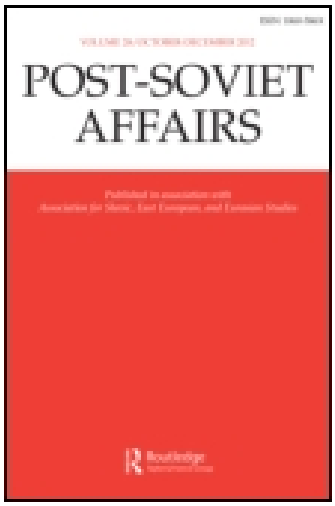

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The State of Russian Science: Focus Groups with Nuclear Physicists

Theodore P. Gerber [a] & Deborah Yarsike Ball [b]
[a] University of Arizona
[b] Lawrence Livermore National Laboratory
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The State of Russian Science: Focus Groups with Nuclear Physicists

Theodore P. Gerber and Deborah Yarsike Ball[1]

Abstract: Two specialists on Russian society and politics examine the condition of Russian science and scientists based on secondary literature, official statistics, and focus groups conducted with 19 Russian nuclear physicists in October 2001. The article discusses the implications of their findings for international security and for Russia's economic and political trajectories.

The fate of Russian science has important implications for international security, as well as for Russia's economic and political prospects. Thus, Western and Russian observers have been justifiably concerned about the crisis that befell Russian science following the collapse of the Soviet system. State funding for research and salaries contracted dramatically, the social prestige of scientists plummeted, and many left science for opportunities in other spheres or emigrated. The number of inventions, patent applica-

[1]Associate Professor of Sociology, University of Arizona, and Russian Political and Military Analyst, Nonproliferation, Arms Control, and International Security Directorate, Lawrence Livermore National Laboratory, respectively. This work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory, under contract No. W-7405-Eng-48. The views represented are those of the authors and do not represent those of Lawrence Livermore National Laboratory, the University of California, the United States government, or any of the individuals who offered suggestions and assistance. The authors express their gratitude to Andrew Hood and Randall Beattie for advice and information about the International Science and Technology Center; George Hobor for research assistance; and Viktor Voronkov, Liubov Ezhova, and Irina Olimpieva for help with the focus groups. We also thank the Center for Global Security Research at LLNL for funding and logistical help and, especially, Eileen Vergino for her support and guidance. Gerber's participation in this project was supported by a University of Arizona Junior Faculty Professional Development Leave and a post-doctoral fellowship from the National Academy of Education/Spencer Foundation.

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tions, and publications by Russian scientists declined. By the mid-1990s the situation had become grim. As two prominent Russian scientists wrote: "The common understanding is that science in Russia is now in a state of crisis. This, however, is an exceptionally rosy view of its condition. … it would be more accurate to describe its current condition as comatose" (Zakharov and Fortov, 1995, p. 693).

We argue that today Russian science is less in a state of crisis than in a state of transition. As the Russian economy has improved, the crisis in science has abated. At the same time, new science institutions and new orientations on the part of Russian scientists have begun to take root. We elaborate and support our argument in two ways. First, we draw attention to developments that suggest the crisis in science has diminished and that new institutions have emerged that should increase the productivity and effectiveness of Russian researchers. Second, we report the results of four focus groups we conducted in October 2001 with nuclear physicists from three formerly closed institutes in or near Moscow.

The Russian economy has grown since 1998, when it bottomed out after the severe financial crisis in August. Greater state revenues as a result of economic growth, improved taxation, and higher oil prices have translated into increased state spending on science. Moreover, for more than a decade, Western governments, foundations, and firms have provided financial support to Russian scientists through competitive grants and contracts. Much of this support has developed or reinforced collaborative relationships between Russian and foreign researchers. Russian scientists have formed their own R&D companies, and Western firms have established facilities in Russia that employ Russian researchers. Official indicators suggest that the salaries, productivity, prestige, and morale of scientists have risen. And, finally, although the Russian government has balked at implementing wholesale institutional reforms that would supplant the centralized, defense-oriented, non-competitive Soviet science system, it has introduced new mechanisms for funding science on a competitive basis.

Our focus group study centers on the views of Russian scientists themselves. We sought to find out how they perceive developments of the last several years, how well they have adapted to the changes that have taken place in Russian science, and what they think lies ahead for them professionally.[2] The results confirm that the "science in crisis" image is one-sided and misleading. Participants did complain about low salaries, lack of respect in society, and other similar issues, but they also expressed positive sentiments about recent changes in the area of science. They noted that state funding has stabilized over the past few years.

[2]Given the small size and specific nature of our sample, we emphasize that the findings are only suggestive. But the results merit attention, because focus groups provide more depth and detail on the views of participants than can be obtained from a questionnaire-based survey (see Morgan, 1996).

More importantly, they indicated that scientists can earn a decent living and conduct interesting research on the basis of foreign and domestic grants and contracts. Not all scientists embrace grant-based financing with wholehearted enthusiasm. To be sure, some prefer the old Soviet system wherein salaries were guaranteed by steady state financing allocated via regular block grants to institutes. But most appear to accept the new system of financing—where competition for grants and contracts is paramount—as inevitable. Some even view these competitive processes as more meritocratic. They think the drastic reduction in the number of scientists has rid Russian science of non-productive "ballast," even as they lament the poor quality and small number of youth entering scientific fields. The participants in our groups also value their newfound opportunities to make international contacts and collaborate with foreign specialists.

Russia's science transition in some ways parallels the economic transition from a state-administered to a market-based system. It has proceeded unevenly and is far from complete. The progress made to date may easily be derailed, spurring a renewed crisis in Russian science. But it is important to take note of that progress and to consider policies that might facilitate additional steps forward.

In what follows, we first describe in greater detail the crisis in Russian science that characterized the early years of the post-Soviet Russian state. We then discuss the important consequences the fate of Russian science has for international security and for Russia's economic and political prospects. Next, we elaborate on the state of transition that we believe aptly describes the current state of science in Russia and explain what it implies about the views of scientists. After describing our focus group methodology, we present the main results from the focus group interviews. We conclude by drawing out the larger implications of our focus group findings and proposing policy measures to facilitate further progress in Russia's science transition.

SCIENCE IN CRISIS

The myriad problems befalling Russian science during the 1990s have been amply documented.[3] The root of these problems was the sharp decline in state funding for scientific research. During the perestroika era, state financing for science remained relatively stable, despite burgeoning economic problems (Mirskaya, 1995). Following the collapse of the Soviet Union in 1991, the state budget contracted radically and science became a low priority, just as severe inflation eroded the value of the ruble. Science financing went into a free fall: between 1991 and 1994 alone, total federal appropriations for science declined in real terms by roughly 75 percent,

[3]For representative examples, see Aldhous (1994a); Aldhous and Dorozynski (1994); Clery (1994a); Pokrovsky (1994); Kneen (1995); Zakharov and Fortov (1995); Lebedev and Milenin (1996); Freemantle (1997); Matlack (1997); Ushkalov (1997); Yurevich and Tsapenko (1998); Feder (1998); Levitin (1998); Varshavskii (1999).

and they have remained roughly at that level ever since (Gokhberg and Mindeli, 2001, p. 44). To make matters worse, for most of the 1990s only partial portions of federal appropriations for science were actually disbursed.[4] Total R&D expenditures (some of which, during the Soviet era, originated from contracts between enterprises and design bureaus) dropped by 70 percent between 1990 and 1992 (Gokhberg and Mindeli 1999, p. 42). According to one estimate (Varshavskii, 1999, p. 61–63), in 1990 R&D spending represented 2.89 percent of Russia's GDP, comparable to the levels of the United States, Japan, and Germany. By 1995 the level represented only 0.75 percent of a GDP that was roughly one-half its previous size, placing Russia in the ranks of Egypt, India, and Portugal on the basis of this criterion.

