cannot resist mentioning an interesting historic parallel.

In 1945, Niels Bohr paid an unsuccessful visit to Winston Churchill. He made his own home analysis and came to the conclusion that the nuclear arms race could only lead to the abyss. He wanted to convey it to Western leaders —and he started with Churchill —the wisest man of the epoch. He tried to explain that

the best way to avoid a nuclear arms race would be to share, to some degree, the secrets of the nuclear weapons with the Soviets. And when he left Churchill's office, the prime minister asked only one question: "Why is this man not in prison?"

When Reagan suggested sharing SDI technology with the Soviets in 1983, no one asked such a question anymore about the proponents of openness. So it was tremendous progress, at least in that psychological aspect. However, traditional SDI, even if the technology was shared, would not have led to strategic stability. It would rather have undermined it, at least in the old framework of the superpower relations.

Now Yeltsin, during his February 1992 meeting with President Bush at Camp David, suggested that indeed superpowers could cooperate, if not in SDI, at least in a kind of limited joint defense. Most probably it is quite different from the so-called GPALS (Global Protection against Limited Strikes). However, it is very difficult to predict how things will develop in this particular sphere. Many of the former warriors of battles over SDI do not share the view that even limited SDI should be developed.

Coming back to the evolution of the national economy of the former Soviet Union, the actual reason for the economic bankruptcy of Soviet power is, of course, much deeper than simple budget allocations. As far back as 1917, at the very dawn of the Bolshevik era, Lenin came to the recognition that in the final account the outcome of the grand historic experiment of Soviet Russia would be determined in face-to-face competition with the capitalist world: the achievement of the best economic efficiency. History and nuclear deterrence have provided a unique time span over the last forty years — without major hot wars — to resolve the disputes by direct economic confrontation. The failure of the socialist economy (at least in its Soviet-imposed version) revealed a fundamental, perhaps even "genetically" inherent, deficiency of the system: its inability to create sufficient incentive and motivation to work and to produce economic wealth.

To compensate for the absence of a genuine economic algorithm, like the marketplace, Soviet rulers capitalized largely on the vast natural resources of the country —in combination with the cheap labor force. That rapacious exploitation of national treasures —rich reserves of oil and gas, for instance —accelerated industrialization, but led to another national catastrophe: environmental degradation beyond any measure known in the developed world.

The legacy of such a predatory policy will be felt for generations to come. And not only in the ecological dimension, but in the strong disproportions in the national economy, oriented toward delivering raw materials as the main source of income.

For decades an embarrassed leadership of the country tried to attribute one economic crisis after another to different mishaps, like droughts or technical shortcomings in industrial planning. But no matter what they did, there was no cardinal improvement of the situation. Before the final curtain fell, rejecting, at last, the obsolete Communist system on the basis of its hopeless performance, in a last desperate attempt, some orthodox architects of the socialist economy argued that the situation was the fault of science. They blamed the scientific and technological community for its failure to build a master supercomputer, capable of centrally running the national economy.

The greatest economic catastrophe was in 1991. Industrial production fell more than 15% in only one year. Similarly bleak forecasts are floating among economists. The same 15%, maybe even a higher drop, is expected in only the first few months of 1992, before some stabilization occurs. In that particular situation the sole hope is associated with the forthcoming privatization, with moving the country toward a market economy. But this transition is assessed now in the framework of a different historic experiment, the one representing a different systemic transformation — a phase “transition,” as physicists would say —in this case, from socialism to capitalism. How can we implement such a transition quickly?

In some of the economic strategies that are suggested in Moscow, and in almost every other corner of the former Soviet Union, a great deal of attention is paid to the formula of forthcoming massive privatization. There is one particular psychological difficulty that is associated with the very history of our system. For seventy years the Soviet people were told that all the things they have—all the assets of the national economy—are common assets, collective property belonging to all of us. The simple traditional formula for privatization, established in international practice on a smaller scale, and still used in the United Kingdom, is when state property could be sold directly to individuals or to groups of people. It wouldn't work in the former Soviet Union because no one could explain to people why they should now have to buy the property that they already co-own. This is why some economists suggested a more sophisticated formula. Instead of selling simply for worthless rubles, populists are prepared now to distribute special bonds or coupons. Each of the bonds is for use in privatization on an equal basis with money. While this interesting economic experiment is still in the state of debate, we could probably compare the beginning of this process with the launching of a massive *Monopoly* game on the scale of the country. The Baltic states, for instance, have already implemented such an experiment. Most of the privatization was on the basis of such bonds.

What are the chances that this experiment, these strategies, would succeed? People are not patient anymore. They want more than the old formula of "bread and defense." After all, the defense budget is going down tremendously. And this is accompanied by the shortage of bread. What are the chances of success of this reverse "phase transition"? We can only speculate about the models which are on the table. Most of these models are based on the recognition of the intrinsic coupling of political and socio-economic dimensions. This is what essentially makes the whole transition a "Catch-22." It causes complications and even keeps several options in this transition open to failure.

One could get a great deal of insight, as most of the analysts are doing now, by comparing the Second Russian Revolution of 1985–91 with the great French Revolution.

The French Revolution, like most revolutions in history, was preceded by tremendous economic and political changes in society, with the rise of the future dominant social layer, the new class. In the French case it was the “third estate” —the bourgeoisie. And eventually this social layer took over. It wanted to create a completely different political and legal framework for itself. Could we find a similar analogy in the Second Russian Revolution, if this is essentially a revolution intended to establish a market economy, based on a capitalist approach?

Who are this “third estate”? This social layer, the class of entrepreneurs, was effectively nonexistent in 1985. If we scanned through the former Soviet Union we would discover very scattered though energetic groups of people, trying to become entrepreneurs. However, clearly it was not yet the class that drove the Second Russian Revolution.

The second candidate for the leadership in such a systemic phase transition could be the class of peasants. However, those who are familiar with the state of affairs in Soviet agriculture tell us that as a politically and socially conscious class the peasants in the Soviet Union have ceased to exist. What we now call “kolkhozniks,” the collectivized farmers, throughout Soviet history were among the most oppressed social groups in the country. In this period of reform, instead of actively moving to privatization, they have proven themselves to be a passive, indifferent, and declassified social layer. Using Marxist terminology, one could call them “lumpenized.” They have neither the will nor the stamina for privatization and hard work on the land. This is why Yeltzin’s reform of land use is not progressing quickly enough.

Such an analysis immediately casts doubts on two potential components of the “third estate” which might have driven the Second Russian Revolution. But then who could have brought

about this revolution? I think this is a genuine historic anomaly in many ways. This revolution was driven not by the emerging economically dominant class, but by the class of employees: white-collar and blue-collar. They simply revolted against their employer, the state. They wanted to have another employer. In many ways such a drive was inspired by the example of the prospering West, perceived as the kingdom of freedom, as well as a consumer paradise. Why not try another experiment?

