the scaffolding dashed about in the fire and smoke; many jumped off and vanished into the flames. One man momentarily escaped from the fire, but got tangled up in the barbed wire surrounding the launch pad. The next moment he too was engulfed by the flames.

All told, some 190 people died that day.

14

NONTHRESHOLD BIOLOGICAL EFFECTS

IN THE YEARS following the successful 1955 test of the Third Idea, a number of thermonuclear devices with differing specifications and configurations designed for various carriers were developed at the two Installations. These were extensions of the original design, but considerable effort and testing were necessary nonetheless.

I worried more and more about the biological effects of nuclear tests. My concern was prompted by the course of events and by my own part in the testing program. An important role was also played by my abstract intellectual bent, as well as my emotional idiosyncrasies (I'm not claiming any credit—or, for that matter, blame—in this respect, merely stating a fact). The long-term biological consequences of nuclear testing (particularly atmospheric testing, in which radioactive fallout is dispersed throughout the hemisphere) can be predicted, and the total number of casualties calculated with some accuracy. What cannot be determined is the identity of individual victims, lost as they are in the human sea. We can never establish with certainty that a *particular* cancer victim or congenitally deformed child is a casualty of nuclear testing. People differ markedly in their reactions to the fact that the consequences of nuclear testing can be described only in anonymous statistical terms. I am baffled, however, by those who simply ignore the problem.

The long-term biological consequences of nuclear explosions are generally associated with so-called nonthreshold effects (where no "threshold," or minimum dosage below which damage will never occur, exists). These include genetic damages, and this prompted a reawakening of my youthful interest in genetics. Dramatic progress had taken place in this branch of science, notably Watson and Crick's decoding of the molecular structure of the DNA molecule (the "double helix") and confirmation of its role in heredity. I read about their

work in a brilliant *Scientific American* article by George Gamow in which he also expressed his own ideas on the genetic code.

Experimental work on the effects of radiation on heredity had been conducted for some time. Even the smallest dose of radiation can damage the mechanism governing heredity (which we now know involves DNA replication and transmission) and lead to disease, or to death. Genetic damage is a matter of statistical probability; to give a somewhat oversimplified example: *if* an active molecule such as hydrogen peroxide produced by ionizing radiation should attack a section of DNA, damage is certain—but *if* it does not act upon that section, there will be *no* effect. The probability of damage is directly proportionate to the radiation dose, but within certain known limits, the character of the damage is not dependent on the amount of radiation. The greater the amount of radiation, the greater the number of people it is likely to affect; but the *severity* of the damage to each victim is not altered. The probable incidence of injury can be determined by multiplying the amount of radiation by the number of people exposed to it. (If we reduce the amount of radiation by a factor of one hundred, while at the same time increasing the number of those exposed by the same factor, the number of victims will remain constant.) This is the nonthreshold situation as it pertains to genetic damage—and similarly in other areas.

Nonthreshold biological effects confront us with a serious moral dilemma. As I said above, their victims are unidentifiable—"anonymous." And while the nuclear tests of the last decades may be responsible for only a relatively small increase in the general mortality and disease rates, considering the billions of persons who will be exposed to nonthreshold effects during the radioactive decay period of the elements generated by the tests, the total number of "anonymous" victims will be staggering. (I am referring here to surface, atmospheric, and underwater testing, not to underground nuclear tests.)

We must bear in mind, however, that the biological effects of very small doses of radiation on the order of naturally occurring "background" radiation are not yet fully known. Research in this area faces serious difficulties, including the impossibility of conducting a controlled experiment, the heterogeneity of the population, and the need for a prohibitively large statistical base. It is not inconceivable that, where small doses of radiation are concerned, natural corrective mechanisms may come into play, and the effect of radiation may be nonlinear. The possibility cannot be excluded that small doses might even have some positive biological effects. For this and other reasons, the statements and calculations made in this chapter should be treated with some caution.