State financing was and remains by far the largest source of funds for Russian science. Thus, sharp cuts in state funding inevitably led to severe financial difficulties for scientific institutes and for scientists themselves. The average official salary of employees in the science sector was 112.5 percent of the national average salary in 1990 (Varshavskii, 1999, p. 62). This figure plunged to 64.4 percent in 1992 (Gokhberg and Mindeli, 1999, p. 60). Thereafter it gained steadily on the national average, reaching 107.4 percent in 1999 (Gokhberg and Mindeli, 2001, p. 58), but throughout the 1990s the national average itself declined steadily because of persistent inflation. To put the salaries of scientists in perspective, consider that in the mid-1990s only 17 percent received salaries above the official subsistence level (Yurevich and Tsapenko, 1998, p. 18). In 1998 the average salary of a scientist was $60 a month (Levitin, 1998, p. 627). The dire situation compelled research institutes to devote increasing proportions of their budgets to salaries. Research institutes could no longer afford to maintain their facilities or sustain subscriptions to scientific journals, much less purchase new equipment or research materials.[5] Expenditures on subscriptions to foreign journals fell from $25 million in 1990 to a mere $500 thousand in 1993 (Ushkalov and Malakha, 1999).

The low salaries of scientists spurred a precipitous decline in the social prestige of their profession. During Soviet times, scientific occupations were among the most prestigious. But according to surveys conducted in 1996 and 1999, only 5–6 percent of Russians viewed scientists as among "the most respected professions," putting them 10th out of 12 professions, behind "workers in trade," "skilled manual workers," "teachers," and even "peasants" (Gokhberg and Mindeli, 1999, p. 100).[6]

[4]For example, in 1994 only 55 percent of the science budget was fulfilled (Dezhina, 1997, p. 79); in 1996, only 60 percent (Saltykov, 1997, p. 18)

[5]For examples of the dilapidation of facilities, deterioration of instruments and materials, and limitations on electrical power and phone service in science institutes, see Aldhous and Dorozynski (1994); Clery (1994a); Mirskaya (1995); Freemantle (1997). By 1995 only one-tenth of previously available scientific journals could be found in Russian research libraries (Levitin, 1995b, p. 489). For more on declining journal subscriptions, see Markusova et al. (1996).

[6]Only "soldiers" and "engineers" ranked lower than scientists.

Meager salaries, deteriorating work conditions, and low social prestige drove many researchers from Russian science. From 1990 to 1994 the number of scientific researchers declined from 993,000 to 525,000, eventually bottoming out at 417,000 in 1998 (Ushkalov and Malakha, 1999, p. 51; Gokhberg and Mindeli, 1999, p. 28). Where did these scientists go? "Internal" brain drain—i.e., scientists leaving science for other forms of activity, particularly business—appears to account for the most significant outflow of Russian scientists from the scientific profession (Yurevich and Tsapenko, 1999). Hard numbers are difficult to come by, but by one estimate 27 percent of Russia's scientific personnel had left science for "commercial structures" by the end of 1992 (Ushkalov and Malakha, 1999, p. 40). Also, many Russian scientists emigrated abroad, where they could find better opportunities to conduct their work. According to estimates of the Center for Science Research and Statistics, this "external" brain drain peaked in the mid-1990s at around 2,200–2,300 per year (Gokhberg and Mindeli, 2001, p. 40). Some observers claim that the costs of internal and external brain drain are even greater than the raw numbers suggest because younger, more talented, and more ambitious scientists are the most likely to "migrate" (Lebedev and Milenin, 1996; Matlack, 1997; Ushkalov, 1997; Letokhov, 1999). Finally, there are fewer and fewer entrants to scientific professions. On top of a general decline in university and graduate school enrollments and graduation rates during the first half of the 1990s (see Gerber, 2000), lower proportions of university graduates have been entering scientific fields (Lebedev and Milenin, 1996; Ushkalov, 1997). Thus, there are few new recruits to take the place of more senior Russian scientists who retire, emigrate, or give up science for other pursuits.

The rapid shrinking of the Russian scientific community, the deterioration of scientists' working conditions, and the need for many scientists to take up second jobs to survive have taken their toll on the output of Russian science and the general morale of scientists. The numbers of inventions, patent applications, and publications by Russian scientists all have declined for most of the last decade (Yurevich and Tsapenko, 1999).[7] Survey data from the mid-1990s suggest that "more than half of scientific workers regret their choice of profession and would not want their children to become scientists" (Lebedev and Milenin, 1996, p. 14).

The dire situation in Russian science led some to suggest that its very survival hung "in the balance" (Pokrovsky, 1994). Reports of desperate nuclear physicists seeking work as tram operators and conducting hunger strikes dramatized the rapid collapse of one of the contemporary world's

[7]According to official data (Gokhberg and Mindeli, 1999, p. 76), from 1992 to 1995 the number of scientific publications by Russian scientists in foreign journals declined from 26,776 (representing 4.91 percent of all published articles) to 22,989 (representing 3.92 percent). Meanwhile, the number of scientific publications in Russia declined by 58 percent from 1990 through 1993 (Lebedev and Milenin, 1996, p. 12). The number of new patent applications in Russia by Russian scientists declined from 28,478 in 1993 to 15,106 in 1997 (Gokhberg and Mindeli, 1999, p. 68).

most successful scientific establishments (see Levitin, 1995b; Holdsworth, 1996; Perera, 1996; Freemantle, 1997; Feder, 1998). Even more alarming was the 1996 suicide of Vladimir Nechai, director of the second largest nuclear research center in Russia (Chelyabinsk-70, now known as Snezhinsk). Nechay, a respected theoretical physicist who spent almost 40 years working on Soviet and Russian nuclear programs, killed himself because he could no longer endure his inability to rectify a situation in which his employees had not been paid for more than five months and were "close to starvation" (Kovaleva, 1996).

CAUSE FOR CONCERN

The travails of Russia's scientists have sparked interest in the West primarily because of the immediate security threat posed by their situation. The seemingly relentless crisis in science has understandably raised fears that desperate scientists might sell weapons-related expertise to countries or organizations that harbor hostile intentions toward the United States. The state of Russian science also affects Russia's prospects for economic and political development. International security will be improved if Russia develops a stable democracy and thriving market economy. A successful scientific community can help on both counts. The Soviet system produced a highly advanced scientific and technological research capacity in Russia, with many capable and well-trained individuals. Science and technology could serve as an important resource in Russia's struggle to restore economic growth, attract foreign investment, and compete in the international economy. If developed effectively, Russia's scientific potential stands not only to fuel economic growth in Russia, but also to benefit Western companies and scientists who will do business with Russian researchers.