The very nature of such an anomaly can create serious obstacles that might be fatal for the current Russian Revolution, and perhaps for Yeltsin's government. The expectation that a new employer would be much better than the previous one requires, in the eyes of the people, a visible change in conditions of material life, as "dividends" of the new freedom. During the last couple of years material life has deteriorated enormously. For many of those who were expecting instant gratification, this is a terrible period of disillusionment. While this disenchantment has not resulted in public riots (which political analysts consider a miracle), this has to be explained. However, there are already signs that against the background of interethnic clashes economic disillusionment is capable of creating strong resistance to Yeltsin's reforms.

One particular form of this economic disillusionment, leading to resistance and riots, might be the breakup of the infrastructure of the regime. This infrastructure is still based on the remnants of the old command economy and the state-owned railway network and oil, gas, and coal producing industries. They are the most valuable parts of the economic and social system, as vital strategic components of the infrastructure.

From time to time we hear that the coal miners of Donbass or Kuabass are on the verge of new strikes. It immediately brings us to the recognition that the strikes of these very coal miners in the Soviet Union, two or three years ago, led to the collapse of Soviet rule or at least contributed significantly.

And as ironic as it might sound, an additional complication is created by the overabundance of pluralism in the country. So long awaited during the Communist monopoly, it is flourishing now in the multitude of political parties and economic scenarios for a transition to a market economy. The uncompromising hot debates between the adherents of different approaches are evolving into a principal obstacle on the way to political, social, and economic reforms. There is only one consolation —practically no political party or movement denies the implementation of the market system. That is how deeply the former centralized socialist economy discredited itself.

However, the particular scenarios to implement the market are different. There are many models: one is similar to the Polish-style “shock therapy”; another a more smooth transition similar to the one in Hungary; and there is even the forced introduction of the market economy, under autocratic rule, or the “Pinochet model.” The real danger is that while the discussions continue precious time is running out. The potential for economic breakup, political chaos, and anarchy (even if it probably looks slim) may give rise to political demagogues, capitalizing on national chauvinistic feelings and nostalgia for a firm hand.

It is very difficult to give a final assessment or specific numerical quantitative predictions in the very complicated system which has been created now as a result of a great anomaly in the social and political revolution in the Soviet Union. All attempts to make any predictions should be discarded. After all, no one was able to predict such a quick and explosive collapse of the Soviet Union and demolition of Communist rule, despite the widely accepted arguments about the robustness and stability of the regime.

In 1989, after the demolition of the Berlin Wall, which led to the reunification of Germany, all of Europe was in a state of motion. In my circle of physicists we joked that something was going wrong with entropy and the second law of thermodynamics on a

worldwide scale. Unification of Germany and the creation of the United Europe clearly were decreasing the entropy. Adding here an important parallel development in modern physics — the grand unification in the theory of elementary particles — would even more enhance the great loss of entropy, in complete violation of the second law of thermodynamics. The only chance to save thermodynamics was in the disintegration of the Soviet Union. The impenetrable closed system, a black hole, exploded like a “Big Bang” with its debris flying in every direction.

Future historians will probably try to explain the process which was launched with the Second Russian Revolution, the process which replaced the collapse inside the black hole with a Big Bang. It is a great historic event.

II. THE INTELLECTUAL COMMUNITY AND REVOLUTIONS

The intellectual community rarely has been the direct beneficiary of revolutions. History gives us many examples of this type. In some respects the intellectual community has played a dual role during revolutionary times: as a patient, the victim of change; and as a doctor, preparing and implementing the revolutionary processes.

It was precisely in this way that the great French Revolution was built on intellectual grounds, on the ideas of enlightenment and reason. And it even provided the principal revolutionary slogans, the ideas of French intellectuals. The logic of such intrinsic interaction between the intellectual community and the revolutionary processes stems from the very fact that there is scientific rational thinking and an eternal quest for objectivity. This essentially drives intellectuals to search for the truth, not only when they are dealing with phenomena in the natural world, but also when they have another object under study: human society. Sometimes we can trace, in history, the examples where this process of intellectual thinking and approach to social political phenomena first was motivated by a deep and often even subconscious desire

to introduce the same type of reasoning one would apply in physics and mathematics to any kind of natural phenomena.

This is why scientists are quite prominent among the first revolutionaries, and often the first prisoners after the success or failure of revolutions. Maybe the very folly of such attempts by intellectuals was and still is in mistaking reason for order, harmony, and determinism. After all, if political thinkers have to borrow a recipe from natural sciences for the resolution of eternal conflict — order versus chaos — they should learn from a great debate among the best physicists of the twentieth century on how much chaos should be allowed in the natural world.

I would like to quote Albert Einstein in one of his letters to Niels Bohr, arguing against quantum mechanics and the uncertainty principle. He said, “God doesn’t play dice.” In a very funny though painful way, Soviet Bolshevik philosophers in the twenties and the thirties used arguments similar to that of Einstein. They pressed physicists, demanding that they “liberate” quantum mechanics from the “bourgeois” principle of uncertainty. And Einstein himself finally fell victim to the attacks of Soviet philosophers. They demanded that the theory of relativity be “liberated” from the dubious role played by imaginary observers.

The lack of conceptual understanding that chaos is an essential part of universal harmony was the reason for the failure of many attempts to interpret social and political phenomena. All the utopian models suggested for rearranging human societies have proven to be hopeless. One can go back and find one of the first models in the speeches of Socrates or during the medieval epoch in Francis Bacon’s model in *The New Atlantis*. As a matter of fact, despite all the criticism, these models were invented and suggested by our fellow scientists. I should add: not for self-promotion — not one of them had pretensions of being promoted as an important political leader.

However, the rational thinking of intellectuals was irrepres- sible. This is how the first science of dissent was born — as the

denial of the simple obvious wisdoms, which had essentially proven to be fragile —in relation to new experimental evidence or new ideas. Maybe Socrates was one of the first of this type of dissidents. And his departure from the contemporary point of view seems indeed quite peculiar. It consisted in the fact that he denied ancient Greek democracy. He thought that the most harmonious and rational way of ruling would be rule by a single person, by someone who is wise. This is how Socrates became one of the first victims, among intellectuals, who tried to intervene in the political arena.