I HAD A THREEFOLD interest in genetics: in addition to my consciousness of the harmful genetic effects of nuclear weapons, and my intellectual curiosity, I had on my mind the ordeal that Soviet biology had suffered at the hands of the Lysenko "mafia." I had already had several brushes with Lysenkoism, and friends and acquaintances, in particular Tamm and people at the Academy of Sciences, had briefed me thoroughly on this subject.

It was in 1956, as I recall, that Zeldovich took me to see Nikolai Dubinin, one of the scientists Lysenko had denounced. We went to Dubinin's apartment, which doubled as his laboratory since genetics was banned at the institute where he was officially employed. Dubinin showed us colonies of fruit flies that he used for his experiments, and he offered a concise account of the enormous advances being made in genetics abroad. He spoke of our country's backwardness in the field, and the billions of rubles that could be saved if new techniques were applied to Soviet agriculture and medicine. Dubinin impressed me with the range of his intelligence and businesslike manner.

Our visit wasn't a pleasure trip; Kurchatov was planning to take disgraced geneticists under his wing, and to make his institute something of a haven for them, and he was anxious to get the opinions of impartial outsiders. Not long after our meeting with Dubinin, I had occasion to ask Alexander Nesmeyanov, president of the Academy, how he could tolerate the destructiveness of Lysenko and his theories; Nesmeyanov replied that he thought Lysenko was slowly but surely losing ground in a rear-guard battle. Nor were honest biologists wasting time—a letter was about to go to the Central Committee which they hoped would change the situation.

It was too bright a picture that Nesmeyanov painted. True, a letter signed by four hundred biologists was indeed sent—but it was dismissed as an unauthorized collective action, and some of its signatories found themselves in trouble. Meanwhile, Lysenko had a full-page spread in *Pravda* presenting his latest theoretical and problem-solving "insights."

There seem to be two main reasons for the ability of Lysenko and his gang to maintain their positions through the Khrushchev era, when it was no longer a simple matter of using the tactics of denunciation and pseudo-philosophy that had served them so well in the 1930s and 1940s. First, Lysenko was always ready with a new idea that promised immense payoffs for Soviet agriculture—the sort of "quick fix" that Khrushchev found irresistible. (And when it fell through, Lysenko would be ready with a new, equally "surefire" idea.) Second, and even more important: the Party agriculture bureaucracy was full of people who had long since cast their lot with the Lysenko mafia. It was too late for these people to change their colors; and so they supported every new Lysenko venture, and bitterly opposed properly conducted biological experiments which constituted a threat to their vested interests. It took the "second October

Revolution" of Khrushchev's ouster in October 1964 to get them to shift their allegiance—which they then did en masse. To my mind, the whole Lysenko saga is extremely revealing about the manner in which our country is run, and is worth the attention of foreign Sovietologists.

ZELDOVICH GOT ME involved in other public issues, but my role in these was relatively passive. One of them involved a 1954 press campaign against a play by Leonid Zorin, *The Guests.* I don't recall the precise thrust of the attacks; the play, written at the height of the post-Stalin "Thaw," contrasted the highhanded greed and selfishness of the new Soviet Party bureaucracy with the honesty of "the people" and "true Leninists" (including recently rehabilitated Old Bolsheviks). Zeldovich who himself eschewed any public role in this affair, urged me to write to Khrushchev in the play's defense. It wasn't the most propitious beginning to my letter-writing career; it was undramatic and unproductive, and done mainly in response to Zeldovich's urging. Still, one has to begin somewhere; and to come out against what Djilas called "the new class" was in itself worthwhile. It was my first letter to Khrushchev, the first step I'd taken outside my own field. I don't recall clearly how the matter ended; I think with some *pro forma* response from a Central Committee bureau.

I also spoke out in the ongoing debate about whether special high schools emphasizing physics and mathematics were necessary, and whether or not they violated certain social and pedagogical principles. Zeldovich and I wrote to *Izvestia* in the schools' defense, concentrating on the arguments in favor of the schools and for the most part avoiding a direct answer to the schools' critics. Our letter sparked a lively exchange and a witty and venomous article in the satirical magazine *Krokodil* by Nosov, the author of the popular children's book *Mr. Know-nothing.*

TO RETURN to this chapter's theme, I was becoming increasingly concerned during this period with the biological consequences of nuclear testing. Working on the article, "Radioactive Carbon from Nuclear Explosions and Nonthreshold Biological Effects" (written in 1957 and published the following year in the Soviet journal *Atomic Energy*), did much to develop my ideas on the moral issues involved in nuclear testing; I will try, therefore, to recall just how I came to write it.