A strong scientific community could also serve as a key constituency for the consolidation of democratic norms in Russia. According to classic works in the sociology of science, there is a strong affinity between the norms and arrangements of the scientific community and liberal-democratic political institutions. The reason is that liberal-democratic institutions are held to encourage the autonomy of science and provide normative support for core values of the scientific ethos: rationalism, universalism, individualism, and autonomy (Barber, 1952; Merton, 1957).[8] Finally, to the extent that Russian scientific researchers are integrated into the global

[8] "Scientists, even those who have no other political interest, are interested in freedom. They are manifestly concerned for the freedom of their own research, cherishing the privilege of unhampered investigation and teaching in academic institutions. They also like to think of science as the intellectual force that challenged the authority of the church and the old forms of learning. They like to believe that the inner spirit of science is one of freedom, that the processes of scientific research require freedoms, and that therefore the political influence of science must be in the direction of freedom—not merely for scientists but for mankind" (Price, 1965, p. 270).

scientific community, it is easier to monitor and regulate their work using international laws and norms. For these reasons, the development and integration of Russian science could reap great economic, political, and security benefits for Russia and for the international community.

On the other hand, a relentless crisis might turn Russian science into a more malign economic, political, and international force. Without fundamental changes in the science institutions inherited from the Soviet period—and a corresponding re-orientation of scientists toward commercially advantageous research—investments in science will remain economically inefficient and unproductive. Disgruntled scientists may associate their loss of material standing and prestige with the economic and political reforms associated with the demise of the Soviet system. Their frustrations could drive them to support political leaders and policies that undermine marketization and democracy. Unless Russian science is again placed on solid and productive economic footing, increasing numbers of scientists may sympathize with voices decrying the influence of Western governments, corporations, and policies in Russia.[9] This, in turn, could fuel anti-Western policies on the part of the Russian government and scientific leaders.

Frustrated scientists also pose a threat to global security if they are tempted to sell their weapons-related expertise to governments with hostile intentions toward the United States or its allies. This threat will be enhanced to the extent that the Russian government seeks to isolate its scientists and scientific research from the international scientific community. On this score, new policies announced during the summer of 2001 requiring scientists in Academy of Sciences institutes to report all contacts with foreigners (see *Izvestiya,* June 2, 2001) and mandating the official registration of all contracts between scientific institutions and foreign entities (Vaganov, 2001) are not encouraging.

SCIENCE IN TRANSITION

If Russian science is to thrive and thus contribute to Russia's economic and political development and ease security concerns, it must undergo an institutional and cultural transformation. The institutional component involves replacing fundamental features of the Soviet science system with scientific institutions and practices that typify Western market-based societies. The cultural component requires that Russian scientists abandon Soviet-era orientations toward scientific professional life and embrace practices consonant with the new science institutions.

Distinctive features of the Soviet science system included a homogenous and highly centralized organization; an overwhelming reliance on

[9]Loren Graham, a long-time observer of Soviet science, senses that parts of the Russian scientific community are "drifting toward communist, nationalist, and anti-Western positions" (Graham, 1998, p. 51).

state financing distributed via block grants to institutes; the absence of horizontal links among scientific institutes, universities, and productive enterprises; an emphasis on military research; politically enforced seclusion from the international scientific community; and sharp institutional boundaries between science education (which took place mainly in universities) and scientific research (which took place in research institutes managed by the Academy of Sciences or government ministries).[10] These institutions and practices greatly limited the effectiveness of Soviet science. Although Soviet scientists could claim some important achievements, their output was considerably lower than might have been expected on the basis of their massive numbers and the resources invested by the state.[11]

The crisis in science inevitably resulted when Soviet science institutions were combined with drastic cuts in the federal budget, a market economy open to global competition, and a political system that permitted citizens to travel abroad. Yet to survive and thrive, Russian science must be open to the international scientific community and replace Soviet-era science institutions with a system of diverse, decentralized, smaller-scale institutions, horizontally linked, financed by grants and contracts from state bodies, international funds, and domestic and foreign firms, and oriented mainly to civilian commercial applications.

No less important, the success of Russian science requires a transition in the attitudes of scientists themselves. Scientists must "buy into" a new and largely unfamiliar philosophy regarding the goals, practices, and rewards of scientific research. Old norms glorified "fundamental" research, collectivism, and "scientific schools"; they disdained commercial orientation and competition for grants (see Gerber, 2001).[12] Many scientists were quite happy with Soviet institutional arrangements, which guaranteed them some resources regardless of their productivity, insulated them from competitive pressures, and relieved them of the need to justify their work in commercial or practical terms (Graham, 1998).

[10]For more detailed descriptions of Soviet science institutions, see Kneen (1984); Vucinich (1984); Graham (1990); Fortescue (1990).

[11]See Graham (1998, ch. 4) and Saltykov (1997) for documentation and explanation of the poor productivity of the Soviet science system. Consider also the biting assessment of an insider: "In the end, the Soviet Union was swamped with far more scientists than it needed. … But despite the huge numbers of Soviet researchers, they made far fewer discoveries of international standing than their colleagues in the West. Soviet scientists began to judge themselves by their own standards, and everyone believed they were doing research of international quality—even when this was manifestly not the case. I knew of countless untalented researchers who could not even spell out the aims of their research, but who managed to get away with it because this inability to explain what they were doing was seen as 'evidence' that they were involved in very fundamental work"(Letokhov, 1999, p. 14).

[12]"Scientific schools" refer to groups of disciples who form around a great researcher—always within a single research establishment—and pursue the leader's research agenda for decades. Many Russian scientists believe that these schools are the distinctive hallmark of Russian science tradition.

In order to resuscitate Russian science, scientists must accept that those institutions are not viable and adapt to the new environment. They must aggressively compete for funding for their work. That means developing an entrepreneurial sense and actively seeking clients—private firms, grant-making organizations, or state bodies that fund research on a contract basis—rather than assuming the state will support them regardless of the demand for or quality of their output. Scientists must learn what their comparative advantages are by becoming familiar with work in their scientific area outside of Russia. They must exhibit enough flexibility to tailor their work to the demands of the market and form synergistic alliances with other domestic and foreign researchers. Some of these alliances may turn into long-term collaborative arrangements, but scientists must be willing to enter into shorter-term collaborations as well.

The competitive, entrepreneurial, commercial, and international orientations that Russian scientists must develop to be successful in the new institutional context cut against the grain of Soviet-era professional norms. Therefore, there must be sufficient institutional change to provide incentives for the necessary cultural reorientation. Similarly, the institutional changes will only bear fruit if they are accompanied by the requisite transformation in scientists' attitudes. In short, the two components necessary for a successful transition in science must proceed in tandem.

GROUNDS FOR OPTIMISM

Many of the institutions of Soviet science remain largely intact (Graham, 1998). The lion's share of science funding is still distributed via block grants to large institutes. Many research institutes remain excessively large and inefficient. The Academy of Sciences still centrally administers a vast network of research institutes that, in turn, are centrally administered, which impedes the development of horizontal links of individual subunits and scientists with commercial entities or funding sources.[13] Administrative and research functions are not organizationally separated, which limits the effectiveness of both. One major reform—the creation of "state research centers"—has amounted to an effort to reinforce existing institutional arrangements and has been generally judged a failure (Schweitzer, 2000).[14]

Yet other signs suggest that the transition has begun. The Russian government has demonstrated some awareness of the need to allocate its funding for science on the basis of competitive principles rather than block grants. To this end, it established the Russian Foundation for Basic Research

[13]See Fortescue (2000) for an account of successful resistance to institutional reforms by leaders within the Russian Academy of Sciences.