Negative utopias, which painted apocalyptic outcomes of great social experiments, had much better luck. All of us are still under the spell of the allegoric parallels with the totalitarian regimes of the twentieth century drawn by George Orwell in *1984*, by Aldous Huxley in *Brave New World*, or (less familiar to Western audiences) by Russian political satirist Evgeny Zamyatin, who wrote his principal novel *We* as early as 1923.

However, probably the earliest prophet of negative utopia was Fëdor Dostoyevsky with his novel *The Possessed*. He essentially predicted the cataclysmic bloody outcome of the attempt to establish large-scale social experiments based on Marxist ideas and their implementation by force. His concerns were the historic cataclysm which my generation in the Soviet Union lived through.

No one knows better than the Soviet intelligentsia how things developed, since this social group was the successor, and in many ways the heir, to the old Russian intelligentsia of the nineteenth century. Even the very word “intelligentsia” is of Russian origin. And I haven’t heard any direct attempt to apply this word to the European or American environment. At my last session of the Congress of People’s Deputies in Moscow in September 1991, I had an interesting conversation with one of the most prominent contemporary Russian writers and a man who was promoting “new thinking” for the Second Russian Revolution, Daniel Granin.

He was serious when he asked me, “Did you find an intelligentsia in the United States?”

The founders of the Soviet State thought they were establishing a social order based on supreme science —scientific communism. What we would usually call science, by definition, was given the role of servant. While “supreme wisdom,” the basics of communism given in the form of pronouncements by classics of Marxism, was to be largely untouched by the armies of the Soviet breed of Marxist philosophers, the rules for functioning of science were not introduced in the holy scriptures of communism as final and rigid. That left real leverage in the hands of those who had to interpret the heritage of scientific communism for the early Soviet state. In many ways it predetermined the role of hostage played by science and the scientific community throughout the major part of Soviet history.

As a serf to the party, science had to contribute in several dimensions of internal development. One of them was to help in indoctrinating the nation, in shaping the future *Homo sovieticus* by the technique of soul engineering. A second role was anticipated by Vladimir Lenin: science had to equip society with the best possible technical knowledge and expertise, so the country eventually could enter into competition with the capitalist world by running a cost-efficient economy. That goal required the pragmatic approach to the cadre of old Russian intelligentsia, the carriers of the knowledge accumulated by humankind. The fear of political and ideological disloyalty of this layer of the social strata, in the early Soviet state, always kept the government and Communist party in a state of paranoia.

Stalin developed further Lenin’s concept of the role of the intelligentsia, in trying to create a new breed of Soviet white-collar workers faithfully loyal to the regime. In addition to party loyalty they also had to be capable of producing knowledge and applying that knowledge for the benefit of the Soviet economy, national

defense, and the party's "historic mission" of social engineering —to create a "new Soviet man."

The history of the complicated interplay between science and the regime, when fully analyzed, will help us understand better the hidden dynamics of Soviet society. If the Soviet intelligentsia was the successor to the old Russian one, in a certain ironic sense the oppressive Bolshevik regime could be considered no less a genuine successor to the autocracy of the tsarist regime. The repression and, to some extent, terror were not completely invented by the Bolsheviks from the very beginning. We can trace some elements of the oppressive policies to the old prerevolutionary Russia. Alexander Herzen, one of the best brains among the Russian intelligentsia in the nineteenth century, who spent the last part of his life in exile in London, quoted an interesting example of the "ingeniousness" of the tsarist police. His friend and colleague in revolutionary thinking and activities, the Russian poet Nikolai Ogarev, once was subjected to a sophisticated search by the police inspectors. Unable to suppress their triumph, after discovery of eight volumes of *The History of the French Revolution*, they exclaimed: "Ah ha, these are revolutionary books." Then they attributed to the same category the last discovery: the book which was called *Sur la révolution du globe terrestre* by Georges Cuvier. It was more than enough for poor Ogarev to be "liberated" from his library and sent to prison for a number of years.

Lenin developed his suspicions about the intelligentsia to a much more sophisticated level. In a number of his articles, beginning with prerevolutionary times, he depicted the Russian intellectuals as a political layer subservient to the bourgeoisie. He even said the attempt to fight for political or individual freedoms and liberty, of which the intelligentsia is extremely fond, was a special hidden invention of the bourgeoisie, to strengthen its domination over the "proletarian" working class.

One explanation of why Lenin was so much against the intellectual social layer, from which he himself emerged, might come

from the fact that his closest former colleagues in the Russian social democratic movement, the most intellectual part of Russian social democracy, slowly drifted toward Menshevism, a milder form of Marxism. Often they criticized Lenin for political extremism and adventurism.

However, there was a deeper reason for hating the intelligentsia. Lenin knew that intellectuals would use rational thinking and reasoning to argue against any kind of adventurist slogans which would be put forward by the Bolsheviks.

Lenin was the first who came forward with the appeal to create a new Soviet intelligentsia which would be faithful to the working class, an intelligentsia that originated from the proletarians. This slogan, if not completely implemented, eventually resulted in a kind of a painful joke, popular during the peak of Stalin's domination: "We intelligentsia are indeed proletarians of intellectual labor."

The call for a new intelligentsia, subservient to the regime, was taken by Joseph Stalin as part of his attempt to implement the whole procedure, based almost on genetic engineering to create a "new Soviet man." The typical approach to produce this new breed was based on what Soviet ideologists in the 1930s used to call "soul engineering." The army of writers, "soul engineers," was mobilized by the Bolsheviks to indoctrinate people.

However, such simple soul engineering was not enough. It was complemented by Stalin with the great terror, a drive which eventually exterminated many of those who were unable or who refused to undergo the process of soul engineering. It was within the context of the great terror that Stalin and others invented unprecedented technical innovations to reeducate the old breed of the intelligentsia. They established a system of intellectual serfdom. The regime built special camps in the gulag where the best scientists and engineers were brought to work on defense projects, demanded by the government. They lived in conditions similar to those of prisoners. Intellectual serfdom clearly had no counterpart even during the tsarist autocratic regime.

Many of those who were quite prominent and who are famous now were intellectual serfs, in these places called sharagas. Among them were such bright engineers as Sergei Korolev, the father of the first *Sputnik*, or Andrei Tupolev, known for a series of passenger jets and bombers, still used by the armies of the Commonwealth of Independent States.

The best description of such sharagas was given by Alexander Solzhenitsyn in his novel *The First Circle*. He himself had experienced a few years of “reeducation” in a similar type of sharaga, where he worked as a technician in radio electronics.

Ironically enough, people who were kept in such special installations to develop a “new Soviet man” were mostly supporters of the regime. Those who, from the very beginning, demonstrated their unwillingness to collaborate with the regime had to emigrate. Others, less lucky, were exterminated. These were people who stayed on the other side of the barricade. Among those who emigrated, we can recall a number of the brightest names in engineering and technology, such as Igor Sikorsky, who brought prominence to helicopters. And many more were on the cultural side of this list: Bunin, Nabokov, Rachmaninoff, Stravinsky.