Early in 1957, Kurchatov suggested (I may have initiated the idea) that I write something about the effects of radiation from the so-called clean bomb. This was prompted by foreign press reports about the development in the U.S. of a "clean" thermonuclear bomb which used no fissionable material and produced no radioactive fallout. Some people thought such weapons would be more

morally and politically acceptable than conventional thermonuclear weapons and could be more widely used, since damage would be limited to the zone affected by the shock wave. I was supposed to show that this was not in fact the case, and to denounce the new American development, without implicating "conventional" thermonuclear weapons. In other words, the original aim of the article was to have been openly political, and the approach one-sided.

But after reading through the extensive humanistic, political, and scientific literature on the subject, I extended the article's scope and reached more balanced conclusions. My scientific sources included articles by Ovsei Leipunovsky (whose brother was one of the inventors of Soviet breeder reactors), Libby, Adashnikov, and Shapiro. Among the writers with a philosophical and humanist perspective, Albert Schweitzer left a lasting impression on me: eighteen years later, as I drafted my Nobel lecture, I would recall his words.

In my article, I dealt with the fact mentioned earlier in this chapter, that "the number of victims of additional radiation is determined by nonthreshold biological effects." Such effects, including carcinogenesis and genetic change, which in theory might occur at even the very lowest radiation levels, could lead to many deaths and cases of disease as huge populations—over the course of many generations—are exposed to them. "The simplest nonthreshold effect," I wrote, "is the influence on heredity. . . . A single ionization event is sufficient to cause irreversible change—a mutation—in a gene. . . . The probability of damage is in direct proportion to the radiation dose." I estimated that the probability of hereditary disease increases with radiation at the rate of 10^{-4} per roentgen. I posited that cancer and damage to the body's immune system (resulting in premature death) may also be due to nonthreshold effects. An estimate for the combined impact of damage to the immune system and the cancer-promoting effect of radiation was calculated based on data reflecting an average life span reduction of five years for X-ray technicians and radiologists whose total lifetime exposure to radiation probably does not exceed 1,000 roentgens. I also suggested that a global increase in mutations of bacteria and viruses (irrespective of the cause of the mutations) might have been an important factor in the spread of such diseases as diphtheria in the nineteenth century, or the influenza epidemic, and that low-level radiation might further increase the rate of mutations. I therefore estimated the total radiation impact to be equivalent to at least 3×10^{-4} per roentgen. Bearing in mind that an average human lifetime is 20,000 days, each roentgen of global radiation will reduce this average lifetime by one week! My overall estimate of the number of human victims of a one-megaton detonation was 10,000.[1] Two-thirds of this

[1][Frank von Hippel of Princeton University has used recent UN surveys of population expo-

huge figure was attributed to the radioactive isotope carbon-14, which is formed during both "clean" and "normal" thermonuclear explosions.[2] Carbon-14 has a half-life of 5,000 years; its damaging effects thus continue over thousands of years. I had assumed during this period the average size of the Earth's population would be 30 billion. The radioactive products of "normal" nuclear explosions—my calculations took account of strontium-90 and cesium-137 only—would do immediate damage, affecting perhaps one-third of the estimated mid-1950s world population of two billion. The "clean" bomb does not produce strontium and cesium, but it does produce carbon-14.