[14]Beginning in 1993, a small number of the strongest and most vital research institutes were to be designated "state research centers," a status that was to provide them with supplementary state funding. However, the number of institutes with this designation quickly proliferated, and the funds delivered never approached the promised amounts. See Schweitzer (2000) for more details.

in 1992 (see Dezhina, 1997). Since 1993 the fund has allocated from 2.5 percent to 6.0 percent of federal funds earmarked for fundamental research on the basis of open grant competitions (as calculated from Gokhberg and Mindeli, 2001, p. 47).

Many Russian scientists have formed their own start-up companies (Aldhous, 1994c; Matlack, 1997; Schweitzer, 2000). These companies face tremendous obstacles, and many struggle, but those that have survived the "Darwinian selection" are "becoming stronger and stronger" (Dezhina and Graham, 2001, p. 7). The government has established other special funds to support small innovative businesses and provide venture capital to high-tech start-ups (see Dezhina and Graham, 2001). Financing for these initiatives remains limited, but they indicate that some leaders within the government appreciate the need to shift government financing away from block grants to more competitive mechanisms of distribution. Without forming new corporate entities, some research institutes have shown creativity in using their equipment and facilities as sources of financing (see Aldhous, 1994c; Kerr, 1994). Even the generally conservative Academy of Sciences has taken initiatives to maximize commercial benefits from its vast properties (Levitin, 1999).

Most importantly, Russian science has opened up to the outside world. With some exceptions (for scientists working in top-security closed cities and others with high-level security clearances), scientists are free to travel abroad without restriction. As our focus groups demonstrate, many view this as a significant improvement in comparison to Soviet times when travel was tightly restricted for all scientists (see also Aldhous, 1994a). Numerous working partnerships have been established between Russian researchers and Western researchers in university or national laboratory settings (Aldhous, 1994b; Clery, 1994b; Kerr, 1994; Matlack, 1997). Scientists are also permitted to enter freely into contracts with foreign firms. Companies such as Boeing, Intel, and Motorola have established research and design facilities in Russia, and others have contracted with Russian institutes and individual scientists (Dezhina and Graham, 2000; Dezhina and Graham, 2001).

In recognition of the opportunities and risks that Russian science poses for international security, the US government has implemented bilateral and multilateral programs intended to develop Russia's scientific potential in civilian-oriented directions. Such programs include Co-operative Threat Reduction, Initiatives for Proliferation Prevention, the Nuclear Cities Initiative, and the International Science and Technology Centers (ISTC).[15] Under an existing 10-year umbrella agreement on S&T cooperation between Russia and the US, signed in 1993, more than 15 US agencies have been engaged in projects with Russian scientists, ranging from from public health and medicine to agriculture, the environment, space, energy, information technology, and a wide range of basic science disciplines.[16] The

[15]For an account of the origins and establishment of the ISTC, see Schweitzer (1996).

European community has initiated some grant programs, including the International Association for the Promotion and Cooperation with Scientists from the Independent States of the Former Soviet Union (INTAS). Some private foundations—including the International Science Foundation formed by George Soros, the MacArthur Foundation, and the Carnegie Corporation—have also contributed substantial funding to Russian scientists. Finally, Western corporations have invested directly in Russian R&D ventures.

The advent of Western assistance in the form of competitive grants and contracts has undoubtedly provided opportunities for the most ambitious and capable Russian scientists to obtain support for their work through non-state channels. Substantial resources have been distributed on a strictly competitive basis.[17] Almost from the start, their purpose has been not just to provide Russian scientists with income, but also to cultivate a commercial, entrepreneurial orientation. Ideally, through participation in these programs, scientists learn how to write grants, interact with colleagues in other countries, gain information on the state of their field, discover where they can contribute, and develop an appreciation for international laws and norms regarding scientific research. But have they actually had such an impact? This is one of the key questions we sought to answer through our focus groups.

There is evidence that Russia's science crisis has, at the very least, abated since 1998. In 1999 federal appropriations for science increased by roughly 40 percent in real terms, relative to 1998 (Gokhberg and Mindeli, 2001, p. 42). Employment in science—which had declined every year since 1990—grew by 3,200 (Gokhberg and Mindeli, 2001, p. 28). University enrollments have increased steadily since the mid-1990s, and the latest official statistics show an upswing in patent applications and in public opinion regarding the benefits of science and technology (Gokhberg and Mindeli, 2001). A recent survey indicates that the desire to emigrate is now considerably lower among scientists in closed cities than it was in 1992 (Tikhonov, 2001). A study of scientists in St. Petersburg reports that a large majority has adapted to the new conditions in one way or another (Yevdokimova, Kugel', and Olimpyeva, 2001). Certainly, the improved performance of Russia's economy has contributed to these positive signs. But they might also stem from the progress of Russia's science transition. To find out, we embarked on our effort to assess how Russian scientists themselves perceive the current situation, the changes that have taken place in recent years, and the role of Western financing.

[16]Congressman Curt Weldon has proposed additional areas and topics on which US and Russian scientists can cooperate (Weldon, 2001).

[17]For example, as of March 2001, the ISTC alone had spent $335 million funding 1,250 projects involving 30,000 specialists in 400 institutes (see http://www.istc.ru/).

FOCUS GROUP SAMPLE AND METHODOLOGY

We carried out four focus groups with a total of 19 Russian physicists in October 2001. Part of our objective was to assess the impact of participation in research funded by the International Science and Technology Center (ISTC), so we sought participants who had participated in some form. Two groups were recruited from the Moscow Engineering-Physics Institute (MIFI). MIFI 1 consisted of seven participants who had previously worked on ISTC-funded projects but did not have ISTC funding at the time of the groups. MIFI 2 involved three participants, each of whom had been part of projects that ISTC had approved but declined to fund. (ISTC's approval of a project does not guarantee that it will receive funding.) The third group consisted of five project directors of current ISTC projects from the Institute of Physics and Power Engineering (IPPE) in Obninsk. The final group was from the Joint Institute of Nuclear Research (JINR) in Dubna and involved four current non-PI participants on ISTC-funded projects. The focus groups were conducted with the assistance of three sociologists from the Centre for Independent Social Research (CISR) in St. Petersburg, one of whom served as the moderator.

The moderator posed pre-established questions designed to elicit participants' assessments of changes in the situation of their institutes during the last three years, their sense of how successful their laboratories are, and their views on the effectiveness of state financing vs. financing from grants and contracts, the social responsibility of scientists, generational differences in the orientations of Russian scientists, and whether they think about leaving science or leaving Russia. Finally, the moderator asked participants to assess the role of the ISTC and, secondarily, the general role of Western support programs in the development of Russian science.

Participants were told at the outset that one objective of the research is to provide some feedback to the ISTC about the effectiveness of its programs and procedures. They were encouraged to contribute both positive and negative feedback. They were assured anonymity in all reports.

Although nuclear physicists are not representative of Russian scientists in general, the direction of the resulting bias is hard to deduce. On the one hand, nuclear scientists are typically viewed as the elite among scientific professions and were certainly viewed as such during the Soviet era (see Gerber, 2001), so the state of science may look especially favorable from their vantage point. On the other hand, their previous elite status means that nuclear physicists had the "furthest to fall" during Russia's science crisis (Clery, 1994a), so their views may be exceptionally negative. In addition, the participants in our groups may not be representative of nuclear scientists, since all except one have received some form of financial support from Western grants. Because the vast majority have experienced some degree of success in the new environment, they may have unusually positive assessments of that environment.

