

Is the NIS Brain Drain Exaggerated?

JEFFREY L. ROBERG

Since the August coup d'état of 1991, the fate of nuclear scientists in the newly independent states (NIS) of the former Soviet Union has been a major concern for the West. The West has generally believed that, since the economies of the new nuclear powers (Russia, Ukraine, Kazakhstan, and Belarus) are in a state of collapse and the political situation is unstable, nuclear scientists will be tempted by offers of high pay to build nuclear devices for Third World countries such as Iraq and Iran. Hysteria over these fears has brought the issue of the "brain drain" onto the policy agendas of Western states, as well as of Russia and Ukraine. This article will examine several issues involved with this alleged brain drain and will attempt to show that the reality falls far short of the hype. While the emigration of scientists is a serious problem, this article will demonstrate that the actual brain drain from Russia and Ukraine is far less than that suggested by the news media.

The Brain Drain: What Is It?

When one talks of the brain drain in Russia and Ukraine one is really dealing with three separate categories of movement by scientists. These categories are external emigration, internal shifts to non-scientific employment with the resulting loss of scientific discoveries, and the decline of the military-industrial complex (VPK).

External: The external brain drain is commonly defined as the act of scientific workers leaving the country in which they reside to live in another country. The external drain has two components: permanent and temporary. Permanent brain drain occurs when scientific workers emigrate, like regular citizens, to other countries. There are generally two perspectives on this type of brain drain. The first states that the loss of scientific workers is dangerous for science. It constitutes a loss of talent for the country from which the individual came and can mean a loss of future inventions as well as a loss of the time and money invested in the education of the individual. The second perspective is that the brain drain is a natural phenomenon and good for science as a whole, since the individual will most likely be able to continue his or her research.

The second component of the external brain drain is temporary. This type of drain occurs when scientific workers travel abroad for brief periods of time, generally for one to six months but not uncommonly staying abroad on contracts of a year or two (*po kontraktu*). This temporary brain drain is far more common than the permanent loss of scientific workers. Working

Jeffrey L. Roberg is a Ph.D. candidate and instructor in the Department of Political Science at the University of Illinois, Urbana-Champaign.

abroad for short periods of time allows scientists to interact with their international colleagues, learn new skills and techniques, and combine specialized knowledge on joint projects. Beyond these professional reasons, working abroad also permits Russian and Ukrainian scholars to earn some hard currency to ease their financial burdens at home. This topic will be further explored below.

Internal: Aside from the external brain drain, something that generally does not receive press coverage in the West is the "internal" brain drain. The internal brain drain also consists of two subdivisions. The more common occurs when scientists leave their vocation entirely to work in commercial enterprises. Typically this stems from the need to earn a survival wage so that scientists can support themselves. This type of internal brain drain results in a net loss for the institute where the scientist previously worked, the country's future scientific and technical capability, and for world science. However, the loss to the science sector is a gain for the commercial sector that can benefit from employing capable scientists. According to Andrei Yurevich at the Institute of the History of Natural Sciences and Technology (IIET), there are approximately 200,000 scientists presently engaged in commerce.¹ Furthermore, 30 percent of the owners of businesses are former scientists.² The second type of internal brain drain happens when a scientist switches scientific institutes or moves to another city. This type of brain drain is a loss for the particular institute or laboratory where the scientist worked, but not for the scientific field in general.

Military-Industrial Complex: Finally, the third category of brain drain is from the military sector, the VPK. In 1992, defense industry factories lost 600,000 persons, and R&D institutions—200,000.³ The West is particularly concerned about this category of scientific workers. The West is worried that unemployed or poorly paid nuclear scientists may offer their secrets and skills to the highest bidder. Academician Nikolai Ponomarev-Stepnoi, first deputy director of the Kurchatov Institute of Atomic Energy, stated that there are several thousand nuclear scientists with knowledge and direct access to secrets of nuclear technology.⁴ Yevgeny Velikhov, vice president of the Academy of Sciences and director of the Kurchatov Institute, has estimated that there are between 3,000 and 4,000 scientists and engineers who possess the necessary knowledge of the design and production spheres of nuclear arms.⁵ A. A. Kokoshin, a corresponding member of the Russian Academy of Sciences, has stated that there are thousands of engineers and scientists who constitute a second or third circle of experts who have access to particular aspects of the design and production of armaments such as delivery and targeting systems.⁶ Ponomarev-Stepnoi went on to say that, as long as nuclear specialists were supplied with work, they would not be forced to go abroad. But if they did, he suggested that they would travel to the West, and not to the Third World, since these scientists were not inferior to U.S. nuclear specialists.⁷ However, Vadim A. Simonenko, the branch chief of Chelyabinsk-70, one of the "closed cities" where the nuclear

program began, stated that nuclear scientists would not leave if they received an invitation to work abroad. He stated that "people here have always been hand-picked [*shtuchnii otbor*] for our institute, and as a result committed people with a sense of duty, so to speak, were gathered here."⁸ These statements appear to have been supported by both the Ministry of Atomic Energy and Russia's Federal Counterintelligence Service. Both have stated that not a single person with knowledge of "nuclear secrets" had gone abroad for permanent residence.⁹ However, Vladimir Belugin, the director of Arzamas-16, said that 700 employees, mostly young people, had quit their jobs in favor of moving into the commercial sector.¹⁰ Speaking at Arzamas-16, Yeltsin himself stated that he does not believe that a mass exodus of physicists will take place because these "people are very dedicated to their cause."¹¹ However, Yeltsin did see the need to ensure the social protection of nuclear scientists and to raise their salaries.¹² At that meeting, Yeltsin promised employees a 700 percent pay increase.¹³ The issue of poor conditions and low pay came to a head in July 1993 when scientific workers at Arzamas-16 threatened to strike. In July, thousands of workers finally received their pay for the months of April and May. However, their salaries for June and July had still not yet been paid.¹⁴ In July 1993, the workers at Chelyabinsk-70 also threatened to strike and demanded that their salaries be paid for May and June.¹⁵ In August 1993, the average monthly salary at Chelyabinsk-70 was 58 percent of the Russian national average.¹⁶

Beginning in January 1992, reports began to circulate that Libya planned to offer contracts to Russian nuclear scientists.¹⁷ *Komsomolskaya Pravda* reported that two staff members of the Kurchatov Institute were offered \$2,000 a month to relocate their research to Libya.¹⁸ Still another [unconfirmed] report states that I. Chernyaev, a physicist, has been working at a secret installation in Libya since mid-1991. He was reported to earn \$60,000 a year plus free housing and cars. The same report said that three other nuclear scientists were also working in Libya. However, these reports of recruitment were denied by Andrei Gagarinsky, the executive secretary of the Soviet Nuclear Society and deputy director of the Kurchatov Institute. He did state that the Kurchatov Institute helped build a nuclear research center in Libya during the late 1970s, but that its function is to examine peaceful problems. He said that the scientists working there are part of a government agreement and are not emigrants.¹⁹ Gagarinsky said that Soviet scientists have been working in Libya since 1977 and had "already trained over 200 Libyan specialists."²⁰ Furthermore, Boris Saltykov, the minister of science and deputy prime minister of Russia, stated on 31 January 1992 that "not a single nuclear physicist has left the country."²¹ It has also been reported that China is recruiting Russian technology and scientists to develop state-of-the-art weapons programs and has already hired "hundreds of technicians" for Chinese plants.²² However, Velikhov of the Academy of

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Sciences and the Kurchatov Institute has said that the Academy has no information that nuclear scientists have gone to China and that none of the experts at his institute had gone there.²³

In October 1992, the scenario that Western leaders feared almost came true. Russian authorities prevented a group of nuclear weapons specialists from boarding a flight to North Korea.²⁴ The group consisted of "engineering and technical workers involved with the issue of strategic rocket forces."²⁵ Authorities said the group was stopped because Russia is a "signatory to the Nuclear Non-Proliferation Treaty."²⁶ In early 1992, Ukraine refused to permit thirty scientists with knowledge of weapons technology to emigrate.²⁷

On 1 January 1993, new travel legislation took effect in Russia. This legislation permits Russian citizens to travel abroad at will as long as they have a new Russian passport. However, there may be some ambiguity in the law as it applies to scientists who possess "state secrets." There have been unconfirmed reports of restrictions placed on the travel of nuclear and chemical scientists who possess "state secrets."