The displacement of the “brains” by revolutions does not necessarily suppress individual productivity. An interesting historic example of this type of emigration producing a positive creative impact could be found in the late eighteenth and early nineteenth century in the United Kingdom. I have in mind the physicist Benjamin Thompson, who had to flee from the revolutionary United States because he was considered a royalist, a supporter of the British crown. So, as a young teacher of physics, he left the United States. It was here, in the United Kingdom, that he first established his name in science. He had a dramatic scientific and political career. At the peak of his political activity, during the Napoleonic Wars, he was prime minister of Bavaria, earning the title of Count Rumford. But his name belongs to science as a discoverer of the mechanical equivalent of thermal energy.

At a certain moment, Stalin thought he had succeeded in rebuilding the mentality and psychology of the Soviet intelligentsia. He found the “new man” who could be promoted as an example for generations —a model of loyalty to the Communist party and an example of the brightest scientific achievements, which could be paralleled only by the achievement of Stakhanov in industrial heroism. Just as Stakhanov was the beginner of a huge line of “heroes of socialist labor,” Stalin thought that Otto Schmidt, mathematician and polar explorer, eventually could become a role model for the new scientists. However, Otto Schmidt, even if he could have developed into a leader of Soviet socialist science, clearly did not fit the model. After the Germans launched the war, Stalin quickly dismissed him, because he was of German origin. But Stalin had another scientist he selected as an exemplary man. He was brought up in a family of farmers. His conduct of agricultural sciences in the perception of the Bolshevik regime promised the delivery of magic technology, capable of producing agricultural miracles. His name was Trofim Lysenko.

In many ways the ideological battle that Lysenko waged first against the president of the Soviet Agricultural Academy, Nikolai Vavilov —and then against the whole discipline of genetics as a science —had another painful, even bloody historic parallel. It reminds one of the ideological debate over the nature of chemistry which took place in France at the time of the Jacobins. As the result of this debate, Antoine Lavoisier was beheaded. Lavoisier had a very powerful and dangerous ideological opponent, the leader of the attacks against the foundations of chemistry —Jean-Paul Marat himself. Marat demanded that science, and chemistry in particular, be completely different, a “people-friendly science,” in his terms.

With Lysenko playing a similar role, the bright Soviet geneticist Nikolai Vavilov was dismissed as the president of the Agricultural Academy. This post was taken by Lysenko’s followers. Then Vavilov died in prison during World War II.

What did the Soviet intelligentsia do within the framework of such a repressive regime? The absolute majority of intellectuals preferred their own way to survive decently. They called it “internal emigration” or “internal exile”: staying inside a narrow circle of a few close friends to be able to talk openly and freely about events in the political world, events outside their small kitchens, where most people gathered to talk. So internal exile in the kitchen was the principal mode of survival for the Soviet intelligentsia for many decades. However, even that was quite risky and dangerous. The regime wanted the intellectuals to become its accomplices. Everyone was under tremendous pressure.

Nikolai Vavilov, in one of his confidential exchanges, which one of his contemporaries later recalled, suggested silently on a piece of paper, in English, “If you your lips will keep from slip / five things you must beware / of whom you speak / to whom you speak/and how and when and where.” However, this wisdom did not help Vavilov himself.

One particular example of how the authorities demanded that everyone give an oath of loyalty and accept the role of accomplices could be provided by the story of Boris Pasternak. In the late thirties, the epoch of the great terror, the regime introduced a humiliating procedure. Every employee of the factory, enterprise, or institution, from time to time, was called to a huge meeting. These were special gatherings convened to condemn the “enemies of the people” and unanimously adopt a resolution calling for capital punishment for the “enemies.” Boris Pasternak was present at one of these meetings of fellow writers when someone demanded capital punishment for a group of Soviet military commanders and marshals accused of being traitors — German spies. Pasternak was the only one in the huge crowd who abstained from the ballot. Later, during the night, he wrote a personal letter to Comrade Stalin, explaining his abstention: he said that he came from a family of intellectuals, with a very strong Tolstovian urge toward nonviolence.

In such a condition of internal emigration, internal exile, I think the Soviet intelligentsia developed a tremendous inferiority complex —a kind of personality split —which later was reflected in the behavior of different people.

The victory in World War II was greeted by many as a chance for the reconciliation of society, based on patriotic feelings. However, Stalin and the regime were not ready for this: many Soviet physicists were put to work first on nuclear and then on hydrogen bombs. Among them were such people as Igor Tamm and his then young pupil, Andrei Sakharov. Igor Tamm could not have been accused of being a blind collaborator with the regime. He himself had a stormy revolutionary youth. In 1917, during a brief period of democracy after the February Revolution which followed the resignation of Tsar Nicholas II and preceded the Bolshevik October Revolution, young Igor Tamm returned from vacation from his classes at the University of Edinburgh. During this time he joined the social democratic movement and became one of the prominent younger leaders of the Mensheviks. And at the first Congress of all Russian Soviets, in June 1917, as one of the very few Mensheviks, he voted to stop the war. He was part of the group known as “internationalists” at that time.

However, he quickly understood during the next few months that there was no ecological niche for the Menshevik type of social democracy during the Bolshevik regime. He left politics and never returned. No one could accuse Tamm of trying to collaborate with Stalin after all his political experience with the regime. It was the feeling of patriotism that followed the end of World War II and very naive strategic thinking that drove the Soviet physicists to “restore” the nuclear balance and stability in the world. They made the hydrogen bomb and delivered it into the hands of Stalin and Lavrenti Beria.

Two scientists were a true driving force behind the Soviet efforts in the nuclear bomb program: Igor Kurchatov and Yuly Khariton. While Kurchatov achieved prominence and official rec-

ognition during the Khrushchev era (he even accompanied Nikita Khrushchev during a famous visit to England in 1956), Khariton was long kept in a shadow of secrecy. He was the scientific head of the classified installation from the very beginning and his involvement in the bomb program was most natural. He co-authored the very first Soviet scientific paper in the still open prewar scientific literature on nuclear physics —the paper on how to achieve the nuclear chain reaction.

Kurchatov and Khariton formed an extremely powerful tandem. But there were many more outstanding people who contributed to the success of the Soviet nuclear bomb project. The heroes of that program were, in many ways, able to parallel the efforts of the Manhattan program. One could identify even the specific counterparts, playing similar roles on both sides of the ocean.