In spite of the potential for bias, the focus groups offer instructive, systematic empirical insights into the current attitudes of Russian scientists

who have received Western funding. Western funding aims to affect scientists' orientations and practices, not just their bank accounts. Only by directly examining the orientations of those who receive such funding can we begin to evaluate whether Western funding and the other institutional changes associated with Russia's science transition have had the anticipated impact. Of course, a rigorous assessment of the impact of Western programs and other changes requires systematic, large-sample comparisons of recipients and non-recipients. But the focus group approach offers a more detailed, contextualized, and nuanced look at the perceptions of participants than does a large-sample survey. Therefore, our focus groups with physicists who have benefited from Western funding serve as a vital preliminary step toward assessing their impact.

RUSSIAN SCIENTISTS ON THE STATE OF RUSSIAN SCIENCE

Here we summarize the main findings from the groups regarding scientists' views on the current state of Russian science. We emphasize views that were expressed in multiple focus groups. We first discuss the positive assessments of the current situation and expressions of support and appreciation for changes in Russian science. Then we turn to the more negative assessments voiced by the participants, along with evidence that some still adhere to Soviet-era norms. Finally, we briefly discuss their views on scientists' social responsibility.

Positive Sentiments and New Norms

Supporting the view that Russian science is in a state of transition, participants in multiple—in some cases, all—groups pointed to several developments that they view positively. They noted improved financial stability, due to increased federal funding, elimination of wage arrears, and new contracts with domestic firms and state ministries. They appreciated the important role of financing from Western grants and contracts. They cited increased contacts with the international scientific community as a key improvement of recent years. Finally, they applauded a system of incentives that rewards initiative and quality in scientific work.

All the groups indicated that the financial situation at their institutes had stabilized or even improved during the last few years:

> "[I]f we are talking about the last 2–3 years, there has been a certain tendency toward stabilization. Before, they didn't pay us our pay and we had the impression that everything was collapsing. Now somehow things have generally become more stable. Not everything—but there is a tendency toward stabilization. … A certain confidence has appeared."(DU)[18]

Apart from the widely noted cessation of wage arrears, many participants alluded to recent increases in state orders and contracts. Of particular interest, one participant claimed that a state contract won through a competitive bidding process currently provides 50 percent of his laboratory's financing. (M2) Another said that state funding for defense-related projects had recently increased, and that this significantly improved the general sense of stability:

> "In the last 2–3 years it seems like the volume of financing connected with military research has increased…. In the preceding years our defense orders were 0 percent, but now we are starting to get them…. And this is positive because as a rule, defense orders are not just for one year; they are for a longer period, and thus give a greater sense of stability."(OB)

Surely the perceived stabilization stems in large part from the improvement in the Russian economy during the last three years. Economic growth, higher prices for oil on the global market, and an improved taxation system have increased the federal budget, making more money available for science. The fact that several interviewees referred to an increase in state "orders" and "contracts" suggests that, increasingly, state funds are allocated on the basis of contracts rather than block grants. Of course, references to defense-related orders probably reflect a renewed emphasis on defense spending on the part of the Putin government. But others pointed to increased demand of Russian firms for technological innovations: "In the last 2–3 years our industrial sector has started to grow. And therefore we have started to see opportunities to make agreements [with firms]."(M1) One interviewee who has worked closely with Duma members who deal with science issues said he noticed a renewed appreciation of the importance of science for Russia's economic development on the part of top politicians and economic elites (DU).

If a recent improvement in state financing accounts for a newfound sense of stability, our group participants also pointed to foreign grants and contracts as a vital source of funding. When asked whether their own labs were among the successful ones, almost without exception they replied affirmatively.[19] In almost every case, they attributed their success at least partly to their ability to adapt to the new environment by attracting funding from foreign sources:

[18]All direct quotations are direct translations by the first author from the Russian transcripts. We indicate which group the quotation is from using "M1" for the MIFI 1 group, "M2" for the MIFI 2 group, "OB" for the FEI group (conducted in Obninsk), and "DU" for the JINR group (conducted in Dubna).

[19]Several added "otherwise, I would not be sitting here with you now," raising the possibility that less successful scientists are underrepresented in our groups.

> We used to work exclusively on military orders—100 percent. For the last 13 years we have had no military orders, except for during the last year or two, and those only amount to about 5 percent of our financing. But nonetheless, throughout the whole period, we have generally had no problems with equipment or with financing—that is, we have had the minimum necessary to receive our pay. Perhaps due partly to circumstances, partly to luck, we were able to reorient all our military orders to civilian uses. And even today we have twice or thrice the volume. It is another matter that the institute does not pay us for this. … Since 1996 we have worked on direct contracts—for example, with Sandia and a company from India—and, of course, on ISTC grants. These have been the strongest incentives and greatest sources of support, and they have allowed us to preserve our cadres. Despite the fact that in the institute the outflow of cadres has been relatively high, we have managed to preserve our cadres. … Our foreign grants have even allowed us to hire eight young specialists during the last 2–3 years. … I am not just flattering myself here, so to speak, because it is enough to just look around our own building to see that there are other divisions which, well, unfortunately [are not successful].(OB)

The linking of success to the receipt of grants and contracts from the West was a common theme:

> "Some groups [in our department] simply died, because they did not receive enough financing and people simply left. … But other groups had some kind of financing, including from the ISTC. These groups survived, of course, and generally continue to live. I would not say they live well. But they live 'not badly' because, thanks to the ISTC, they were able to renew their scientific facilities and to support young specialists. We were saying earlier that many people left the institute, but they didn't leave those groups that had ISTC projects. Practically nobody left, because they received enough to get by and they saw that they might have a chance to get additional funding."(M2)

All the groups acknowledged the important financial contributions made by grants from funds such as the ISTC, NATO, and INTAS, and contracts with foreign firms and partners: "When foreign grants started to appear, then we understood that science would survive, that new clients were emerging, that it would be possible to do something"(M2). Some emphasized that grant support was indispensable for their research:

> "It is not our country, but [foreign] foundations that support us. Everything that we do, we can only do via foundations like ISTC, TACIS, grants and so on. … Without question, support from West-

> ern foundations is of definitive importance. … The money we get from foundations is n-times more than we get from state financing."(DU)

> "So this is our research, which is very interesting but not a main priority of Minatom. If we hadn't received the support of the ISTC, then this work simply would not have been done, despite the fact that it generated fascinating results."(OB)

Apart from purely professional benefits (the possibility to conduct research), participants clearly appreciate the higher salaries they earn from grants. For example, participants in the DU group said that ISTC salaries are 2 to 2.5 times more than they receive from their institute, referring to the ISTC component of their earnings as "definitive."