While our focus has been on the potential consequence of a brain drain of nuclear scientists, the brain drain itself is not an inherently negative

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phenomenon. For Russia and Ukraine, the brain drain is a double-edged sword. Those scientists who have traveled abroad temporarily to conduct research have been able to gain some financial security and keep their skills honed. This has a direct and dual impact on their home country since money earned abroad is then spent

in the home country's economy and work conducted abroad can also benefit the home country. Naturally the risk is that scientists who go abroad temporarily may choose to remain there. Reportedly there are roughly 50,000 U.S. employers from private companies, universities and private laboratories that may be interested in the scientific talent of the former Soviet Union—especially the physicists, mathematicians, and chemists. For that matter, five out of six professorial posts at Minnesota's Institute of Theoretical Physics are held by Russian natives.²⁸

Reasons for the Brain Drain

Empirical research has shown that two primary factors have led to the brain drain. In interviews conducted during the academic year 1992-1993 in Russia and Ukraine, the following two reasons were most commonly given. First, living conditions for scientists have become very difficult. The average scientist has not been able to care for his or her family with the salary that he/she receives. And second, scientists have traveled abroad for professional reasons—to be able to conduct their work without problems of obtaining supplies, journals, etc. To state this more succinctly, scientists not only want

to live well, but they also want to be able to carry out their work. Scientists used to be among the elite of Soviet society, in some cases granted privileged access to food, cars and summer homes. These days however, the governments of Russia and Ukraine lack the funds to continue to support science (in particular fundamental science) at the same high level. Because of this, scientists are suffering from low pay and an inability to buy necessary equipment and supplies. Many institutes have not been able to afford to keep their subscriptions to foreign publications current. Other factors for going abroad either permanently or temporarily are connected with the general political instability, social transformation, and an increase of ethnic tensions in Russia and Ukraine.²⁹ The internal brain drain may also be explained, in part, by the changed political conditions. Under the old ideological regime of the Soviet Union, science was practically the only "island of decency and freedom" where talented people who wanted to be creative and independent from ideological pressure could come to work.³⁰ Thus, the internal brain drain may in part be seen as a natural occurrence. Now that people can become members of other professions without fear of persecution, some of the scientific workers may be exercising their freedom of choice.

As is well known, many scientists have suffered salary decreases or unemployment as a result of the breakup of the Soviet Union. Science's share of national income in Russia has fallen from 5.6 percent to .52 percent during the period 1990 through 1993, although Russian science had planned to receive .72 percent of the national income for 1993.³¹ For 1994, science's share of the national income is planned to increase slightly to .77 percent.³² In Ukraine, the Academy of Sciences has received 85 percent of its last year's budget while prices increased 400 percent.³³ Over the last two years, Russian science has been reduced in size by roughly 10 to 15 percent.³⁴ However, in Ukraine during the period 1990-1991, R&D personnel decreased by only 4 percent—from 318,900 to 305,000.³⁵ While figures differ, the reduction of the scientific workforce looks as though it will continue in the short term.³⁶ This decrease in the number of scientific workers comes primarily from the lack of funding for science. Those scientific workers who have not had their jobs eliminated have had to be content with low pay and poor working conditions. Scientific workers who are unable to live and work under these circumstances have either gone abroad, although not always continuing their scientific activities, or ceased to work in science. A practical example of this reduction can be observed in the space industry where 70,000 engineers, workers and researchers left the industry in 1992.³⁷ It should be stated however, that the reduction in scientific personnel may not be a purely negative phenomenon. First, the reduction of personnel may be beneficial because of the previous over-staffing of scientific institutions. And second, the general lack of funding has caused the closure of "ghost" institutes that were not fully equipped, staffed, or accomplished little of scientific value.

A great deal has already been said about the poor salaries received by scientific workers in Russia and Ukraine. To give a realistic picture of what

this means, as of 1 September 1992, monthly salaries in the Academy of Sciences for Russia³⁸ (at the dollar exchange rate of 448 Rubles) were as follows:

	<i>Director</i>	<i>Dept. head, academic secretary</i>	<i>Senior researcher</i>	<i>Junior researcher</i>
Russia	R9,000 (\$20)	R7,200 (\$16)	R6,450 (\$14.4)	R3,750 (\$8.4)
Ukraine	R10,100 (\$22.5)	R8,750 (19.5)	R5,610 (\$12.5)	R2,820 (\$6.3)

Although living expenses are far lower than in the West, scientific workers had a difficult time surviving on these wages. This situation has only just recently gotten better in Russia. In November 1993, President Yeltsin issued the decree "On the Material Support of Scientists." This decree increases a scientist's monthly salary by 50 percent if the scientist holds a scientific degree of the rank of either candidate or doctorate of science.³⁹ As of December 1993, the new monthly salaries of scientists in the Russian Academy of Sciences holding a scientific degree⁴⁰ (at the exchange rate of 1,567 rubles) were as follows:

	<i>Dept. head, academic secretary</i>	<i>Head of the group</i>	<i>Senior researcher</i>	<i>Junior researcher</i>
Russia	R172,000 (\$110)	R148,000 (\$94)	R105,000 (\$67)	R56,000 (\$35.7)

By contrast, the subsistence level in December 1993 was 62,000 Rubles.⁴¹ However, despite the increase in salaries, scientists are still facing the problem of government non-payment of their full monthly salaries.⁴²

Budgetary problems are also having an effect on the Russian federal nuclear centers at Arzamas-16 and Chelyabinsk-70. When nuclear science was considered a top priority, these centers received 500, 600, or even 800 young and talented specialists at a time from the best universities and institutes. Now, the nuclear centers receive very few young people for reasons of housing or salary.⁴³ This would not be so bad if it were not for the fact that the previous generations of specialists who worked at Arzamas-16 and Chelyabinsk-70 are leaving. As of February 1992, 100 manual workers had left Chelyabinsk-70.⁴⁴ While Arzamas-16 formerly produced nuclear weapons, it is now responsible for their dismantlement. For this reason, support for the scientific workers at this center must, at the very least, meet the subsistence level.⁴⁵

The lack of budgets and resources for the support of science has led to the following situation. Judging from various poll data, approximately 50 percent of Russian scientists appear ready to travel abroad either for temporary contract work or for permanent relocation. Without knowing specifically how these polls were conducted, these following results have been reported. In February 1992 a poll reported that 51 percent of Moscow scientists

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were ready to travel abroad for temporary work, while 6 percent were prepared to permanently emigrate.⁴⁶ A second poll conducted in 1992 by the Socio-Psychological Sector of the Institute of the History of Natural Sciences and Technology of the Russian Academy of Sciences reported that 83 percent of scientists expressed their preparedness to go abroad and work.⁴⁷ Fifty-seven percent of these scientists wanted to work for several years on contract; 12 percent preferred to never return to Russia. This poll had 3,000 respondents from scientific research institutes of the Russian Academy of Sciences and several other institutes. Another poll reported in April 1993 and conducted by the Institute of Socio-Political Research of the Russian Academy of Sciences stated that 48 percent of Russian scientific workers wanted either temporary or permanent work abroad, but 30 percent did not intend to go abroad. The remaining 20 percent were unable to answer.⁴⁸ This poll data suggests that scientific workers are ready to travel abroad to find work and to be able to care for their families. These polls may be deceiving in that the scientist who travels abroad only for temporary work may choose to stay abroad permanently. It is generally believed that the longer a researcher stays abroad, the less likely he or she will be to return home. While the numbers do not look particularly bright, 30 percent of scientists in the Russian Academy of Sciences are still willing to remain in their country and to work under any conditions.⁴⁹

Science Minister Boris Saltykov in September 1992 stated, “I don’t want to dramatize the problem of the brain-drain. We can’t stop it. It will end when scientists can work and live better here than abroad. It is better for a

scientist to go to Columbia University than to go into business [here in Russia], because at least he is still doing something for world science."⁵⁰

Does the Brain Drain Really Exist?

As this article has already implied, there has been a lot of discussion in the West about the belief that nuclear scientists of the former Soviet Union will run to the highest bidder for work. But just how many scientists are really traveling abroad? Once again, we must consider the distinction between those traveling abroad to emigrate and those who are traveling for a determined period of time on contract. The number going abroad permanently is actually limited. While accurate data are difficult to obtain and differ depending upon the source used, the Center for the Study of Statistical Science (TsISN) of the Ministry of Science, the Analytical Center of the Russian Academy of Sciences, the Russian Ministry of Internal Affairs, and the Dobrov Center for Scientific and Technological Potential and Science History Studies in Kiev, Ukraine, all agree that the permanent brain drain of scientists—those holding a degree of doctor or candidate of science—has been less than 1 percent of the total number of R&D employees. To give the reader some sense of the numbers involved, TsISN and the Academy of Sciences stated that 508 scientists permanently left Russia during the period 1991-1992.⁵¹ That comes out to less than 1 percent (0.8 percent) of the total number of the Russian Academy of Sciences personnel.⁵² More generally, 1,523 people who worked in the sectors of science and education emigrated in the first half of 1992. Again this did not reach even 1 percent of the number of employees in R&D.⁵³ More recently, the Russian president's report has stated that as many as 9,200 Russian scientists have found jobs abroad in 1992. However, it is unclear from the ITAR-TASS report whether these people were specifically scientists or more generally scientific workers; whether they were from the Academy of Sciences or from all scientific sectors; and whether they went abroad for permanent or temporary residence. In the same report the author listed the total number of research workers and science instructors as 900,000. If the 9,200 are meant as a subset of the 900,000 people who are research workers and science instructors, then the brain drain is only 1 percent for 1992.⁵⁴ The State Committee for Statistics (Goskomstat) and the Ministry of Internal Affairs confirmed the relative insignificance of the brain drain even more concretely.⁵⁵ During the month of June 1992, 5,420 people left Russia. Of these people, 54 percent had complete or incomplete higher and secondary specialized education. There were a total of "47 scientific workers [1 percent] and of these just six had a scientific degree."⁵⁶ Oleg A. Ikonnikov wrote that the permanent external brain drain for 1992 was 2.5 percent or 4,572 persons. This figure included workers, specialists, leading scientific researchers and planning-construction developers.⁵⁷ Emigration of doctors and candidates of science in Ukraine for 1990-1992 totaled 159 or 0.3 percent of R&D employees with scientific degrees.⁵⁸