However, I think there was no Soviet counterpart to Robert Oppenheimer. There was no one in the USSR who experienced or voiced even the slightest doubts about delivering the ultimate superbomb into the hands of Stalin and Beria. It is true, of course, that the famous Peter Kapitsa, one of the greatest Russian physicists of the twentieth century, left the nuclear program almost at the very beginning in 1946. But he did so as a result of a personal conflict with Beria. Nobel prize-winning theoretical physicist Lev Landau tried to stay as far as possible from the actual designs. He had a deep internal conflict with their production —not surprising in a man who suffered in the purges of 1937.

There were reasons why there was no Russian Oppenheimer, the open adversary of the hydrogen bomb —or why there was no one who would doubt the need for the Soviet Union to develop its own nuclear weapons. The bleeding wounds left by World War II were still fresh and painful. Everyone remembered that, even according to official assessments, the country lost more than 20 million of its citizens. If, among the scientific community, there were individuals who did not share the ideology of the regime they were patriots. Also, it would have been extremely risky to oppose

the ideological dogmas promoted by Stalin in the presence of Beria as supervisor of the atomic program. Many of these people believed the Soviet Union needed its own strategic weapons to restore parity with potential enemies. They were also optimists that the postwar period in the USSR might be quite different than in 1937. Many hoped the wartime grand unification of Soviet society against the principal enemy, the Nazis, would change the repressive character of a Communist regime and that the Soviet Union could even join the international community of free nations.

The team of Kurchatov and Khariton was driven by genuine motivation, by enthusiasm. Both men provided the utmost examples of tireless, unselfish effort. They also proved themselves to be not only moral leaders, but also physical protectors. A few years after the war, the government boldly launched a new wave of repression and ideological pogroms, under the slogan “struggle against cosmopolitanism.”

Stalin needed the nuclear bomb desperately; he was already a few years behind the Americans. In fact, the first test explosion took place four years after the Americans had already achieved a breakthrough. The international race —initially to build the nuclear bomb —was lost irreversibly to the United States. Despite that, however, there was an equally important race: an internal competition. The ruthless government had another group of scientists and engineers who were given the task to ready themselves to play the role of a “shadow nuclear team.” The very presence of such shadow competitors introduced a kind of sword of Damocles over the heads of the Kurchatov-Khariton team members. The forthcoming test in 1949 was awaited with a mixture of great hope and desperation by both teams, the actual creators of the nuclear weapons and the shadow team —among which there were candidates to become the “Lysenkos of physics.” The success of the test liberated the actual weapons designers from direct threat and finally led to the dissolution of the shadow team. But it in no way liberated the Soviet scientific community from the role of intellec-

tual serfs of the system still instilling genuine fear. The real awakening came with the Twentieth Party Congress, which was an eye-opener for most of the people. It unlocked, though only for a few moments, the gates for internal exiles too and inspired people to rethink the past history.

With the advent of the Brezhnev regime, the intelligentsia was split into two large groups. One was still subservient to the regime. Many, among intellectuals, were yet unable to reconcile their behavior and conscience and were not ready to burn the bridges of dependence on the regime. Clearly “being precedes consciousness,” as the Marxist dictum says. The other group was much smaller: only a few among the intellectuals were ready to break with the establishment: people like Andrei Sakharov, Yuri Orlov, and others. The regime, substantially weakened, was unable to undertake any kind of massive repression as in the past, replacing it with episodic imprisonment of open and active dissidents and implementing, in place of soul engineering, a special kind of psychiatric treatment against some of them.

Looking at this particular practice with what we know nowadays, we can only ridicule the typical diagnosis of the “illnesses” of these dissidents: for example, “delirium of social reformism.” I guess in 1985, with the advent of Gorbachev as general secretary of the Communist party, this particular formula of diagnosis had to be immediately abandoned. Otherwise the first patient who would have had to be treated for such an illness would have been Mikhail Gorbachev himself,

The *perestroika* period launched the massive escape for internal exiles. I was part of that particular group of the Soviet intelligentsia which promoted *glasnost*, new thinking, and political reforms. We were all extremely excited. We realized that we were living in unusual revolutionary times. Valery Bryusov, a Russian poet of the early twentieth century, once said: “One is blessed who has visited this world in its crucial moments.” We felt that we were indeed living these crucial moments.

Slogans of the Second Russian Revolution came from the Soviet intelligentsia, from Soviet scientists, writers, intellectuals, and thinkers —and not only slogans.

In fact, quite a few prominent leaders of the Pugwash movement came from inside the Soviet scientific community too, with its drive for international ties and cooperation: Peter Kapitsa, Lev Artsimovich, and others. The best scientific brains on both sides of the ocean applied their minds to the thermonuclear deadlock. Through the most difficult periods of confrontation during the Cold War, the Pugwash meetings remained the only reliable channel for important arms control discussions between the Soviets and Americans.

Among interlocutors on the American side were Georg Kistiakowsky and Jerome Wiesner, presidential science advisers in different administrations of that epoch. Even Henry Kissinger, when he was still a professor of political science at Harvard, was a participant in Pugwash brainstormings. Several important initiatives in international arms control found their way through quiet diplomacy at Pugwash-style meetings of scientists. Such was the case with the first, most important treaty banning nuclear tests in the atmosphere, in the sea, and in space. The scientists tried very hard at that time, in the early sixties, to extend the ban on underground testing, to make it comprehensive. It is only now with the Cold War left behind that there is a historic chance to eliminate all types of nuclear explosions forever.

The early ideas of Pugwashites were precursors of the new thinking and the global breakthrough of the late 1980s. There were even more important documents of the epoch, coming from the scientists, those who were brave enough to raise their voice of dissent, as Andrei Sakharov did. The very first draft of the Soviet constitution, the constitution that had a chance to be the first democratic one, was written by Sakharov in 1989. I remember the days when he was writing this draft. He was able to finish this draft only a few hours before the extraordinary session of the Congress

of People's Deputies in mid-December 1989. And the very first chapter of this constitution called for the end of the monopoly of the Bolshevik party and the introduction of the multiparty system.

I was only a few meters from Gorbachev's chair at the Presidium when Sakharov, made desperate by denial of the opportunity to speak from the podium, approached Gorbachev asking for a few seconds to speak. Gorbachev switched off the microphone he controlled so that only a few people could hear the subsequent conversation. Because I was close enough, I can quote, as a witness, what Sakharov said: "I have to speak against the Communist party monopoly. I've got a huge bag of letters from my constituency, demanding the abolition of the party monopoly."

In response Gorbachev said, "So what? I've got three bags from my constituency demanding to keep it."¹

That was how Sakharov was denied the last chance to speak. The stenographic records of the Congress report dryly on Sakharov's last appearance at the podium with the microphone switched off: "Sakharov on the podium. He opens his mouth. Nothing can be heard."