Group participants noted a number of concrete instances where funding from international grants led to longer-term collaborations with foreign partners and firms. One physicist described at length a joint Russian-Japanese project involving the utilization of plutonium, adding that, "if we hadn't receive support from the ISTC, this project never would have happened."(OB) Grants encourage the formation of "capable (*trudosposobnyye*) research groups."(DU) In some cases, they lead to direct contracts with foreign firms. Moreover, the grant-writing process can be a valuable education in and of itself. One participant expressed frustration that his proposal was not accepted by ISTC even after ISTC had provided seed money for its development. Yet he went on to describe the importance of the seed grant for his later success:

> "Working within the framework of ISTC gave me enormous experience and understanding about what our foreign colleagues need from us and how to receive their financial support. That first grant opened the path to all the other grants I since received. It became clear what to do and how to do it. Naturally, the other grants compensated for the fact that the ISTC proposal was not funded."(M2)

Participants in all the groups expressed deep appreciation that Russian science had become more open to the international community: "Abroad, they properly evaluate the level of your work. When you are not in your own closed system, when everything is open, it is only a positive for science."(M2) As they repeatedly emphasized, newfound opportunities to travel abroad and make contacts with foreign colleagues have permitted them to determine their true standing in the international scientific community, learn what kind of work interests foreign entities, and establish collaborative relationships that can and often do lead to additional funding. Here again, many group participants cited the important role of Western grants:

> "The second [major contribution of Western grants] is that [they] truly integrated us—especially those of us who were in defense-related areas—into the international community."(OB)

> "We can use [Western-funded] projects to attend international conferences, which gives us opportunities for international discussions. That is, we can 'show ourselves' and have a look at others. This is very important—it gives us the opportunity to establish international connections."(M1)

Another specific collective benefit of foreign grants noted by several participants is the purchase of equipment, especially computers. One OB participant said that 95 percent of the computers in his department were purchased with ISTC funds, without which there would be 30 people per computer. There was universal agreement that the institutes' computer facilities had been greatly improved by grant funds. Some also see Western funding as a source for other types of equipment: "It gives us the possibility to purchase more or less modern measuring devices, which we can use for purposes other than completing the [grant-funded] project."(M1) However, other participants were skeptical that Western grants permitted the purchase of significant equipment apart from computers.

A number of the physicists we spoke with expressed the view that the changes of the last decade—including the opening up of Russian science to the international community and the shift from block funding to grant- and contract-based financing—had led more meritocracy among Russian scientists:

> "I can cite another positive development: in the last 10–11 years it has become clear 'who is who.' I consider this a positive factor. Before, everyone was brought down to the same level. The international level of each group was not known. Because of [the opening of Russian science], those who had not been working on a high level either left science or "died" (in quotation marks). The ones who survived are those who can work at an international level, and they, of course, to this day receive money from the branch ministries, from Minatom, and in particular, from foreign foundations. I think it is a positive factor that it became evident both to scientists and to others what level you are at."(M2)

While many commentators assert that mostly top-flight researchers have left Russian science, several participants took the opposite view: "It seems to me that as a result of the financial crisis the institute was cleansed of some 'ballast.' … Those scientists who remain in the institute are, shall we say, not 'ballast' but some of the best. They are those who have been able to re-orient themselves scientifically because of their professionalism, training, and erudition."(M1)

Also testifying to a sense of meritocracy, one participant questioned complaints in his group about growing "stratification" (*rassloyeniye*) among scientists: "No! What 'stratification' means is this: some people work Saturdays and Sundays until 10 pm. Others work from 8 to 5 and then they feel there is stratification. They say 'look at so-and-so, look at how much he gets paid.' So it is a controversial question."(OB) Another member of the group replied that everyone would work hard if they had a project that was funded. But even he then allowed, "to some extent they [those who do not have funded projects] are guilty for continuing to work on themes that do not attract support rather than look for new themes."(OB)

The sentiment that the new basis of financing rewards the most capable and energetic scientists and weeds out those less capable was fairly widespread. Several other positive aspects were also mentioned, though generally by only a few individuals. Western grants were seen as more reliable sources of funding insofar as they tended to be delivered directly to project participants, leaving little opportunity for siphoning off by bureaucrats and managers. The new environment gives scientists more independence from institute administration. The influence of political factors on scientific work has decreased, and censorship has practically disappeared. Managing grant-funded projects gives scientists experience and training in managerial skills, which prepares them to take on leading roles in the administration of their institutes. The quality and number of students entering scientific fields has improved in the last several years. Finally, several members of the DU group demonstrated a critical orientation toward Soviet science institutions by sharply criticizing the Academy of Sciences as a venal bureaucratic organization that contributes nothing to Russian science but consumes enormous amounts of money.

In sum, each group pointed to recent positive developments in Russian science. One such development—the modest improvement in financing during the last several years—probably has more to do with the restoration of economic growth in Russia and higher oil prices abroad than with any institutional or cultural transformation. However, other positive developments clearly represent evidence that the institutional and cultural transition of Russian science is under way. These include opportunities to conduct research, purchase equipment, and make a decent living based on grants and contracts from Western sources, increased interaction with foreign colleagues and partners, and a more meritocratic system of incentives in science. At least some Russian scientists have accepted a new way of doing business, aptly captured by the following admonishment: "If you want to get paid, get to work. If you want to travel abroad, know the [foreign] language. If you don't know the language, learn it."(OB)

NEGATIVE ASSESSMENTS AND OLD NORMS

In addition to the surprisingly large number of positive sentiments and new norms among our group participants, some negative assessments of recent developments were expressed and lingering commitments to Soviet-era norms were evinced. Four themes were especially salient: regret over the decline of state financing, concern about the lack of good-quality new recruits to Russian science, complaints about the growth of new forms of bureaucracy, and ambivalence toward grant-based financing, which recalls the traditional hostility toward grants characteristic of Soviet-era scientists (Gerber, 2001).

While participants acknowledged recent improvements in the availability of funds, they nonetheless lamented the meager level of state financing as compared to the Soviet era. They viewed the drop in state financing as the main culprit for the low salaries and low prestige of scientists, obsolescence of facilities and equipment, and the departure of colleagues from the field of science. They are particularly irked by the government's failure to honor its public commitment to devote 4 percent of its annual budget to the support of science. Several opined in this fashion: "If we multiply the 1.4 percent we actually receive by three, that would make 4 percent [of federal budget expenditures] and all of our current problems, like attracting young specialists, would be solved."(OB)

Participants expressed grave concern about "the aging of their institutes." They perceive the sparse salaries and low prestige as adversely affecting their ability to attract the best and the brightest to the field of science. "People are proud to call themselves 'businessmen' even it means they sell eggs at the market, but the title 'scientist' is laughable; it's a synonym for a starving person."(M1) Because of the low appeal of a career in science, the field generally attracts only mediocre students: "As a member of our admissions committee, I can say that most of those who come to work as graduate researchers are C-students (*troyechniki*)."(OB)

They also cited the more materialistic orientation of young Russians as well as broader failures of the Russian education system:

> "When we started to work in science, we never thought about how much we would be paid. … The new generation of scientists immediately asks about pay and about how stable their salary will be." (M1)

> "The system of education, for reasons unknown to me, is now producing young people with a level of education that is, let's say, several times worse in comparison to earlier times. … There is a lack of intelligent people [among the young scientists]. Recent graduates come to us and I see their level of education. It is possible to teach them—they are not stupid—but they simply do not know physics. I don't know how they get any grades. Their level of education is very, very low."(DU)

> "The young scientists we get are—excuse me for saying so—unformed material, who either want to get out of the army (because our staff and graduate students are exempt from the army) or have some other motivation, or just have nowhere else to go. Or they cannot do anything else except enter our institute—no firm will hire them because they are dawdlers. … You see, we get the leftovers."(OB)

The groups also complained about bureaucratic obstacles to their work. These come in various guises. One group emphasized the Russian government's new export control policies, which some participants find excessive and burdensome to comply with:

> "A negative development is that now we have to send all publications and authorization materials to Minatom. The bureaucracy has grown and now we have export control. There are new branches that work on this, and the people who create intellectual property are obliged to jump through all these new bureaucratic hoops, including export control. All this makes it harder to get work done."(OB)

Another (M1) cited growth of bureaucracy within his institute, which he attributed to the increasing complexity and indeterminacy of the system for financing science. In the past, the State gave the institute a certain sum of money, which the institute director then handed out according to his criteria. Today, new regulations require scientists to write reports justifying how the money will be spent before receiving funding:

> "The system of expenditures they have introduced in our institute is completely inappropriate, because we are not allowed to operationally change or re-allocate the money we have. Let's say we need some money for repairs. They say to us: 'there is no line for this in the budget.' That's it! We need money for this, but there is no line in the budget. The money is there somewhere, and we are willing to allocate it, but there is no line in the budget. … Now there are dozens of budget lines, all of which have to be stipulated in advance. But we do not know in advance what we will need. Say that tomorrow the roof starts to leak, and we have to fill a hole there. That costs money. … The system of expenditure should be more flexible and liberal."(M1)

More importantly, from the perspective of assessing whether Russian scientists have embraced new norms, participants voiced a variety of criticisms of grant-based financing. For instance, some took the flip side of the view that grant-based financing is more meritocratic: they decried the inequality that it produces among scientists and among research groups (though they usually appeared to accept it with some resignation): "Some

[scientific] collectives receive a great deal of financing, others receive very little. Well, you can't do anything about it, we have entered a market system. But I still consider this a negative. … Yes, we absolutely have begun to experience inequality."(OB)

To some, grants and contracts inherently subordinate scientific to commercial considerations and lead to the abandonment of fundamental science in favor of applied research: "[Western funds] won't give anything for ideas, [they] will only support a concrete undertaking, something that Western participants need or the production of some kind of special materials."(M1) The putative emphasis on applied work leads scientists to propose projects that they think will be funded rather than those that most interest them:

> "Well, let's say I propose some sort of technique for processing uranium—that will be of interest [to Western funds]. But if I propose a theory of fields with multiple time dimensions, they will say 'why don't you work on that in your spare time?'"(DU)

> "I would like to work on something that is good for my soul, good for science, but in order to feed myself and my colleagues I am obliged to work on topics that are given to me, that foundations will pay for."(DU)

The necessity of continually writing new proposals and submitting reports and accounting statements distracts from scientific work: "On top of everything else, we are now obliged to engage in bookkeeping activities!"(M2) These problems stem from the institute's lack of resources to hire staff who specialize in grant administration. Another downside results from the need to attract multiple grants in order to economically support a laboratory: "There is another problem associated with the lack of financing: proliferation of research projects (*mnogotem'ye*). Because projects are generally poorly financed, a lab with, say, 15 people will be working on 20 projects at the same time."(OB) In the view of some, the quality of scientific work suffers as a result: "On the one hand, people are overburdened with work; on the other, the quality of the work naturally suffers. I sense we are starting to do poorer-quality work—we're doing much more, but worse."(M2)

Some see ulterior motives on the part of Western funding sources. For example, one participant believes Western grant programs are designed to accomplish "the transfer of technological innovations."(DU) As an illustration, he described a Western-funded project in which the Russian team developed a new technique for processing beryllium plates. The Western partners got to make use of the technique and reap vast profits, while the Russian team got only the short-term benefit of the grant. Other participants recounted, often with some emotion, stories which they believe demonstrate that the intellectual products generated by Russian scientists are effectively "stolen" by Western partners (DU, M1). Not that they object

in principle to the selling of Russian scientific know-how: "You know, the bad thing is that [our ideas] are sold well below their value. It would be fine if they were sold for what they are worth, but the way things are now, it is a form of robbery."(DU)

An M1 participant claimed that Western foundations exploit Russian science by gathering vital information about the capacities of Russian scientists: "They don't mind not getting a financial return, because they get much more valuable information about the potential of our scientists in various areas. Therefore, both sides profit, but they actually profit more." Finally, an OB described an opinion—which he and other recipients of Western grants do *not* share—that foreign foundations "engage in intelligence activities and purchase very valuable information from Russian scientists on the cheap."(OB)

Many wished that the Russian government provided all the funds necessary for scientific research. If the state raised the level of science financing, then all the key problems—low prestige, recruitment issues, aging equipment—would be solved. One interviewee expressed the view that scientists deserve state support regardless of whether their results have practical value:

> "Scientists are, to put it simply, an elite within our state. Therefore, the government should just support us, regardless of whether our science has any use. A scientist needs to think, to live in his world; he should not have to spend time looking for orders and contracts, because his task is not to seek clients for his work but to live in the world of abstraction, to occasionally create something useful from this world."(OB)

Others, particularly in the M1 group, complained about the absence of a coherent state plan for the development of science. Without firm state direction of the country's scientific endeavors, only chaos and confusion could result in science.

But even though many participants may like the idea of state support for science with no strings attached, none seem to hold out much hope that a resurgence of state financing to Soviet-era levels is in the cards. Instead, they exhibited a sense of disappointment and betrayal when talking about their treatment by the Russian state:

> "It is of course very painful. Painful. After all, we had a paternalistic state—a state, you understand, which was both our mother and our father and everything for us. You understand what I mean by these terms. And suddenly, for the last 10 years, instead of a paternalistic figure the state turns out to be more like the stepmother or stepfather who does not like you at all. It was a complete turnaround. I don't know what my colleagues think, but in my mind it was a complete reversal. And you start to feel very uncom-

> fortable when you realize that you are working but the state does not reward you for it. It is a very strong break."(M2)

Fatalistic acceptance of the new environment is also evident in this participant's lament:

> "We have made the transition—rightly or wrongly—to the path that is typical of the West and the United States in particular, where you work on one contract then move somewhere else and work on something completely different. In my opinion, the system we used to have was much more favorable for the development of science as such—where a person focused on one thing for his whole life. That was a much better system, and that is why soon we will not have any more science."(M1)

Like it or not—and many of them do not—our participants appear to accept that financing based on grants and contracts will remain an essential source of funding for research.

> "Science is, to some extent, being transformed, and it will turn into an area of production (*proizvodstva*), when everything will be regimented, where the possibilities for the scientific search will be sharply curtailed. We will write beautiful proposals and receive money for our projects. That is, Russian science is now on the path of Western science itself. All financing comes through the framework of projects."(M2)

If such sentiments are widespread among Russian scientists—and we cannot say whether they are without large-scale survey data—they constitute strong evidence of that Russia's science transition is under way.

Social Conscience?

The soacial conscience of Russian scientists can directly affect whether they would be willing to sell their expertise to rogue states in order to earn money. If Russian scientists believe strongly that researchers bear some responsibility for how their work is used, they might exert normative pressure on their colleagues not to work for unsavory clients. To get at this topic, we asked the participants if they think that scientists have any particular social responsibility.