If we consider the number of scientists traveling abroad for temporary work the percentage varies between 1 and 3 percent of the general

population of R&D employees.⁵⁹ In Russia, for the 1991-1992 period, 1,701—less than 3 percent—of the employees of the Academy went abroad.⁶⁰ While in Ukraine, 400 specialists with scientific degrees—less than 1 percent—went abroad during the period 1990-1992.⁶¹

This article has tried to demonstrate that the brain drain defined as a mass exodus or emigration from the country really does not exist. More important, for its impact on science in the newly independent states, is the internal brain drain. The Russian president's report stated that "in 1992 the share of migration abroad did not exceed two percent of the total movement of scientific personnel from the purely scientific domain to other spheres of activity within Russia or across the territory of the former Union."⁶² The ITAR-TASS report stated that "in addition to one scientist, migrating abroad, there are 10 scholars, who have abandoned scientific research for the sake of a more highly paid job."⁶³ The danger of the internal, as opposed to the external, brain drain has more recently been upheld. A survey of 675 scientists and specialists who were dismissed from work, voluntarily or otherwise, during the first five months of 1993, reported that only eighteen of those surveyed (under 3 percent) traveled abroad for work either permanently or on temporary contract.⁶⁴ This clearly demonstrates that the number of scientists going abroad has remained relatively consistent over 1991, 1992, and 1993, while the internal brain drain has witnessed an increase in the number of scientists changing their fields of work.⁶⁵ Unfortunately, this survey is the only published data that currently exists on the external brain drain. During a round table meeting at his ministry, Minister of Science Saltykov stated that Russian officials have no data on the number of scientists who have emigrated permanently or have traveled abroad on temporary contracts for 1993.⁶⁶

Rather than concentrating on the number of people going abroad, we should consider who those people are. If we examine different departments we will see that only a small percentage are leaving each department. The problem is that those who are leaving tend to be "the cream of the crop," although to date, not a single Nobel Prize winner has emigrated from Russia.⁶⁷ Generally speaking those going abroad are the scientists who have established international reputations and are young enough to still make a very large contribution to world science, as well as younger scientists who are dissatisfied with the living and working conditions. The fear is that Russia and Ukraine will lose their potential to perpetuate their science schools since the best people are not remaining to educate the younger members. Sergei Leskov makes this point even more succinctly. He says that it is "difficult for a collective to make up for the loss of a talented leader, and the effectiveness of the work as a whole unquestionably declines."⁶⁸

For the period of 1985-1991, 58 percent of the people who left Russia on contract were the younger scientists, those aged 31 to 45.⁶⁹ For the period 1988-1992, approximately 50 percent of all Ukrainian doctors and candidates of sciences and specialists who emigrated abroad were aged 40 or younger.⁷⁰ From the Academy of Sciences in Ukraine (which we can generalize to Russia), 20 percent of emigrating scientists are aged 30 or

below; 40 percent are between the ages 31 and 40; and 40 percent are above age 41. There is a similar percentage of emigration from branch science. Twenty percent are aged 30 or below; 30 percent between the ages 31 and 40; and the remaining 50 percent are aged 41 or older. And finally, from the university system 15 percent of emigrating scientists were 30 or younger; 33 percent between the ages 31 and 40; and 52 percent were aged 41 or older. Thus, across the spectrum of science (e.g. Academy of Sciences, branch, and university), 52 percent of emigrating scientists are below the age of 40.⁷¹ If the majority of scientists emigrating or going abroad for temporary work are aged 40 or younger, What can we say about those staying behind? Data reported by Yuri Klochko suggests that if the scientist is younger than the age of 30, his or her working conditions are not good.⁷² He reports:

<i>Age groups</i>	<i>Decided to leave R&D occupation, %</i>	<i>Thinking about leaving R&D occupation, %</i>
<25	15	61
25-29	21	26
30-44	6	35
>45	6	18

These data support the data collected by the Institute of History of Natural Sciences and Technology, which reported that 60 percent of the scientists leaving science for commercial activities are under the age of 30. This is the group that receives minimal pay and is highly socially mobile.⁷³

Of the scientists who traveled abroad temporarily on contract, 46.3 percent went to the U.S., while 46.1 percent traveled to Western Europe.⁷⁴ According to TsISN, the top five nations for receipt of Russian emigrants in 1992 in the fields of science and education were: Australia (27.5 percent), the United States (15.6 percent), Israel (15.3 percent), Germany (10.1 percent) and Greece (7.2 percent).⁷⁵ However, the Analytical Center of the Russian Academy of Sciences states that almost one half of all emigrating scientists go to the U.S., one quarter to Germany and the rest to other countries. This discrepancy may be in part definitional. TsISN includes in its figures not only scientists but also scientific workers, laboratory technicians, and people with higher educations. To muddy the water further, TsISN states that Israel appears to be the main recipient of Russian scientists (42.1 percent) followed by the U.S. (38.6 percent).⁷⁶ There has also been an increase of scientists traveling to the Third World. For example, in the first half of 1992, one hundred Russian scientists went to Mexico. Furthermore, articles written about Russians or Ukrainian scientists in Argentina and South Korea are not uncommon.⁷⁷ While specific data on the destination of Ukrainian scientists do not exist, figures for the general population show that for 1992, 45.2 percent (16,100) of emigrants traveled to the U.S., 31.7 percent (11,300) to Israel, 13.8 percent (4,900) to

Germany, 3.4 percent (1,200) to central European countries, and 5.9 percent (2,100) to other countries.⁷⁸

While the absolute number of scientists leaving the country is very small, the fields that these scientists represent are very important. In Russia, 13.2 percent of the scientists who emigrated abroad permanently are from departments of physics and astronomy, and 11.6 percent are from departments of biochemistry, biophysics, and chemistry.⁷⁹ Almost half of all the scientists emigrating to the U.S. are represented by three branches of science: (1) biochemistry, biophysics, and chemistry; (2) general physics and astronomy; and (3) oceanography and atmospheric and geographic physics. Of all scientists going to Israel, 15.4 percent represent these fields.⁸⁰ These figures can be compared with the figures for scientists going abroad for temporary contracts. According to the Main Administration for External Affairs of the Russian Academy of Sciences (GUVS RAN), 52 percent of those going abroad were specialists in the field of solid state physics, nuclear physics, mathematics and programming; 27 percent were in the fields of biology and biotechnology; and 12 percent were chemists.⁸¹ Only 9 percent of those traveling abroad temporarily were from the humanities.⁸² Emigration data for Ukraine show a similar trend. From 1990 to 1992, physicists made up 37.5 percent of all emigrants from Ukraine.⁸³ This was followed by biologists who were 14.4 percent of the total, economists, 3.8 percent and computer scientists, 3.1 percent. While the total number of scientists emigrating abroad is quite small, some institutes have suffered from manpower losses due to "group emigration." Yuri Klochko stated that in Ukraine, sixteen researchers have left the Institute of Semiconductors, and twelve left the Physical Engineering Institute of Low Temperatures.⁸⁴

What does all of this mean in real numbers? As can be gleaned from the figures stated above, the ratio of scientists permanently emigrating to those traveling abroad temporarily is roughly 1:3. In the famous theoretical division at the Lebedev Physical Institute of the Russian Academy of Sciences, only four or five of the fifty-five scientists have emigrated permanently. Roughly five to seven others are on contract abroad for one or two years, and the remaining forty or so scientists have been traveling abroad for periods of three months per year.⁸⁵ In the theoretical department of the Kurchatov Institute, of the fifty-five people in the department, only forty remain.⁸⁶ Furthermore, of the 111 scientists on permanent staff at the Bogoliubov Theoretical Laboratory, Joint Institute for Nuclear Research at Dubna, only two of them have gone abroad permanently. About 10 percent of the Dubna scientists are abroad on long-term contracts of one to three years and about 30 percent travel abroad regularly for periods of two to four months a year.⁸⁷ As these figures demonstrate, the brain drain as a mass emigration of scientists is overstated. While it can be argued that the field of physics does not represent science in general, it can also be argued that physicists possess the brightest job prospects in the West based on their internationally respected expertise. Thus, the brain drain of scientists in other fields will probably be about the same or less than in physics.

How Can Russian and Ukrainian Science Be Helped?

Help from the West: When speaking about braking the brain drain, four methods are usually mentioned: joint projects; Western use of scientific equipment from the former Soviet Union; philanthropic grants or business deals to support Russian and Ukrainian science; and international research centers such as the International Science and Technical Center funded by the international community to help nuclear scientists redirect their work to civilian uses.