But we all *heard* what he wanted to say. The draft of the constitution was published by the newspapers a few days later, after Sakharov had already died. However, the revolution was continuing.

III. SCIENCE AND THE "SOVIET UNION"

Future analysts will ask: what happened to the supreme ideas of Marxist scientific communism? Why did such an experiment planned in historic dimensions fail, destroying under its collapsing ruins one of the largest scientific and technological communities of the modern world?

¹ Indeed, better late than never: Gorbachev has by now clearly undergone his own personal *perestroika*, at least on that issue. In December 1991, a few days before stepping down from power, in a newspaper interview he said, "The goal is to accelerate the shaping of genuine political pluralism. Democracy cannot live without it."

The past leaders of the country clearly overinflated the size of the academic and engineering communities. It was even an object of pride for them to claim that every third scientist in the world was Soviet. Even if the official statistics were right, the actual budget was not large enough to support the productive research of such an army of scientists.

A still bigger exaggeration was the social myth of the Bolshevik epoch that half of the engineers in the world were in the Soviet Union. How does one reconcile that assertion with the general technological backwardness of the USSR as compared with the Western world? The massive decline in professional standards of the engineering community reveals the profound failure of the social system in preparing and using the cadre of engineers. However, it would be wrong to consider that the scientific and engineering technological communities were uniformly mediocre and backward in the Soviet Union. Rocketry has consistently been one of the exclusions. The space program, from the very beginning in the early fifties, was surrounded with special care by the government. One explanation of the success of the Soviet *Sputnik*, and its descendants, is that the system, for several decades, was using space achievements as proof of the superiority of socialism over capitalism.

However, the whole area of the space industry was originated by the military's need for rocketry. Early successes in the nuclear program were associated with the needs for nuclear deterrence. Later, the atomic sciences became a kind of cult for many years, before the Chernobyl accident destroyed the nuclear spell. Here too the spectacular rise and failures of science were unrelated to any real interest the Bolsheviks might have had. They cared nothing for science per se.

In talking about the impact of revolutions on scientific life, I could not avoid reflecting that revolutions rarely try to spare their brains. Even if no one was beheaded on the guillotine —as was the founder of chemistry, Antoine Lavoisier, at the peak of the

French Revolution —there were many other tests that the scientific community had to survive.

In 1917–20, at the peak of economic chaos and civil war in Russia, a very thin layer of the scientific intelligentsia was indeed an endangered species, not only because of the blood being spilled everywhere in the country, but also because of the unavoidable economic disaster. At that historic moment, Maxim Gorky, who played a role as a moderator between the intellectuals and the regime in the early Bolshevik rule, talked to Lenin about launching extraordinary measures to rescue a very small group of intellectuals —scientists, writers, and artists. As a result of this pressure, Lenin agreed to initiate special food rations for this endangered intelligentsia. This gesture played a very important role in establishing an uneasy relationship between the Bolshevik government and the scientific community. On the one hand, scientists clearly were given a minimal living for survival. On the other hand, if they did not know it at the time, they were doomed to be converted into intellectual serfs by the future Bolshevik regime. Only a very few scientists at this juncture in history understood that the system would not be kind to or supportive of creative work. Among them was the famous physiologist and Nobel prize winner Ivan Pavlov. For a brief moment in 1920, he tried to leave Russia, unable to work in the atmosphere of the “war communism economy.” He approached the Soviet government with a petition for an exit visa. His colleagues in Scandinavia had created a special chair for the renowned academician. The scientific community has only recently learned what Lenin’s reaction was to this application. On the petition written by Pavlov, Lenin wrote: “Ivan Pavlov is known as an outspoken opponent of the Communist party and Soviet power. This is why it is highly undesirable that Pavlov should go abroad. He would use this opportunity to denounce us. I suggest that we not give him an exit visa but instead double his food ration.”

We can only smile at this episode. In a certain sense it tells us that Lenin was probably quite familiar with the technique Pavlov used to study and develop *conditioned reflexes*.

In many ways, “Soviet” science is facing a similar risk of losing its brains in these extremely difficult economic conditions of this transitional period. Using an earlier notion from the early Soviet years, I would say we are entering a period of “war capitalism.”

What kind of intellectual and legal legacy is this scientific community in the Commonwealth of Independent States trying to preserve now? The past offers us an insight. The Russian Imperial Academy was established in 1725. It was originated exclusively due to the tremendous energy and determination which Peter the Great brought to this issue. In the process of thinking and preparing the draft and the charter of the future Russian Academy, he visited most of the Western European countries. He spent a substantial period in England, learning about the Royal Society. There are no official records of that particular period which could indicate whether he had a chance to talk to Sir Isaac Newton, who was at that time the president of the Royal Society. However, there are records, and even letters, in which Peter the Great and Edmund Halley talked about potential ways of developing science, especially applied science related to sea navigation, in the young Russian Empire. In a very funny way, Peter the Great was much more exposed to the archenemy of Newton, his great German contemporary Leibnitz, who developed his own proposals. He suggested that Russia, which had to overcome sheer illiteracy, should not start with establishing an Academy of Science. He strongly advised that Russia should start with colleges, universities, and educational institutions. However, Leibnitz did not impress Peter the Great.

Despite his advice, Peter decided to open the Russian Academy, although he died a few months prior to its inauguration. Nevertheless, the Academy was built and the first few decades of its activities brought outstanding scientific discoveries, through the

work of such scientists as Leonard Euler, Daniel Bernoulli, and others.

The Soviet Academy in many ways was the heir to this great Russian Academy, famous not only for the names of its foreign guest researchers, but also for the names of its genuine Russian geniuses, like Mikhail Lomonosov and Dmitry Mendeleyev. However, the Soviet Academy was immediately put under the strict control of the Soviet government and the Communist party —and, as such, became a product of the social conditions of its epoch.

Fortunately, two completely different factors played an important role in saving Russian science through the Soviet Academy. One of them was the combination of the deep and strong traditions established by the great Russian scientists of the eighteenth and nineteenth centuries and their pupils, the “keepers of the flame,” who survived the period of indoctrination and pressure. They were able to pass on the flame of real science to the next generation, despite every attempt by the government to change the heredity of this intelligentsia.

There was a second factor which played a very important role, though it was not intended to keep science alive, at least in the form that was established by Lomonosov and Mendeleyev —the militarization of Soviet science. As painful and sad as it was, it provided the flux of almost limitless material resources to support not only applied sciences associated with the design and production of weapons and rockets, but also basic sciences, such as physics and chemistry. Unfortunately, due to the ideological intervention and internal misfortune of Soviet biology brought on by Lysenko, Soviet biology was unable to take advantage of similar support, even if designed with completely different motivations.