By 1957, the total power of the nuclear bombs that had been tested around the world added up to nearly fifty megatons. According to my estimates, this would mean 500,000 casualties. Moreover, the figures were increasing swiftly. I concluded my article:

> What sort of moral and political conclusions should be drawn from the figures cited? One argument used by those who maintain that testing is "harmless" is that cosmic rays are a source of greater doses of radiation. But this argument does not alter the fact that to the suffering and death already existing in the world there would be added hundreds of thousands of additional victims, including people living in neutral countries and yet-unborn children. The two world wars increased the mortality rate in our century by less than ten percent—but that does not make war a normal phenomenon.
>
> Another argument frequently encountered in various countries' literature is that the progress of civilization and the development of new technology have led to human casualties in many other cases, as well. The example of automobile accidents is often cited. But the analogy is neither precise nor apt. Automobiles improve people's lives; they only cause harm in case of an accident, and careless drivers can be held criminally responsible. In contrast, each and every nuclear test does damage. And this crime is committed with complete impunity, since it is impossible to prove that a particular death was caused by radiation. Furthermore, posterity has no way to defend itself from our actions. Halting the tests will directly save the lives of hundreds of thousands of people, and it also promises even greater indirect benefits, reducing international tension and the risk of nuclear war, the fundamental danger of our time.

of 1,000 to 25,000 cancers and genetic disorders per megaton, which is consistent with Sakharov's earlier estimate.]

[2] Carbon-14 is produced when neutrons from a thermonuclear explosion interact with atmospheric nitrogen. The numbers of neutrons produced by "clean" and "normal" charges of the same power are about equal, and so are the amounts of carbon-14.

The article was published in 1958, a few months after Khrushchev had become chairman of the USSR Council of Ministers and announced that the Soviet Union was unilaterally halting all nuclear tests. This was an auspicious beginning for the Khrushchev era; but seven months later, testing was resumed.

At Kurchatov's request, I also prepared a more popular version of the *Atomic Energy* article, which appeared in English, German, French, Spanish, and Japanese translation, in magazines published by Soviet embassies and propaganda agencies. The German version was published in *Die Sovietunion Heute* (*The Soviet Union Today,* distributed by the Soviet embassy in West Germany) under the title "The Radioactive Danger of Nuclear Tests"; in it, I praised the historical significance of the Supreme Soviet's decision to institute a unilateral cessation of testing, noting that this represented a serious step toward banning nuclear weapons and reducing the danger of nuclear war; and continued:

> There is good reason for the other great powers which are working on nuclear weapons to follow the USSR's example. Since the USSR and the other countries of the world socialist system are pursuing a policy of peace, the continuation of testing cannot be justified by the need to preserve military parity.

I explained the essence of the nuclear threat and offered statistics I had prepared for *Atomic Energy,* although the editors of the translations, instead of using the original article's upper *and* lower limits for the number of potential victims, used only the figures I had calculated for the upper limits. Thus, my estimates, high enough already, most likely appeared to Western readers to have been exaggerated for propaganda purposes. I concluded by criticizing some statements made by Edward Teller and Albert Latter in their book *Our Nuclear Future:*[3]

> In most instances, [Teller and Latter] do not use absolute figures, but resort instead to unsubstantiated comparisons with other causes of death that have nothing to do with the subject at hand. From this one might conclude that a package of cigarettes is more harmful than nuclear testing. . . .

[3] [Criterion Books, 1958.]

"It is obvious," I said, "that we are dealing with a clear case of logical, moral, and political confusion," and I cited the following passage from the book:

> It is said that not even a single human life should be put at risk. But wouldn't it be more realistic and more in keeping with humanity's ideals if we strove for a better life for all of mankind?

I remarked:

> This last idea would undoubtedly be correct if the authors had in mind peaceful coexistence, disarmament, and, above all, a halt to nuclear testing, and not the dangerous idea of mutual deterrence based on military parity which is only one step away from preventive war.
>
> The Soviet state was compelled to develop nuclear weapons and conduct tests to provide for its security in the face of American and British nuclear weapons. But the USSR's goal is not universal nuclear destruction, but peaceful coexistence, disarmament, and the banning of nuclear weapons.

Khrushchev himself authorized the publication of my articles. Kurchatov discussed the matter twice with him and then referred some minor suggested editorial changes to me. Khrushchev approved the revised versions at the end of June, and they were sent off immediately to the editors.