First and foremost, Russian and Ukrainian scientists prefer the path of joint projects to keep their science establishments afloat. By working toward

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a scientific goal which is valued by international science, Russian and Ukrainian scientists feel that they are actually earning the money coming to their aid. During numerous interviews, the attitude was expressed by the chief scientific secretary of the Russian Academy of Sciences on down to the scientist in the laboratory that Russia and Ukraine are not looking for charity. They know that their science is on par with (and in some cases exceeds) the level of the international community. Russian and Ukrainian scientists would like to remain at home and still conduct world class science. Academician Ponomarev-Stepnoi has also suggested joint projects with the West to keep nuclear specialists employed and in their home country.⁸⁸ Projects might be initiated on topics such as a global ABM defense system, or enhancing space satellites' power supply.

Along these lines, the European Organization for Nuclear Research (CERN) in Geneva has several joint scientific projects with Russian scientists, in particular with the Joint Institute for Nuclear Research at Dubna. CERN would like to expand its ties with scientists in the newly independent states. CERN brings physicists to Geneva for a determined period of time to work on problems that are jointly useful to world science and to the institutes that sent the physicists there.⁸⁹ In February 1992, Nobel Prize winner Carlos Rubbia of CERN said that twenty to twenty-five physicists would be granted financial support to work at CERN every year.⁹⁰ In 1993, twenty Russian scientists were conducting research at CERN.⁹¹

A second form of support that can be given to science in the newly independent states is through the use of equipment purchased during Soviet times. Russia and Ukraine have much equipment that now stands idle because of a lack of funds to use it. Zhores Medvedev has reported that in the great science city of Dubna, the world's largest synchrotron used in heavy ions physics currently sits idle because of a shortage of funds.⁹² This is in no way an isolated case. All across the former Soviet Union, various types of scientific equipment lie idle. Academic Igor M. Makarov, chief scientific secretary of the Russian Academy of Sciences stated that Russia has a wide array of excellent scientific equipment, such as the largest radio telescope as well as the best optical telescope in the world.⁹³ He also stated

that Russia has sixty ocean-going ships fitted out with the latest equipment for research of the oceans, which currently stand idle in harbors. Makarov has asked world science to not permit the collapse of the world famous scientific schools and equipment that exist in the states of the former Soviet Union. He has issued an invitation to foreign scientists to come and pay for the use of this equipment so that it will not be permitted to decay. In this manner, the West can help support the material base of science in the newly independent states and in turn, scientists of these states would not be forced to accept charity. In so doing, Western scientists gain the benefit of conducting scientific research at a lower cost than in the West since the necessary equipment may already exist in the newly independent states. Medvedev has also reported that the "administrations of the scientific academies have recently indicated that if there is insufficient money, they will abandon research in favor of supporting [their personnel]."⁹⁴

On 10 December 1992, George Soros created the International Scientific Fund (MNF), by donating \$100 million to prevent the collapse of the scientific community in the newly independent republics of the former Soviet Union.⁹⁵ The task of this fund is also to preserve the existing high level of science and create a more open form of organizing and financing fundamental research and education.⁹⁶ Soros' approach has been to help those scientists who are working in the newly independent states and do not wish to emigrate.⁹⁷ Soros' funds are being distributed by the MNF directly to individual scientists and not through the bureaucratic morass of the Academy of Sciences. Distribution of the funds has been in two phases: 6 million dollars was dispersed immediately to provide six months of emergency support to individuals and small research groups. These grants of support were made on the basis of biographical data, number of publications in leading journals since 1988, and a short paper about the goals of the individual's research. The application also included a detailed budget with names of recipients stated.⁹⁸ Of the 32,732 applications received, 25,436 winners received the sum of \$500 from MNF.⁹⁹ Nearly 80 percent of these grants were awarded to Russian scientists, followed by the Ukrainians and Belarusians who were awarded 11.5 percent and 2.65 percent respectively. The remainder of the grants went to other newly independent republics of the former Soviet Union. More than 57 percent of the Russian scientists who received grants work in institutes of the Russian Academy of Sciences with 21 percent in the university system and 22 percent in branch institutes. Furthermore, the majority of the \$500 grants were awarded to physicists (35 percent), followed by biologists (25.1 percent) and chemists (23.8 percent).

The second phase consists of \$85 million for long-term research grants, educational programs and technical equipment. The remaining \$9 million will cover administrative costs.¹⁰⁰ The application process consists of scientists presenting "an itemized and justified budget, descriptions of institutional resources and environment and full disclosure of other support whether governmental or not."¹⁰¹ The Russian government has announced that it will neither tax these grants nor discontinue support of any project

because the researchers receive a grant.¹⁰² Furthermore, imported equipment which is purchased with grant money will be permitted to enter through customs tax-free. Applications to the MNF will be reviewed by evaluating the past achievements and scientific potential of the individual scientist. To date, the MNF has received 10,353 applications for long-term research grants, of which 8,701 have been awarded funding.¹⁰³ Soros' funding is scheduled to last for only two years. It is hoped that by that time, the state will be able to finance science on its own.¹⁰⁴

The Soros MNF has not been without its critics. The fund has been criticized for the way grants are dispersed.¹⁰⁵ Four lines of argumentation have been put forth. The first two arguments question the requirement for having not less than three publications in refereed journals either in the former Soviet Union or in the West. First, because of censorship in scientific publications in the former Soviet Union, workers in many fields are unable to meet this requirement and thus were unable to take part in the competition for grants. In particular, people who worked in areas of secrecy such as theoretical or experimental physicists, applied mathematics, etc., are unable to compete. Second, several of the Soviet journals which count as publications to receive the grant belonged to the Academy of Sciences. These journals tended to publish academicians or corresponding members rather than researchers not associated with the Academy. Third, the competition for Soros funds is unfair because it makes a very subjective choice about what is fundamental and what is applied science. In the former Soviet Union, these two types of sciences often merged. And finally, the competition for funding has been set up along lines of the existing scientific directions of the institutes of the Academy. Therefore, while the Academy contains roughly 110, 300 employees and the branch scientific research institutes (NIIs) have roughly 707,400 employees, three-fourths of the scientific workers in Russia do not qualify for funding under the conditions of the competition for civilian fundamental science.¹⁰⁶ A separate line of criticism has been heard that the Soros fund is not saving science in the NIS but rather destroying it. Some critics of the MNF have suggested that the donation of \$100 million is just a clever way to learn who the top scientists are and what lines of research have been or are being conducted in the newly independent states. The argument continues that the West will then in effect steal these ideas.¹⁰⁷

The MacArthur Foundation is also providing financial assistance to the intellectual and scientific community in the newly independent countries of the former Soviet Union.¹⁰⁸ The foundation is concentrating its efforts in four areas: (1) energy efficiency and environmental protection; (2) legal and economic reform; (3) human rights, including rights of minorities and women; and (4) development of an independent mass media. The foundation's program has a yearly operating budget of \$3 million and has already allocated all of its funds for 1994. Three types of grants have been set up; two of them are based on open competition. The first type of grant is for individual research and writing by scholars in the newly independent countries. These grants can last as long as eighteen months with the average

award being \$10,000. The second type of grant offered by the MacArthur Foundation is for travel to conferences. These travel grants are for a maximum of \$5,000, and the average award is \$1,000. Travel grants are also based on open competition. The final type of grant is for special and joint projects with the West. Typically these are two-year grants with awards ranging from \$50,000 to \$100,000, although awards have been made ranging from \$5,000 to \$300,000.

Private companies have also provided employment and support for Russian and Ukrainian scientists. AT&T Bell Laboratories has already signed a one-year contract with the General Physics Institute of the Russian Academy of Sciences. Under the terms of agreement, one hundred Russian scientists and technicians will conduct research on fiber optics.¹⁰⁹ Boeing Co. has also planned to use Russian engineering knowledge about lighter metals to make their airplanes more fuel efficient, and to use Russian wind tunnels because wind tunnels are in short supply worldwide. Sun Microsystems Computer Corp. has signed a licensing and joint development agreement with the Russian concern Elvis Ltd. to develop hand-held computers to communicate by satellite.¹¹⁰ Elvis Ltd. consists of fifty-three Russian scientists. Sun has bought a 10 percent equity position in the company. And in October 1992, Pratt & Whitney became the U.S. representative for the Russian rocket engine maker NPO Energomash. The agreement will allow the Russian company to sell its heavy payload engines to U.S. space and defense programs.¹¹¹

Even the U.S. Energy Department hired 116 scientists at the Kurchatov Institute to conduct fusion research at their Moscow institute for the modest sum of \$90,000 for one year. Obviously this one contract cannot take care of all of the 10,000 people who work at the institute, but it is a beginning. On the other hand, the United States gains a "lot of scientific bang for the buck."

Special help has come from the American Physical Society and the American Astronomical Society which have helped their colleagues receive journals and offered support for equipment or personnel. The Astronomical Society gave \$30,000 of support to its colleagues.¹¹² The American Mathematical Society has also developed an aid program, under which \$550,000 is to be distributed by monthly grants of \$50 and \$25 to "Russia's highly qualified mathematicians and graduate students."¹¹³ Furthermore, the American Association for the Advancement of Science is offering scientific journal subscriptions to former Soviet scientists either free of charge or at reduced rates.¹¹⁴ One program initiated by the European Physical Society is helping to supply journals to the newly independent states. The program is to supply fifty-two institutions of the former Soviet Union with twenty-nine journals for three years, though every institution will not receive all the journals.¹¹⁵ Furthermore, the six publishing houses who publish these journals have agreed to reduce their price by 50 percent.