There were two forms of militarization of science, established and very well known in international science. The first explicit form is associated with direct involvement of the scientific community in deliberate invention and design of weapons or armaments. This form of militarization was most important through-

out the Soviet period. Stalin and Bolshevik leaders needed a magic wand to rescue them from confrontation with the capitalist world. So, in that sense, the Russians followed the case of Alfred Nobel, who designed dynamite, or F. Haber, who during World War II suggested the use of poisonous gases as chemical weapons. In the area of chemical weaponry alone, which for many years was the principal source of support for Soviet chemistry, we have as a legacy of this period almost a hundred thousand tons of obsolete chemical weapons. Their very presence represents a dangerous challenge, not only to the scientific community, but to society as a whole. Destruction of the arsenals of chemical weapons —thanks to a banning treaty —will require serious and expensive measures.

The second form of militarization was indirect: involvement of almost every individual scientist in the Soviet Union in support work on contracts or grants given by the Ministry of Defense or military industry. This was the most dangerous development. In an often hidden way, the military-industrial complex established its domination over the Soviet intellectual community, whereas in most other societies the survival and development of basic science was always based on the relationship between science and society.

There are two schools of argument in this debate. How can one justify immediate support of basic research which is not going to produce valuable practical results within the next five years or maybe even within the next generation of scientists? Some of the thinking stresses that eventually, after several generations of scientists, the results of today's basic science would be used by industries everywhere, and the final revenues today cover all the money spent by the government and taxpayers in the past.

The second view is much more radical: the support for contemporary basic research has already been paid for by the priceless achievements of the past generations of scientists, such as Faraday, Maxwell, and Mendeleev. Their scientific discoveries are so widely used now that the revenues that people get from these past discoveries more than pay for basic research for the centuries ahead.

However, this point of view alone would not save science, in the current atmosphere in the Commonwealth of Independent States, which is in a condition of political and economic deterioration. The scientific community nowadays is losing not only the budget and economic support —it has found itself in a rather hostile psychological climate.

The implementation of scientific discoveries and technologies throughout the Soviet period was accompanied by negative side effects. This has caused a rise of antiintellectual sentiments in the former Soviet Union that we are experiencing now. The negative indirect impacts attributed to science, such as the Chernobyl disaster, essentially wiped out nuclear energy science from Soviet technological and scientific life. There were several other environmental consequences of Bolshevik rule, such as air and water pollution, loss of valuable soils through erosion due to the building of exemplary Stakhanovite enterprises of socialist industry, as well as the monstrous dams across great Russian rivers—even attempts to change the climate in vast areas of the Soviet Union by redirecting the flow of the northern rivers. This particular project, which was conceived during the last thirty years of Soviet power, was supported by the official government and was almost ready for implementation. The rivers of Siberia had to be redirected to bring waters to arid areas of former Soviet Central Asia, such as the deserts of Uzbekistan and Turkmenistan. The project created concerns about the irreversible damage to the environment. Throughout this period, the official Soviet Academy of Science did not contribute much to the protection of environmental interests or the balance between humans and nature, as evidenced by the most criminal documents, legislating the beginning of construction works at such places as Lake Baikal, as well as the “Lenin-grad Dam,” which has essentially spoiled a huge area of the Finnish Bay. Many of these projects were implemented with the approval of —I would rather say the rubber stamp of —the So-

viet Academy. This explains the tremendous idiosyncrasies among the taxpayers and the “man on the street” against science.

The ongoing political chaos only reinforces such feelings. Take one particular example of how this antiintellectualism has been expressed recently. In 1989, a public opinion poll was taken in Moscow, perhaps the largest intellectual center of the country. Participants were offered a list of the most important national institutes like the Council of Ministers, the national health system, the Supreme Soviet, the Communist party, the Academy of Science, the KGB, and so on. The question was which of these institutions played the most negative role throughout the Soviet period. I was myself amazed to discover that the Academy of Science appeared as one of the top enemies of the public in that list, well ahead of the KGB. It created a hot internal debate. My own explanation of such an anomaly is that in the first few years of *perestroika* and *glasnost* the KGB tried to stay low key. The scientific community, in contrast, was in the first rank of those engaged in the political struggle against the former regime. It was within Academy of Science and the intellectual community that the real dissent was originated in Soviet life during the last several decades. The general public took self-criticism, initiated by the academics and scientists in the mass media, as a signal that something was deeply wrong in the Academy of Science, even compared to the KGB.

However, what was happening at that time was a very positive phenomenon. The scientists were bringing up all the issues of *perestroika*. In some sense I could compare that period of the very active politicization of scientific and intellectual community, from 1985 until the current period, with the self-sophistication of the Enlightenment in Western Europe in the end of the eighteenth century.

The Academy of Science and the scientific community provided the early nucleus of condensation for political rethinking. It was inside the Moscow academic community that a first political club

(Moscow Tribune) was organized. Brainstorming of different political issues was led by Andrei Sakharov and a few other outstanding scientists, writers, historians, philosophers. I too took part in many of these brainstormings. Eventually, this political club played an important role in sending the first deputies and first delegates from the scientific community to the first popularly elected parliament in the country: the Congress of People's Deputies of the Soviet Union, Congress of People's Deputies of the Russian Federation, and so on.

This club gave rise to another very active political organization inside the Academy of Science which was called the Club of Voters of the Academy of Science. It still exists and helps to elect deputies from academic institutes to represent the scientific community in the Parliament of the Russian Federation.

However, what we have now is a situation in which the whole Soviet scientific community could be declared an "endangered species." There are different dangers in the current political and economic chaos accompanying transition to a market-economy system. One particular problem, which is discussed worldwide, is the "brain drain." I would separate the brain drain as a component of the problem which, in my view, is not a danger at all. First, I would dismiss the potential negative impact of the external brain drain —that is, the risk that former Soviet scientists would emigrate or would be invited to different foreign countries. After all, the very notion of a "brain drain" on an Academy-wide scale is purely a Russian invention. It was conceived and implemented by Peter the Great and played a tremendous role in establishing the scientific culture in this originally almost illiterate country. Isn't it time that Russian science should repay the international scientific community?