I have quoted at such length from both articles because of the importance of the nuclear test issue, and because the quotations accurately reflect my frame of mind at the time when I was just beginning to stray from the official position. Later recollections are no substitute for what I actually wrote all those years ago. (The fact that those articles were edited should also be taken into account.) In 1959, my article (the scholarly version, I believe) appeared in the collection *Soviet Scientists Against the Nuclear Menace.*

To the best of my knowledge, no notice of these publications of mine was taken in the West, probably because my name was still quite unknown—no one associated it with the author of works on controlled thermonuclear reactions published two years earlier. Although it is no longer true in my case, the poor use Western journalists make of their archives and reference works, and the lack of interest they show in new names still amazes me.

When nuclear tests were driven underground in 1963, the biological effects of nuclear radiation ceased to alarm people. I was no exception. But the 1986 disaster at Chernobyl brought the matter back to public attention in a particularly tragic manner.

LATE IN 1957, Grigory Barenblat, a young specialist in theoretical mechanics who had collaborated with Zeldovich on a number of articles, asked me to help his father, Isaak Barenblat. I had met the senior Barenblat, a well-known endocrinologist, not long before, when Klava had gone to him for an examination. He had allegedly told his patients jokes about the "intimate relationship" between Khrushchev and Ekaterina Furtseva, the first woman elected to the Presidium, and he had been arrested. (The topic was a popular one—probably less out of any interest in the putative "intimacy" between the head of state and the minister of culture, which in any case probably was just gossip, than in the sensational fact that a woman[!] had been admitted to the Presidium. Many years earlier, when the colleagues of the great German mathematician David Hilbert objected to Emmy Noether's admission to the Philosophy Faculty of Göttingen University on the grounds that she was a woman, he had exclaimed: "But gentlemen, after all, the Philosophy Faculty is not a bathhouse!" This "bathhouse" principle was extraordinarily tenacious in the Soviet Union.) Isaak Barenblat, it was later learned, had been denounced by a colleague, someone he had considered a friend. I decided to write, with Grigory's assistance, to Khrushchev himself, and sent off the letter to the Central Committee that same day. About two weeks later (I know it was in January 1958), I was summoned by the head of the Central Committee's general department. After some elaborate preliminaries, including questions about my relationship with Barenblat and heartfelt sighs—"To say such things about such respected people"—he told me Khrushchev had assigned Suslov to look into my letter.

Two days later, Suslov summoned me. It was around eight o'clock in the evening when I entered his spacious office in the Kremlin. An unusual carved wooden table by the window was set for tea. We sat facing each other; next to Suslov was a desk on which lay a dossier on Barenblat and a notebook in which he made occasional entries. He drank tea and munched pastries as we talked. I took a few sips from my glass.

"I'm very glad to meet you, Andrei Dmitrievich. You're asking me about—what was his name again?"

"Dr. Barenblat. Mikhail Andreyevich, I'm convinced that he has done nothing that merits criminal punishment. He's an honest man and a fine doctor."

"I've looked into his case. He said some inadmissible things. He's not our type of person at all, we found 300,000 rubles at his home, and yet he lives on macaroni from the student cafeteria."

I found it impossible to come up with an appropriate response to the remark about the macaroni. I'm convinced that it reflected a deeply rooted facet of

Suslov's psychology, whether it was hatred of Party enthusiasts of an earlier era, with their disdain for money, or simply a generic distaste for misers. I simply replied that a popular physician in honest practice could easily save 300,000 rubles (30,000 of today's rubles); a great state shouldn't be so concerned about jokes in any case. During the war, Barenblat had proved himself a faithful defender of our system—what were words compared to deeds?

Suslov listened to me with a slightly condescending air. He repeated several times that Barenblat had said "inadmissible things," without specifying what they were. I asked again, what were words compared to deeds? The impasse began to assume a certain ominous quality. Finally, Suslov said: "I'll take another look at the case. Let's move on to something else. Do you know anything about this decision?"