And finally, Yevgeny Feinberg, a physicist at the Physical Institute of the Russian Academy of Sciences (FIAN), has suggested the formation of international research centers set up in the former Soviet Union to

capitalize on the scientific potential that already exists there and to limit the brain drain out of science and out of the country.¹¹⁶ Feinberg suggests that an international research center would be connected with an institute and in general would, first, collaborate with countries outside of eastern Europe to organize large-scale research programs, for instance in fundamental physics; and second, organize intensive courses with lectures by eminent professors.¹¹⁷ Feinberg said FIAN has been organizing an international research center with a theoretical physics institute in Copenhagen that was established by the Nordic countries (Finland, Sweden, Norway, Denmark, Iceland) called NORDITA.¹¹⁸ Two international research centers have already been set up. These are the Dubna Joint Institute for Nuclear Research and the Serpukhov Institute for High Energy Physics. The idea of international research centers has been taken up by Minister of Science Saltykov, who discussed the idea with John Gibbons, President Clinton's science advisor. Saltykov has suggested centers "of excellence in space and reactor technology that would be open to researchers around the world."¹¹⁹

One center that has been organized by the international community is the International Science and Technical Center (ISTC). The ISTC was set up by the United States, Japan and the European Union to counter the possibility that weapons' scientists from countries of the Commonwealth of Independent States might be lured by large salaries to build weapons for certain "deviant" countries like Iraq, Iran and Libya. The ISTC will "farm out" civilian-oriented projects in order to redirect defense scientists' and engineers' efforts toward peaceful applications. One hundred million dollars is being put into this project in order to help some 300,000 scientists.¹²⁰

Self-Help: While these Western initiatives help, clearly Russian and Ukrainian science are dependent on their governments for their main funding. A variety of programs have been created toward this end, a few of which are listed below. In April 1992 Russian President Boris Yeltsin created by decree the Russian Fund of Fundamental Research (the Gonchar Fund). This Fund was established to offer grant support to fundamental scientific research projects on a competition basis. It has roughly \$12 million at its disposal.

A different type of proposal was formally presented in January 1993 by Minister of Science Saltykov. He stated that in order to preserve the best components of Russian science and technical potential, Russia should concentrate resources on priority directions as well as provide for free scientific creativity and decentralization in the scientific-technical sphere.¹²¹ This is not a new suggestion, but until now it has gotten little attention, probably because of the inequality of the idea.¹²²

A non-financial form of self help is the creation of an unemployment service for scientific employees and engineering-technical workers of scientific research institutes, construction bureaus, and laboratories. This service finds work for scientists in their specialization or even for those who wish to change their specialization.¹²³ The service was set up through the science newspaper *Poisk*.¹²⁴

Similarly, a Union of Developers of Nuclear Warheads headquartered at Arzamas-16, joins together the two Russian federal nuclear centers—Arzamas-16 and Chelyabinsk-70. Because of the current problems facing nuclear scientists, the Union “is forced to look for additional sources of income and is accepting proposals for scientific-technical projects and long-term cooperation on nonmilitary problems, from both state organizations and private entrepreneurs, including foreign ones.”¹²⁵

In Ukraine, the government created the State Innovation Fund to promote the development and implementation of the achievements in science and technology.¹²⁶ The Fund will be made up of capital from the state budget and deductions from enterprises, associations, and organizations, as well as by voluntary contributions.¹²⁷ Ukrainian doctors have appealed to the international community to help them create an “international center for studying the effect of small doses of radiation upon the genetic system of man.”¹²⁸

Being Taken Advantage of?

One complaint heard in the Russian press is the low status and pay that Russian and Ukrainian scientists receive when working in the West. One article states that a scientist working abroad “receives three times less than a colleague who is occupying the same position.”¹²⁹ A second article complained of Ukrainians and Russians being used as a cheap labor force. The author writes that [Ukrainian and Russian] scientists are paid “around 1500 dollars a month. But the average salary of a scientist in the USA is 50-90,000 dollars a year.”¹³⁰

In November 1992, eighteen institutes of the Russian Academy of Sciences signed an agreement with U.S. Livermore Laboratory that is working on the SDI program. The Russians offered to sell laser technology to the Americans. The outcry that resulted in Russia was not from signing the agreement, but because of the low price that had been negotiated. One of the contracts specified a \$25,000 payment for seven reports. Russian experts as well as Lawrence Livermore’s rivals in the U.S., Japan and France have said that “one report including a list of basic experiments on the subject, their results, future prognoses and numbering 200 pages, is worth no less than \$200,000-250,000.”¹³¹ The article goes on to state that on this deal alone, Russia has lost no less than \$1 million.¹³² Minister Saltykov has also commented on this type of problem. He once mentioned that “Quite often, Russian institutions sell great products for pennies.” He added that his job was to make certain they received a fair price for their work.¹³³

Why Should the West Help?

From some corners, it can be heard that there is nothing the West can do to help science in the newly independent states. This line of thinking is supported by Academic Alexei Abrikosov, a Russian scientist who has worked at Argonne National Laboratories in the United States since 1991. Abrikosov feels that there is only one way to preserve Russian science: “Help all the talented scientists leave Russia as fast as possible and wave

good-bye to the rest."¹³⁴ This article does not support his view.

Even if the West is unable to help all of science in the NIS because of its own financial troubles, at a minimum it should help out of selfishness. First, by helping support science in the newly independent states the West is promoting stability within the new countries. Money used to support science will also have some carry-over effect for the average citizen. By supporting science the West not only helps to ensure that scientific and technical progress will aid the production of consumer goods but secondly, will allow scientists to remain in Russia and Ukraine and earn a living wage. Thus, the intelligentsia will be able to help form the new structure of Russian and Ukrainian society. If the scientific cadres go abroad, other elements will be able to force their will to be heard not only at the ballot box but also on the streets. The scientific community was a large supporter of Gorbachev's glasnost and perestroika. Likewise, they can play a role in today's unstable political climate. Third, a Russia which comes out of these hard times as a friendly "democratic" society will permit the United States to reap the rewards of a "peace dividend" since Russia will not be our primary security concern. Fourth, if scientists in the NIS do permanently travel abroad, they will be competing for jobs with scientists in the West. One look at the unemployed scientists in the Silicon Valley in California suggests that this is not desirable. And finally, Soviet and post-Soviet scientists have made many significant contributions to world science. While they do not have as many Nobel Laureates as the United States, Soviet science is internationally recognized as containing some excellent scientific schools, especially in the fields of physics and mathematics.

However, some concern has been raised about the prospect of granting aid to scientists who are currently working on military projects and developing new generations of weapons that could ostensibly be aimed at the West. While this concern may be well placed, it should not be the sole deciding factor as to whether the United States and the West choose to help the scientists of the newly independent states of the former Soviet Union. Obviously there have been problems with Russian and Ukrainian compliance to international treaties such as the Chemical Weapons Treaty. However, it is the position of this article that this type of a problem can be attributed to government action or inaction rather than to individual scientists. For example the chemist Vil Mirzayanov was arrested and charged with divulging "state secrets" after he co-authored an article with Lev Fyodorov (who was also arrested but released the next day) in *Moscow News* which stated that Russia was developing a binary chemical weapon which was not in compliance with the Chemical Weapons Treaty.¹³⁵ These two scientists were attempting to pressure the Russian government into compliance with the stipulations of the treaty. Fyodorov stated in a 1992 interview, "It is my duty as a scientist and a citizen of Russia to tell the public about the myths of chemical disarmament in this country."¹³⁶ This is a clear demonstration of the moral and ethical character of many scientists. Furthermore, most of the funding by philanthropic organizations is being awarded to individual scientists on a competitive basis rather than to

organizations like the Russian Academy of Sciences which are viewed by the West as too bureaucratic. The West has been concerned that funding given to the newly independent states of the former Soviet Union would be used to support moribund bureaucratic agencies rather than to buy scientific equipment and support individual scientists. This seems to be more of a problem with governmental aid rather than various philanthropic organizations like the MacArthur Foundation. To make sure that grants are being spent in the manner expected, the John D. and Catherine T. MacArthur Foundation requires update reports for grants which last more than a year.¹³⁷

Will the Brain Drain Continue?

The factors leading to the brain drain are not necessarily new, though earlier, two factors existed to prevent the drain. First, the material conditions of Soviet scientists were always more difficult than those of Western scientists; however, they were tolerable. Scientists were able to feed their children and care for their families. The second factor was constant ideological pressure supported by the practical impossibility of emigration. Today, the ideological pressures are gone, but so is the Iron Curtain that prevented Soviet scientists from traveling abroad either as temporary or permanent residents. As already stated in this article, the finances to conduct scientific activity while receiving a living wage currently do not exist in Russia and Ukraine. But with the new travel legislation that took effect 1 January 1993 some scientists are exercising their rights to go abroad.