Seriously, however, I don't believe that the scale of the external brain drain could be considered as dangerous as the scale of the problem *inside* the former Soviet Union. The number of people who could securely find jobs outside the former Soviet Union, for instance, would be fairly limited due to different (mostly eco-

conomic) considerations. The internal brain drain is a much more serious problem. The economic situation in Russia, and in other republics, has forced scientists to struggle for sheer economic survival, to avoid hunger and starvation. The current salaries of typical Soviet scientists are miserable compared to a decent living standard. A recent decree of the Russian Academy issued only a few days ago established a ceiling for the salaries of directors of institutes of the Academy. So the salaries for the leading scientists and administrators are now measured at slightly more than 3,000 current rubles. If we convert this into dollars, that is only about 30 to 40 dollars a month.

The most dangerous situation we can find now affects the younger generation of scientists, who are paid the equivalent of 10, 15, or 20 dollars per month and are clearly unable to support their families. It is from this particular stratum that the internal brain drain is stealing scientists. They are seeking sheer survival — and this survival could be found in newly created commercial enterprises, cooperatives, and joint ventures. While in principle this might be a healthy development in moving to a market economy, unfortunately, at the moment, the work in these sectors is still unsophisticated. The brains of scientists are used for rather routine applied software or simple biotechnology projects at best, but not for further development of basic science.

This economic disaster in many ways is bringing with it a bitter revenge. The long dependence of Soviet science on the military-industrial complex is having a strong impact. The very first step taken by the military-industrial complex after Gorbachev declared the first reduction of the military budget a few years ago was an immediate drastic cut in R&D money, while all the weapons and armaments were kept intact. This led to the termination of grants and contracts in almost every area in physics, chemistry, and even biology —not to mention applied engineering. At the peak of the military cuts, the “Soviets” are in danger of losing their most important assets, truly international treasures, the cadre of high en-

ergy physicists, molecular biologists, biotechnologists, and experts in space technology and space research.

Having spent so many years in the space area, I can give you a few examples of what is at risk now in space assets accumulated by the Soviet Union. In many areas of space technology, the Soviets are unchallenged even by the American space community. There are several categories of launchers in the arsenal of the Soviet space community which are completely absent from the current spectrum of American space activity, such as the super-launcher *Energia*, which could be successfully applied to enhance the much-publicized American space program based on lunar/Mars exploration to build a manned space station in terrestrial orbit. I am not going to debate the issue of whether the emphasis on manned exploration or on the very expensive manned installations in space is meaningful, at least in the current fiscal climate. However, since the United States has expressed, and reiterated, determination to develop such a program, it could get numerous benefits from interacting with existing Soviet space assets.

In many ways, all of us recall that the principal driving force in space exploration, and in building space technology, was precisely the competition between two space programs launched by *Sputnik I* — what we can call the “Space Race,” which drove the space programs on both sides of the ocean. With the risk that Soviet space assets could simply sink or disappear, our American friends very soon could face another syndrome which could inhibit their space program. I would call it “the loneliness of the long distance runner.” At the same time, we should recall how much international cross-fertilization helped the American space program and the Soviet space program too. One can go back to the history of the last years of World War II. Werner von Braun, designer of the ill-fated V-2, was essentially the man who brought the rocket culture to the United States. Who knows: there may be dozens of such brains like Werner von Braun who could perish in the current economic decline of the Soviet Union.

I remember vividly that a few years ago, at the peak of Gorbachev's popularity, as well as his international initiatives, he himself promoted many grand international ventures, including international projects in space. One particular project he was very fond of related to flight to Mars. Among the space scenarios of launching sophisticated telescopes, unveiling secrets of the universe, or launching orbital labs which would enhance our knowledge of global change and in particular of ozone layer depletion and global warming, there was always a special interest in flying to Mars. This interest one could find not only in the former American administration; it was also entertained by the Bolshevik government long before Gorbachev came to power. The Brezhnev government supported the project to send a mission to Mars and to bring back a sample of Martian soil.

In some way, such an interest in flying a mission to Mars, unmanned or manned, was considered by Soviet authorities the type of "ultimate science" after which there would be no need to support any petty scientific projects. Everything would be received at once: soil from Mars would answer all the questions of the secrets of solar system formation, and so on. Bolsheviks entertained this ultimate science, as they promoted Marxist scientific communism, which was going to answer *all* the questions.

In the last attempt I witnessed, Gorbachev suggested a joint U.S./Soviet mission to Mars, I think he saw Mars as an alternative to funding SDI, for the military-industrial complex. I was waiting in the line to be introduced to President Reagan at a state dinner in the Kremlin when Mikhail Sergeevich seized my hand and said, "Mr. President, this is the scientist I was talking about. He is inciting both of us to fly to Mars." I confess it was at least a slight exaggeration. I had always supported unmanned exploration. For a brief moment President Reagan was indeed interested. I saw sparks in his eyes. I could see that Gorbachev wanted, immediately, to capitalize on the first psychological impact. He said, "You know, Professor Sagdeev has very close friends in the United

States who are equally energetic in promoting flight to Mars.” At this very moment Gorbachev made an unforgivable mistake. Instead of giving the name of General Abrahamson, he gave the name of Carl Sagan.² So the project died.

No one is talking anymore about a flight to Mars in the former Soviet Union. In the eyes of our taxpayers, the space program as a whole is criminal, an accomplice of the former Bolshevik regime. It was precisely in the interests of Bolshevik propaganda that many of the launches were undertaken and, after every launch, the Soviet government and the TASS news agency would issue a brief triumphant communiqué. “Another victory of socialism! Another proof of the superiority of the system!” Taxpayers have come to the conclusion that we probably don’t need any more proof.

However, the issue of rescuing the assets of our science is still with us. This problem, the issue of survival, of possibly rescuing the best parts of the Soviet scientific community, is coming from two different lines of thinking. It is undeniable that due to its shortcomings, such as indoctrination and overbureaucratization, Soviet science achieved much less than it could have with the resources it spent. But at the same time, it had a large number of really bright young scientists. It had leaders of internationally known scientific schools, in almost every field of contemporary science. What remains of the science of the former Soviet Union should be considered an international treasure.

Second, and not least important of the arguments, is that to support the Russian scientific community would symbolize political support for the forces of democracy, because it was the scientific community that prepared and launched the fight against the totalitarian regime. It now needs help. It needs help against extermination by economic chaos and it needs help against the potential risk of the resurgence of reactionary forces. In many ways, I think we are living now, emotionally and psychologically, through

² At the time General Abrahamson was director of the SDI program. Carl Sagan was an outspoken critic of the SDI program and of the Reagan administration.

times similar to those when the Soviets very impatiently waited for the opening of the second front. It was a great victory and a joy for all of us when the second front was launched from this very country, the United Kingdom, across the English Channel.

The same type of second front, not military, but the hand of friendship and support, should now be given to the Soviet scientific community. This second front would help assure that the political changes in the former Soviet Union are irreversible.