Their reactions and answers were quite revealing. All four groups were at first palpably perplexed and discomfited by the question. Two responded with a deafening silence, two others with outright suspicion—for example, one participant in the DU group hastily declared that now was the time for him to take a cigarette break (he was persuaded to stay). Rather than respond to requests for clarification, the moderator asked participants to interpret the question as they saw fit. Some focused on professional ethics, noting that scientists have not only a responsibility, but

also an interest never to falsify results or otherwise deceive their clients. Others referred to a general duty to do work for the benefit of society. One participant noted that nuclear physicists disagree with the view propounded by the "greens" that they are responsible for destroying the environment: to the contrary, physicists believe that nuclear power makes a valuable contribution to humanity and to preservation of resources. (OB)

But in each group, some respondents eventually discerned the intent behind the question. In no case did they agree that a scientist bears moral responsibility for the use to which his or her work is put. To the M1 group, this is a matter of personal conscience, not one of general moral standards. The M2 group concurred with the following view:

> "I don't think that these days scientists or anybody else spends a lot of time trying to develop weapons of mass destruction. But unfortunately, it often turns out that one starts off with a certain objective and ends up achieving something different. … It is very hard to pinpoint the moment when the researcher can say: 'that's enough, we cannot work any further on this theme because of where it will lead us.' Not just in physics, but in all branches of science we often don't know where our work will lead us. All these secondary applications appear along the path, and sometimes the final result is not evident. Therefore it is very hard to understand where you should stop."(M2)

In contrast to this rather abstract, evasive approach, the DU group rallied around a very concrete disavowal of the idea that the scientist bears responsibility for how his work is used:

> "[Participant 3] It seems to me that everything now is determined by money and salary. There are no moral or ethical considerations, and there have not been for a long time. When people are stealing billions, it is a joke to even suggest such considerations.
> [Moderator] I am asking what you think about responsibility.
> [Participant 1] Well, for example, let's say someone from some foundation approaches me and says: 'I'll pay you 1000 dollars if you do this for me, some kind of process or technology. I do it and I understand that this person could take it and use it …
> [Participant 3] … for military purposes …
> [Participant 1] … and apply it as a weapon of mass destruction. On the other hand, he could also use it as a medicine. Naturally, he comes to me and says: make it for me as a medicine. I am not going to think about the fact that he might bury 20 million people with it, right?
> [Participant 4] Of course not!
> [Participant 1] I'm going to give it to him as a medicine, because he bears responsibility for how it used. … If I know that he could kill 20 million people with one gram, I am not going to think about

it. He asked me to make it as a medicine, so I'm not going to think about the other use. …
[Moderator] So, if you see that it can be used as a weapon of mass destruction, then you, all the same, will do the work on the medicine, knowing that it can be used …
[All participants] Absolutely!"(DU)

The OB group agreed that money is the scientist's overriding concern: "I don't know; for me personally—this may sound rude—a scientist is something of a prostitute. He works on the themes that he is paid to work on. There is no moral choice there."(OB) They also spoke of the need to deal honestly with clients. More generally, their complaints about the system of export control might reflect a perception that politicians have gone too far in limiting the freedom of scientists to take on any clients they want. In another discussion, they appeared to view the restrictions on the export of nuclear technology to Arab countries posed by the threat of terrorism as something of a nuisance, rather than an important aspect of international security.

If the focus groups offer a representative picture of how Russian scientists think about such matters, it appears that their professional ethics do not include a sense of moral responsibility for how their work is used. Unfortunately, this suggests that we cannot rely on professional ethics to dissuade Russian scientists from peddling their expertise to clients with terrorist or criminal motives.

CONCLUSION: FACING THE CHALLENGES TO SCIENCE IN TRANSITION

In the absence of an ethical/moral barrier to the diffusion of Russian scientists' weapons-related expertise, it is all the more essential for international security that Russia's science crisis be reversed. Our focus groups strongly suggest that the transition necessary for this to happen has commenced. At the very least, the "science in crisis" image is obsolete. Participants did report continuing frustration at the loss of state financing, the difficulties of attracting good-quality new recruits to science, and the growth of bureaucracy. They are troubled by some aspects of financing based on grants and contracts. But they also pointed to positive changes in Russian science in recent years, many of them tied to the availability of those same Western grants and contracts, greatly improved exchanges with the international scientific community, and a newfound stability in their institutes' financial situation.

It is important, but tricky, to determine whether the enthusiastic sentiments in our groups predominated over the negative views or vice-versa. Two pieces of evidence suggest that overall, our participants accentuate the positive. First, we asked participants whether they had recently considered leaving science or emigrating. None said that they ever seriously thought about leaving science. A few said that at some point in the

last decade they had thought about trying to find work abroad, but even those abandoned the idea. They spoke eloquently of the deep satisfaction that doing original, independent, creative scientific work gives them. A few participants suggested that they were too old to learn a new trade or seek work abroad. The interviews left the impression that the sentiment is widely shared by the participants:

> "From the start, scientific work was simply very interesting: you are a young scholar, you are doing something, researching something, and yet get some kind of results. They please you, and you get great satisfaction from them. Then, everything around us started to crash, and everybody faced a decision: to remain or not to remain in science. Well, by then, in fact, age played a role, for me and for my colleagues. It was a bit too late to start up in finance or in trade or something, so we stayed in science. Moreover, if there had been absolutely no financing at all [for science], then probably we would have left. But since there were, all the same, some possibilities, we tried to adapt to current conditions and continue the activities we had been undertaking. And now I like doing science more and more."(M1)

Several also said specifically that emigration did not appeal to them. They referred to acquaintances who had taken up scientific work abroad and were very unhappy, or they cited an unwillingness to leave their friends, family, and colleagues in Russia.

There is a second reason for concluding that the positive sentiments of our group participants outweighed their negative sentiments. Despite having just spent the better part of two hours discussing the difficulties facing Russian science, only 5 of the 19 participants listed problems pertaining specifically to science as one of the three most pressing problems facing the country, in response to an open question on the brief survey they completed after the session.

The positive balance of assessments in the focus groups gives us grounds for hope that Russian science has moved from a state of crisis to transition. The persistence of certain "old" norms testifies not to the absence of a transition in science, but to its inevitably drawn-out and uneven nature. We can hardly expect a normative reorientation to take place rapidly, especially when institutional change in Russian science has been slow, apart from the advent of grant-based financing and open international travel. Inevitably, the fortunes of individual scientists will continue to diverge radically, as some are better positioned than others—because of ability, luck, or a combination of both—to take advantage of the new emphasis on work with practical, profitable applications. Many scientists who lose out in the process will be discouraged and blame the reforms. But the key to the positive development of Russian science is not to make all scientists happy—which is neither possible, given limited resources, nor

even desirable—but to provide a structure of incentives that offers hope to those most energetic and capable.

If Russian science has survived its most severe crisis and is now on a path of transition to a different, perhaps "leaner and meaner" footing, it is at least in some measure because of Western grants and contracts and access to Western colleagues. Now is certainly not the time to diminish efforts to shift Russian science to a market-based, civilian-oriented, internationally integrated footing. The US should continue to provide selective financial support for Russian scientists on a competitive basis, emphasizing those proposals that have potential commercial applications. For its part, the Russian government would help matters by refraining from policies that seek to isolate Russian scientists from foreigners, such as the Academy of Science regulation issued in June 2001 that scientists had to report all contacts with foreigners. It should also demonstrate to scientists that it values their work by honoring its public commitment to finance science at the level of 4 percent of the annual budget, especially now that the economy is growing. But the lion's share of this financing should not be handed out in the form of block grants to institutes or via the Academy of Sciences. Instead, the majority of state funding should be distributed on competitive principles. A share should also be devoted to promoting the research capabilities of university departments, in order to improve prospects for recruiting a new generation of top quality specialists.[20] Instituting special grants for young specialists also might contribute to this end.

We do not wish to create an overly optimistic impression. Russian science has suffered severe blows since the collapse of the Soviet Union. Many serious obstacles remain to its successful resurgence. As long as its difficulties continue, so will the threat to international security. No amount of scholarly research can precisely assess the magnitude of this threat. But as more research on the actual orientations of Russian scientists becomes available, we believe that the "science in crisis" perspective should and will give way to a more complex but more accurate picture of the transition under way in Russian science—and a better sense of how to facilitate it.

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