Nuclear physicists and other scientists cannot be denied the right to leave the country. This is a violation of their human rights. However, at the same time, the proliferation of nuclear technology in the world through "brain drain" may jeopardize international security.¹³⁸ Civilian scientists are not subject to travel restrictions. Georgy Yeliseev of the Kurchatov Institute, says the West, itself, is encouraging the "idea of emigration."¹³⁹ He goes on to say that "it is true that they are earning considerably less than other scientists in those countries, although they possess the same skills, but it is over 100 times more than they would earn in our country."¹⁴⁰ Thus, if the West wants to discourage the brain drain of nuclear scientists, it will have to come up with a support system to stem it. Under the current conditions of political and economic instability in Russia and Ukraine, the drain will continue, though this author suspects that more scientists will travel abroad on temporary contract rather than permanently. Money for temporary contracts already exists, but the West has been tightening its emigration laws to stem the tide of emigrants from the former Soviet Union and east-central Europe. The scale of the brain drain is ultimately dependent upon the living

“ . . . if the West wants to discourage the brain drain of nuclear scientists, it will have to come up with a support system to stem it.”

and professional conditions of scientists in the newly independent states. But as has already been demonstrated, to currently speak of a massive brain drain of scientists in the new countries is to overstate the reality of the situation.

Notes

¹ Interview with Andrei Yurevich, head of the Social Psychology Sector, Institute of History of Natural Sciences and Technology (IIET), Russian Academy of Sciences, 22 October 1992.

² Interview with Andrei Yurevich, 22 October 1992.

³ Lomanov, German, "Military-Industrial Complex Losing Personnel," *Moscow News*, No. 12, 19 March 1993, p. 7.

⁴ "Mass Exodus of Nuclear Scientists Viewed," *Moskovskiy Novosti*, No. 6, 9 February 1992, pp. 18-19, translated in the Foreign Broadcast Information Service [hereafter FBIS], 5 February 1992, p. 5.

⁵ "World Center for Nuclear Scientists Urged," *Frankfurter Rundschau*, 28 February 1992, p. 14, in German, translated in FBIS, 4 March 1992, p. 12-13; Estimates differ as to the number of scientists who possess the detailed knowledge of nuclear technology. For examples, see also "Arms Expert on Plans To End Scientific Exodus," *Izvestiya*, 5 February 1992, p. 6, translated in FBIS, 11 February 1992, p. 8. In this article U.S. CIA Director Robert Gates has stated more specifically that 1,000-2,000 scientists in Russia possess the requisite knowledge; *Komsomolskaya Pravda* has placed this number between 2,000 and 2,500 who really possess sensitive information. See "Workers of Nuclear Research Town Interviewed," Moscow Russian Television Network, 1310 GMT, 8 February 1992, translated in FBIS, 13 February 1992, p. 52. More recently, Tatyana Viktorovna Samolis, the press secretary to the Russian Foreign Intelligence Service has said that there are some 1,500 to 2,000 scientists who work in the munitions sector but only a few dozen scientists know "everything, right down to the details." See "Primakov Aide on Problem of Nuclear Scientists," Ostankino Television First Channel, 2220 GMT, 6 March 1993, translated in FBIS, 9 March 1993, p. 27.

⁶ "Arms Expert on Plans to End Scientific Exodus," p. 8; In the same article as footnote No. 5, *Komsomolskaya Pravda* stated that approximately 10,000 to 15,000 people know secrets of this type. However, Yuri A. Trutnev, first deputy scientific head of the experimental physics institute at Arzamas-16 has suggested that this number should be increased several-fold. He argues that since Arzamas-16 is fifty years old, several generations have worked there. See "Workers of Nuclear Research Town Interviewed," pp. 52-53. Tatyana Viktorovna Samolis, the press secretary to the Russian Foreign Intelligence Service has stated approximately 100,000 people fit this category. See "Primakov Aide on Problem of Nuclear Scientists."

⁷ "Mass Exodus of Nuclear Scientists Viewed," p. 5.

⁸ "Nuclear Brain Drain So Far Theoretical," *Rossiya*, No. 6, 5-11 February 1992, translated in FBIS, 11 February 1992, p. 7.

⁹ See "'Apprehensions' of Brain Drain 'Unfounded,'" ITAR-TASS, 1019 GMT, 30 March 1992, in FBIS, 30 March 1992, p. 2; and "'Hullabaloo' Raised 'Deliberately,'" *Interfax*, 1239 GMT, 30 March 1992, in FBIS, 30 March 1992, p. 2.

¹⁰ Kacherov, Alexander, "Economic Woes Stir Fears at Russian Nuclear Weapons Site," *Clarinews*, 13 July 1993.

¹¹ "Decree on 'Federal Centers' Issued," *Tass*, 1357 GMT, 28 February 1992, translated in FBIS, 2 March 1992, p. 2.

¹² "Decree on 'Federal Centers' Issued," p. 2.

¹³ Mosin, Igor, "Arzamas-16 Is Agitated," *Pravda*, 25 June 1992, cited in Horrigan, Brenda., "The Changing Fate of a Russian 'Secret City,'" *RFE/RL*, p. 51.

¹⁴ Kacherov, Alexander., *Clarinews*, 13 July 1993.

¹⁵ "Russia's Secret Cities," *The Economist*, 25 December 1993 - 7 January 1994, p. 68.

¹⁶ *Ibid.*, p. 68.

¹⁷ "Foreign Ministry on Libyan Bids to Physicists," *Interfax*, 1700 GMT, 10 January 1992, in FBIS, 13 January 1992, p. 26.

¹⁸ "Role of Third World Viewed," *Komsomolskaya Pravda*, 21 January 1992, p. 1, translated in FBIS, 22 January 1992, pp. 1-2.

¹⁹ See "Proliferation Threat Assessed," *Pravda*, 21 January 1992, p. 4, translated in FBIS, 22 January 1992, p. 3; and "Kurchatov Official Dismisses Brain Drain Issue," *Komsomolskaya Pravda*, 23 January 1992, p. 3, translated in FBIS, 24 January 1992, p. 3.

²⁰ "Kurchatov Official Dismisses Brain Drain Issue," p. 4.

²¹ "Minister Denies Nuclear Physicists' Emigration," *Interfax*, 1339 GMT, 31 January 1992, in FBIS, 3 February 1992, p. 41.

²² "China Looks to Russia for High-Tech Weapons Edge," *The Moscow Tribune*, 2 December 1992, p. 4.

²³ "Academy of Sciences Denies Nuclear 'Brain Drain' to PRC," ITAR-TASS, 1330 GMT, 30 December 1992, in FBIS, 31 December 1992, p. 13.

²⁴ Reuters. "Russian Nuclear Specialists Halted at Airport," *The Moscow Times*, 10 February 1993, p. 3.

²⁵ *Ibid.*, p. 3.

²⁶ *Ibid.*, p. 3.

²⁷ Helmstadter, Sarah. "The Russian Brain Drain in Perspective," *RFE/RL*, Vol. 1, No. 42 October 1992, p. 58.

²⁸ "Proliferation Threat Assessed," p. 2.

²⁹ Allakhberdan, Alexander G. «Neobkhodim monitoring po izucheniyu migratsii uchenykh [It is necessary to monitor by studying the migration of scientists],» *Delovoi Mir*, No. 116 (430), 19 June 1992.

³⁰ The physicists this author interviewed especially believed science to be an "island of decency." This point was emphasized by Yevgeny L. Feinberg of the Physical Institute of the Russian Academy of Sciences (FIAN) on 15 April 1993 and by Academic Vitaly L. Ginzburg at (FIAN) on 28 April 1993; See also an article by Leskov, Sergei. "Brain Drain Hits Science," *The Moscow Times*, 10 December 1992 p. 8.

³¹ On 14 February 1994 the Russian Minister of Science Boris Saltykov released figures on financial support of Russian science at a "Round Table" in his office; See also *Poisk*, No. 4 (194), 22-28 January 1993, p. 2.

³² Minister of Science's "Round Table," 14 February 1994.

³³ «Eto sladkoe slovo-dotatsiia [It is a sweet word-subsidy],» *Poisk* No. 3 (193), 15-21 January 1993 p. 4.

³⁴ «S nadezhdou ne rasstavites [Don't part with hope],» *Poisk* No. 5 (195), 29 January - 4 February 1993, p. 3. Some reports put the reduction of personnel at 20-30 percent. See «Na angliiskom nas luchshe slyshat [They hear us better in English],» *Poisk*, No. 50 (240), 17-23 December 1993, p. 3.

³⁵ Klochko, Yuri A., "Salient Findings of the Ukrainian National Study on Intellectual Migration," Dobrov Center for Scientific and Technological Potential and Science History Studies, Kiev, Ukraine, 1993, p. 6.