He placed before me the text of a Presidium decision to announce a unilateral halt in nuclear testing. The typewritten text had the usual red stamp on the margin, a warning that no copies should be made. A section of the page had been cut off with scissors. "We're going to announce this at the Supreme Soviet session in March," Suslov said. "What's your reaction?"

I was excited. "I knew nothing of this; I don't think anyone at our Installation knows about it, not even our director, Khariton. I believe it's very important that nuclear tests be stopped; they're responsible for significant genetic damage—but we should have been informed of such a major decision beforehand so that we could tie up loose ends at the Installation."

Suslov didn't ask what I meant by "loose ends"; that probably would have pushed our conversation into an area where he was not comfortable. He changed the subject.

"You referred to the 'genetic consequences' of testing. What are your thoughts on genetics? Kurchatov is setting up a genetics laboratory right now—do we need it, or could we do without it?"

I replied that genetics was of enormous theoretical and practical significance; our country's past rejection of it had been very damaging. In the beginning, genetic theory had been deduced from variations in inherited characteristics. Now, however, a new theoretical foundation had been provided by molecular biologists; and it was molecular biology that was to be studied in Kurchatov's new laboratory: an important and necessary beginning. A laboratory of this type could not be set up at the Lenin All-Union Academy of Agricultural Sciences so long as it was still being run by reckless opportunists and schemers, I added.

Suslov listened closely, asking questions and taking notes. I don't recall whether Lysenko was mentioned by name, but it was clear enough whom and what I meant. I have no idea whether Suslov took any steps concerning the quarrel between the Lysenkoists and the geneticists before Khrushchev's October 1964 ouster. It's possible that when the moment came, Suslov recalled the information about genetics I'd given him six years earlier, or even took another look at his notes. As for Barenblat, he was given a two- or two-and-a-half-year sentence, but was released after one year, and I'd like to think that my intercession played some part in this relatively mild treatment.

MY COLLEAGUES at the Installation could not believe their ears when they learned of the forthcoming halt in testing. But it was decided not to change any of our plans, since we suspected that testing might be resumed before long—which is indeed what happened. The Americans and British were even more surprised than we were by Khrushchev's decision, which was announced at the session of the Supreme Soviet when he assumed the post of chairman of the Council of Ministers. They insisted that negotiations on verification procedures continue, to ensure that any test ban was being observed, and declared that they would in any case proceed with their own planned tests, which would take about a year to complete.

In the summer of 1958, the United States and Great Britain began a long series of tests, and a propaganda war ensued. We claimed that an unprecedented initiative on the part of the USSR had again failed to find Western support. The West claimed (mistakenly) that the USSR had prepared itself for the halt in testing while the U.S. and Britain were caught by surprise, before they'd been able to carry out the scheduled programs. Then and only then would it be possible for the U.S. to follow the USSR's example.

Meanwhile, it became apparent that the devices scheduled by the Installation for testing were extremely important, both technically and conceptually. Could devices so nearly ready for our arsenal be renounced? Could a portion of them, at least, be accepted without testing? Was it possible to design new devices, perhaps with inferior characteristics, that could become part of the arsenal without prior testing? Or was it altogether inconceivable to accept untested devices under any circumstances?

While we were heatedly engaged in discussing the new situation, orders came from Khrushchev to prepare to resume testing, because of the American and British refusal to follow our example. Thus the question was decided politically without regard to its technical aspects. At the Installation, it was "all hands on deck" as we prepared for testing in the late fall.

I found what was happening completely unacceptable, both politically and morally. I felt that such rapid changes of position would lead to a complete loss of trust in the USSR on this already exceedingly complex issue. Also, I had by this time calculated that every one-megaton atmospheric test would cost ten thousand human lives! If the USSR now resumed testing, the signing of a test

ban agreement might well be delayed for several years—meaning tens, perhaps even hundreds, of megatons of atmospheric detonations, and hundreds of thousands or millions of new casualties. Even if my estimates were on the high side, the number of potential human casualties was still colossal. I proposed that the USSR should:

1) In no case begin testing within a year of Khrushchev's announcement—the Americans and British had said a year was all they needed.