³⁶ The problem of determining the exact decrease in scientific workers is due to the fact that different definitions of a scientific worker are used. The Center for the Study of Statistical Science (TsSN) of the Russian Ministry of Science has reported that in 1991, 2.4 million people occupied jobs in the science and scientific services sector. This number decreased to nearly 2 million in 1992. See the TsSN of the Russian Ministry of Science, forthcoming OECD Report 1993. Igor Goldman writes that the number of people occupying positions in Russian science fell from 2.2 million in 1989 to 1.4 million today. See Goldman, Igor. «Zvezdy padayut za bugrom [Stars fall behind the knoll],» *Delovoi Mir*, 21 April 1993, p. 11. And Boris Yurolov of the Administration of Economics and legal regulation of scientific-technical progress of the Russian Ministry of Science stated that in 2.9 million people were engaged in the sphere of science and scientific services in 1991 and by the beginning of 1993 only 1.1 million worked in this sphere. See «Tsel nauchno-tekhnikeskoi politiki—vyzhivanie rossiiskoi nauki [The aim of scientific-technical politics—survival of Russian science],» *Delovoi Mir*, 16 January 1993, p. 13.

³⁷ Koriukin, Kirill. Russia's Space Programme Takes Off With Foreign Boost," *The Moscow Tribune*, 10 April 1993, p. 11.

³⁸ "You Can't Work on Empty Stomach [sic]," *Business World Weekly*, No. 41, 24 November 1992, p. 14.

³⁹ Cited in *Poisk*, No. 46 (236), 19-25 November 1993, p. 2; See also «Zima nauki nashei [The winter of our science],» *Poisk*, No. 49 (239), 10-16 December 1993, p. 3; and «Ekonomika uchenykh stepenei [The economics of scientific degrees],» *Poisk*, No. 43 (233), 29 October - 4 November 1993, p. 3.

⁴⁰ This information on monthly salaries was supplied by Mikhail A. Smondyrev of the Bogoliubov Theoretical Laboratory, Joint Institute for Nuclear Research at Dubna, 15 February 1994.

⁴¹ Cited in *Nezavisimaya Gazeta*, No. 21 (697), 3 February 1994, p. 4.

⁴² Reported by Alexander Gurstein, ILET, 26 January 1994 and Mikhail Smondyrev.

⁴³ "Better Use of Nuclear Institute Urged," *Rossiskaia Gazeta*, 11 July 1992, p. 4, translated in FBIS, 17 July 1992, pp. 7-8; "Nuclear Scientist Downplays Impact of 'Brain Drain,'"

Rossiiskaya Gazeta, 21 November 1992, p. 4, translated in FBIS, 24 November 1992, p. 20; and "Russia's Secret Cities," p. 68

⁴⁴ "Nuclear Brain Drain So Far 'Theoretical,'" p. 7.

⁴⁵ See "Better Use of Nuclear Institute Urged," p. 8 and "Nuclear Scientist Downplays Impact of 'Brain Drain,'" p. 20.

⁴⁶ "51% 'Ready To Go,'" Tass, 1623 GMT, 18 February 1992, in FBIS, 19 February 1992, p. 1. The sample size and population is not known to this author.

⁴⁷ IIET, Social-Psychology Sector, unpublished paper 1992. Given to the author by Andrei Yurevich, Head of the Sector. The following data is from this paper.

⁴⁸ Goldman, Igor'. «Zvezdy padayut za bugrom [Stars fall behind the knoll],» *Delovoi Mir*, 21 April 1993, p. 11.

⁴⁹ «Tsifra [Number],» *Poisk*, No. 5 (195) 29 January - 4 February 1993, p. 2.

⁵⁰ Shogren Elizabeth. "SOS for Russian Science," *Los Angeles Times*, 20 September 1992

⁵¹ TsISN of the Ministry of Science and the Russian Academy of Sciences, forthcoming OECD Report, 1993, p. 12.

⁵² TsISN of the Ministry of Science, forthcoming OECD Report, 1993, p. 12.

⁵³ Rossiiskaya Akademiya nauk: Analiticheskii Tsentr [Analytical Center of the Russian Academy of Sciences], «Nauka Rossii segodnia i zavtra [Science of Russia today and tomorrow],» December 1992, Moscow, pp. 194-195.

⁵⁴ See "President's Report Views 'Brain Drain Problem,'" ITAR-TASS, 0747 GMT, 9 April 1993, in FBIS, 9 April 1993, pp. 39-40.

⁵⁵ The following data is from "Insignificant' Number of Science Workers Join Brain Drain," *Izvestiya*, 30 April 1993, p. 15, translated in FBIS, 5 May 1993, p. 40.

⁵⁶ "Insignificant' Number of Science Workers Join Brain Drain," p. 40.

⁵⁷ See «Umov Rossii ne otnyat! [The brains of Russia are not being taken away!],» *Poisk*, No. 1 (243), 7-20 January 1994, p. 3. One recent report does not agree with any of the official data cited above. Reported by *Ostankino Television First Program*, more than 9 percent of scientists have already left Russia. However, it is unknown whether the 9 percent represents only one sector of science or science in general. More specifically, the data source for this report is also unknown. In a related report, the United Nations has estimated the brain drain to cost the CIS countries nearly \$50 billion annually. See "Scientists in Brain Drain Number Over 9 percent," *Ostankino Television First Program*, 2100 GMT, 8 December 1992, translated in FBIS, 18 December 1992, p. 48.

⁵⁸ Klochko, p. 8.

⁵⁹ The percentage of scientists travelling abroad varies depending on how the author defined temporary work. Boris Saltykov has said that "between 500 and 600 scientists working in the Russian academy's research centres have signed contracts to work in Europe, the United States, Israel and Japan for periods between 12 months and three years." See "Further on Remarks: Minister Denies Nuclear Physicists' Emigration," Tass, 1219 GMT, 31 January 1992, in FBIS, 3 February 1992, p. 41.

⁶⁰ TsISN of the Ministry of Science (forthcoming OECD Report), 1993.

⁶¹ Klochko, p. 8.

⁶² "President's Report Views 'Brain Drain Problem,'" p. 40.

⁶³ *Ibid.*, p. 40.

⁶⁴ «Kuda uxodit molodost nauki? [Where are the young of science going?],» *Poisk*, No. 43 (233), 29 October - 4 November 1993, p. 14; See also «Umov Rossii ne otnyat! [The brains of Russia are not being taken away!],» p. 3.

⁶⁵ «Kuda uxodit molodost . . .»

⁶⁶ Minister of Science's "Round Table," 14 February 1994.

⁶⁷ «Umov Rossii ne otnyat! [The brains of Russia are not being taken away!],» p. 3.

⁶⁸ Leskov, p. 8.

⁶⁹ Rossiiskaya Akademiya nauk: Analiticheskii Tsentr, p. 195.

⁷⁰ Interview with Yuri Klochko, Dobrov Center for Scientific and Technological Potential and Science History Studies, Kiev, Ukraine, May 1993. The following discussion is taken from this interview.

⁷¹ Klochko, p. 10; See also TsISN of the Ministry of Science and the Russian Academy of Sciences, «Emigratsiya Uchenykh: Problemy i Realnye Otsenki [The Emigration of Scientists: Problems and Real Evaluations].» This paper was part of a project titled "Internal Migration and Emigration from the Former USSR: regional and social-political aspects," Moscow, 29-30 September 1993. Survey data for Russia shows that those scientists and specialists most actively transferring to other areas of work are under the age of 40. See «Kuda uxodit molodost . . .»

⁷² Klochko, p. 10.

⁷³ Social Psychology Sector, IIET, Russian Academy of Sciences, 1992, p. 2.

- ⁷⁴ Rossiiskaya Akademiya nauk: Analiticheskii Tsent, p. 195.
- ⁷⁵ TsISN of the Ministry of Science and the Russian Academy of Sciences, «Statisticheskaya otsenka emigratsiya nauchnykh kadrov [Statistical Evaluation of Emigration of Scientific Cadres],» 1993 (forthcoming).
- ⁷⁶ TsISN of the Ministry of Science, (forthcoming OECD Report), 1993, p. 13
- ⁷⁷ Rossiiskaya Akademiya nauk: Analiticheskii Tsent [Analytical Center of the Russian Academy of Sciences], «Nauka Rossii segodnia i zavtra [Science of Russia today and tomorrow],» December 1992, Moscow, p. 195; Brilev, Sergei. "Former Soviet citizens rush to Argentina," *Moscow News* No. 20, 14 May 1993; the Social-Psychology Sector of the IJET, Russian Academy of Sciences reported that 35 Russian scientists currently work in South Korea, including people who build fighter aircraft. One-hundred twenty more were expected to join them by the end of 1992.
- ⁷⁸ Klochko, p. 7.
- ⁷⁹ TsISN of the Ministry of Science, (forthcoming OECD Report), 1993, p. 12.
- ⁸⁰ *Ibid.*, p. 13.
- ⁸¹ Data from the Main Administration for External Affairs of the Russian Academy of Sciences is cited in the report by the Social-Psychology Sector, IJET, Russian Academy of Sciences, 1992, p. 1.
- ⁸² Report by the Social Psychology Sector, IJET, Russian Academy of Sciences, p. 1.
- ⁸³ See Klochko, p. 8.
- ⁸⁴ *Ibid.*, p. 8.
- ⁸⁵ Feinberg, Yevgeny L. "Soviet Science in Danger," *Physics Today*, May 1992, p. 36.
- ⁸⁶ Interview with Vitaly D. Shafranov, Head of the Theoretical Division, Plasma Physics Department at the Kurchatov Institute (now renamed the Russian Research Center) on 13 April 1993.
- ⁸⁷ This information was supplied by Mikhail A. Smondyrev of the Bogoliubov Theoretical Laboratory, Joint Institute for Nuclear Research at Dubna, 15 February 1994.
- ⁸⁸ "Mass Exodus' of Nuclear Scientists Viewed," pp. 5-6.
- ⁸⁹ «Russkie fiziki pochtii genialny [Russian physicists are almost geniuses],» *Poisk* No. 3 (193) 15-21 January 1993.
- ⁹⁰ "Burbulis Meets With Nuclear Research Official," *Interfax*, 1934 GMT, 10 February 1992, in FBIS, 12 February 1992, p. 2.
- ⁹¹ «Diplomatiya vysokikh energii [Diplomacy of high energy],» *Poisk*, No. 44 (234), 5-11 November 1993, p. 1.
- ⁹² Medvedev, Zhores A. "Lean Times for Science," *The Moscow Times*, 2 March 1993, p. 8; See also his "Collapse of Atomgrads," *The Moscow Times*, 3 March 1993, p. 8; and see «Vzlet i padenie «bolshoi» sovetской nauki v Rossii [The Rise and Fall of 'Big' Soviet Science in Russia],» *Novoe Russkoe Slovo-Russian Daily*, 26 February 1993 p. 21 and 27-28 February 1993, p. 7.
- ⁹³ All remarks attributed to Makarov were conveyed to this author during an interview conducted with Academic Igor Mikhailovich Makarov, Chief Scientific Secretary of the Russian Academy of Sciences, 15 February 1993.
- ⁹⁴ Medvedev, 2 March 1993, p. 8
- ⁹⁵ Levine, Joanne. "Soros Gives \$100 Million for Research," *The Moscow Times*, Thursday 10 December 1992, p. 5;
- ⁹⁶ "Santa Soros," *Poisk*, No. 51 (189) 18-24 December 1992, p. 1.
- ⁹⁷ «Yu. Orlov: 'Borotsia «protiv» nauchilis, a «za» - net [Yuri Orlov: The struggle 'against' they learned, but 'for' - no],» *Argumenti i Fakty*, No. 10, March 1993, p. 3.
- ⁹⁸ «Mezhdunarodnii nauchnii fond [International Scientific Fund],» *Poisk*, No. 51 (189) 18-24 December 1992, p. 7; «Tsena pobedy-500 dollarov [The Price of Victory-500 dollars],» *Poisk*, No. 3 (193) 15-21 January 1993, p. 1.
- ⁹⁹ «Ne oskudeet li ruka dayushego? [Can a helping hand stay rich?],» *Poisk*, No. 47 (237), 26 November - 2 December 1993, p. 1; The following information is also from this article. See also "Demand Exceeds Supply as West Helps East," *Physics World*, Vol. 7, No. 2, pp. 5-6
- ¹⁰⁰ Levine, p. 5.
- ¹⁰¹ Gamel, Kim. "American Millionaire Donates \$100 Million to Stop the Brain Drain," *The Moscow Tribune*, 11 December 1992, p. 5.
- ¹⁰² Gamel, p. 5.
- ¹⁰³ «Ne oskudeet li ruka dayushego? [Can a helping hand stay rich?],» p. 1
- ¹⁰⁴ «Yu. Orlov: 'Borotsia «protiv» nauchilis, a «za» - net,» p. 3.
- ¹⁰⁵ The following discussion is nicely summarized in an article by Moisei Gelman, «Esli by ia byl Dzhordzhem Sorosom . . . [If I would have been George Soros . . .],» *Delovoi Mir*, 23 March 1993, p. 11.
- ¹⁰⁶ Gelman, p. 11. This author is unaware of what method Gelman used to calculate the

- number of employees in the Academy and Branch Scientific Research institutes.
- ¹⁰⁷ «Nauchnaia mysl est iavlenie planetarnhoe [Scientific thought has a planetwide phenomena],» *Izvestiya* No. 58, 30 March 1993, p. 5.
- ¹⁰⁸ The following information is from a conversation with Dr. Andrew Kuchins of the John D. and Catherine T. MacArthur Foundation.
- ¹⁰⁹ See Shogren.
- ¹¹⁰ "Sun Teams With Russian Company," *The Moscow Tribune*, 19 March 1993, p. 10.
- ¹¹¹ Adams, Jim. "U.S.-Russian Space Engine Makers Sign Deal," *The Moscow Tribune*, 30 October 1992, p. 12.
- ¹¹² Goldman, p. 11.
- ¹¹³ Bohlen, Celestine., "Atomic Transition Ends Security for Russia's Elite," *New York Times*, 11 July 1993, p. 7.
- ¹¹⁴ Helmstadter, p. 60.
- ¹¹⁵ Interview with Yevgeny L. Feinberg, FIAN, on 15 April 1993.
- ¹¹⁶ See Feinberg, pp. 37-38.
- ¹¹⁷ *Ibid.*, p. 37.
- ¹¹⁸ Interview with Yevgeny L. Feinberg, FIAN, on 15 April 1993.
- ¹¹⁹ McDonald, Kim A., p. A38.
- ¹²⁰ "U.S. Offers to Scientists Called 'Stunt,'" *Komsomolskaya Pravda*, 18 February 1992, p. 1, translated in FBIS, 19 February 1992, p. 1.
- ¹²¹ *Poisk*, No. 5 (195), 29 January - 4 February 1993, p. 2.
- ¹²² See for instance the speech by L. V. Keldysh at the "First Conference of Scientists of the Russian Academy of Sciences," held 10-12 December 1991, repored in *Courier RAN*, No. 1, March 1992, p. 11 (in Russian).
- ¹²³ «S nadezhdou ne rastavaites [Don't part with hope],» *Poisk*, No. 5 (195), 29 January - 4 February 1993, p. 3.
- ¹²⁴ *Ibid.*, p. 3.
- ¹²⁵ "Nuclear Scientists Union Issues Statement," TASS, 0300 GMT, 21 March 1992, translated in FBIS, 23 March 1992, p. 4.
- ¹²⁶ "State Fund To Be Created To Finance Science," *Uryadovii Kuryer*, No. 10, (56), March 1992, p. 11, in Ukrainian, translated in FBIS, 25 March 1992, p. 62-3.
- ¹²⁷ "State Fund To Be Created To Finance Science," p. 62.
- ¹²⁸ "Physicians Appeal for Genetic Studies Assistance," Radio Ukraine World Service, 1500 GMT, 25 March 1992, in Ukrainian, translated in FBIS, 27 March 1992, p. 56.
- ¹²⁹ «Ischezaushii unikum» *Moskovskii Novosti*, No. 45-46, 15 November 1992, p. 8.
- ¹³⁰ «Eto sladkoe slovo-dotatsiya [It is a sweet word-subsidy],» p. 4.
- ¹³¹ "Someone is Losing. Who's Gaining?: Russian Academy Institutes sell unique laser technologies for peanuts," *Rossiiskiy Vesti*, printed in *Business World Weekly*, No. 41, 24 November 1992, p. 14.
- ¹³² "Someone is Losing. Who's Gaining?" p. 14.
- ¹³³ McDonald, Kim A. "Russian Science Still Threatened Despite Reforms," *The Chronicle of Higher Education*, 28 April 1993, p. A38.
- ¹³⁴ Leskov, Sergei. «Akademik Abrikosov nakhodit plyusy v . . . «utechke mozgov» na zapad [Academic Abrikosov finds pluses in . . . 'the brain drain' to the West],» *Izvestiya*, No. 83, 5 May 1993, p. 5. When this article was published it created quite an uproar among scientists in Moscow. See also Leskov, Sergei. "America's Soviet Scientists," *New York Times*, 15 July 1993, p. A15.
- ¹³⁵ «Khimicheskoe vooruzhenie prodolzhaetsia! [Chemical weapons continue!],» *Nezavisimaya Gazeta*, 25 October 1992, p. 1; Estrade, Bernard. "Concern Mounts Over Scientist's Detention," *The Moscow Tribune*, 30 October 1992, p. 5; Van der Laan, Nanette. "Scientists: Russia Won't Come Clean," *The Moscow Times*, 4 December 1992, p. 5; Champion, Marc. "Scientist Says Russia 'Dishonest' in Treaty," *The Moscow Times*, 12 January 1993, p. 5.
- ¹³⁶ Van der Laan, p. 5.
- ¹³⁷ Phone conversation with Dr. Andrew Kuchins of the John D. and Catherine T. MacArthur Foundation, 22 February 1994.
- ¹³⁸ "Human Rights Specialist Sees Obstacles," *Interfax*, 1442 GMT, 13 February 1992, in FBIS, 19 February 1992 pp. 2-3.
- ¹³⁹ "Nuclear Expert on Emigration of Arms Specialists," WPROST, 8 March 1992, pp. 38, 39, in Polish, translated in FBIS, 19 March 1992, p. 9.
- ¹⁴⁰ "Nuclear Expert on Emigration of Arms Specialists," p. 9.