2) Redesign the devices scheduled for testing, so that they could in principle be deployed without testing.

3) Renounce the doctrine that no device could be adopted without testing as being inflexible, dogmatic, and inappropriate to the coming "test-free" era.

4) Invest substantially in computers and new calculating techniques with a view to a wider use of calculations in place of tests.

5) Develop new experimental methods for modeling various functions of devices without full-scale testing.

In September 1958 I brought these proposals to Kurchatov, whom I regarded as the only person who had any chance of influencing Khrushchev, and the one official in our ministry who might be sympathetic to them. We met at his small house at his institute. We sat on a bench beneath dense, overhanging foliage—Kurchatov called his cottage a "forester's hut," I think in memory of his father's house, his childhood home. Because of an illness two years earlier, doctors had severely curtailed his working hours, and he often summoned people to the cottage instead of going to the Institute. He would take notes in a thick notebook he had camouflaged with the dust cover of Nehru's *Memoirs*.

Kurchatov listened closely to what I had to say. He was in basic agreement with me. "Khrushchev's in the Crimea now," he said, "vacationing by the sea. I'll fly to him if I can convince my doctors to let me go, and I'll present your ideas to him."

At the end of our conversation, which lasted about an hour, Kurchatov's secretary, Pereverzev, appeared with a camera and proceeded to take a series of pictures of us from a variety of angles. Kurchatov's dog, who'd been getting under his feet the whole time, also got into several of these shots. Pereverzev was putting together a photobiography of Kurchatov. He eventually produced several collections of photographs and gave me one that included the pictures he'd taken that day.

Kurchatov's trip to Yalta was unsuccessful. Khrushchev found our proposals unacceptable. I do not know the details of their conversation, but I heard that Khrushchev was extremely displeased and that from then until Kurchatov's death a year and a half later, he no longer enjoyed Khrushchev's trust.

A couple of months later new tests took place—and were indeed a great success and important from a technical point of view.

In a 1959 speech to the Twenty-first Party Congress, Kurchatov stated that the West's unwillingness to follow the USSR's "prudent example" had forced us to resume testing:

> . . . during the spring and the summer of 1958, the USA conducted more than 50 tests, which forced our country to resume tests in the fall. It should be noted that the tests proved very successful, and demonstrated the extreme effectiveness of various new design principles worked out by Soviet scientists and engineers. The Soviet Army has acquired a more powerful, reliable, and less costly nuclear and thermonuclear weaponry.

It is not surprising that Kurchatov, after failing to change the official position, now publicly supported it. He was both sincere and correct in his assessment of the test results—not that this in any way alters the fact that we could have done without atmospheric tests if we had by then concluded something on the order of the future Moscow Limited Test Ban Treaty.

At his last public appearance Kurchatov declared: "I am glad that I was born in Russia and have dedicated my life to Soviet atomic science. I deeply believe, and am firmly convinced, that our people and our government will use the achievements of that science solely for the good of mankind."

Kurchatov's sincerity in this is unquestionable; at least he certainly wanted this to be true. However, I think now that it would have been better not to have spoken of "Soviet" science, since for me science has no national boundaries, but that is what Kurchatov said, and he chose his words consciously.

I had great respect for Kurchatov, despite the differences in our position and in our whole outlook on life. In the spring of 1959, while Kurchatov was still alive (he died in February 1960), I went for a walk at the Installation with Davidenko, who had known Kurchatov well. Davidenko was not quite so enthusiastic as I. "Kurchatov is a fine person," he said, "a major scientist and an excellent organizer. He loves science and has made great contributions to it. He's a decent man, warm and caring, loyal to old friends and comrades. He has a sense of humor and he's certainly no bore. But don't overestimate his closeness to you! Kurchatov was first and foremost an 'operator,' and what's more, an operator under Stalin—and he was like a fish in water then."

Davidenko was right about some things, but I think he was underestimating Kurchatov's open-mindedness and willingness to take risks in unusual situations, as evidenced in that 1958 trip to see Khrushchev.