ernment funding agency] gives us excellent support in paying the traveling and living expenses," says Fossat. "When one colleague came over recently for a few weeks, he stayed with me so as to save his French living expenses. With that money he could feed the families of the six young people working with him for a year."

Aid is also trickling in from other Western sources. Two years ago, the American Astronomical Society raised $50,000 from its members, which was distributed as $100 grants. "It sounds small," says Stan Woosley of the University of California, Santa Cruz, who helped to organize the grants. "But we were told that it made the difference between people staying in the field and not." The Society is now making a second round of 250 $500 awards, much of the money coming from the International Science Foundation (ISF). The ISF is now on its second round of larger grants and has earmarked around $1 million for astronomy in the former Soviet Union. The European Southern Observatory (ESO), a collaboration of nine European nations which runs a large observatory in Chile, is providing a similar sum in grants.

But some Russian astronomers are adapting to the mood of the times and taking a more entrepreneurial approach to funding. A team led by Viktor Afanasiev, a former director of the SAO, secured a scientific trip for his team to the 4-meter telescope at Kitt Peak in exchange for building a new spectrograph for the instrument. "It was amazing; it worked," says one American astronomer. Other researchers at SAO are trying to raise money by establishing a visiting astronomer's program, whereby foreign astronomers pay $100 a night to observe there, including flights from Moscow. Terry Oswalt from the Florida Institute of Technology was a guinea pig for the program: "It's the darkest site I've ever seen—including Mauna Kea [in Hawaii]."

But astronomy is never going to be a great moneymaker. "Organized visits from foreign scientists work well, but they don't improve things in general," says SAO's Valentin Lipovetsky. Large sums will be needed for state-of-the-art computers and electronic imaging equipment if astronomers in Russia and the other republics are to do any useful science in the future. "The bottom line," says Woosley, "is that eventually the former Soviet Union has to solve its own problems." Russian astronomers can only hope that their strong traditions will help them weather the financial storm. "The next few years will be critical," says Richard West of ESO, "but if the economy stabilizes, then with Russia's long track record of excellence in astronomy, it would be difficult to imagine astronomy disappearing completely."

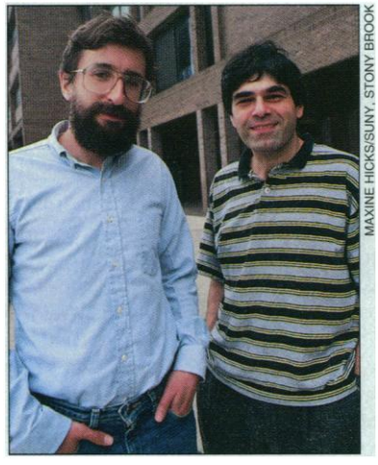
–Nina Hall

Nina Hall is a science writer in London.

MATHEMATICS

A World-Class Community, Scattered Around the World

For several weeks a year, the Euler International Mathematical Institute in St. Petersburg buzzes with the creative energy of top mathematicians from around the world. It's fitting that outstanding mathematical talent should gather in Russia, which has produced some of the twentieth century's finest mathematicians. But the Euler Institute doesn't quite feel...Russian. Perhaps it's the institute's 386-class personal computers, its Finnish heating system, or its swank furniture, fax machines, and laser printers. It's a far cry from the Soviet days, when seminars—the lifeblood of Russian math—were often held in cold, spare apartments.



MAXINE HICKS/SUNY, STONY BROOK

Greener pastures. Leon Takhtajan *(right)* and Vadim Schechtman, both left Russia in 1990 for Stony Brook.

A foreign visitor to the Euler Institute could easily get the impression that mathematics is flourishing in post-Soviet Russia. But nothing is further from the truth. The Euler Institute is something of an anomaly: Established in 1989 by the Soviet Academy of Sciences with international assistance, it is part of an effort to stem the hemorrhage of mathematics talent to the West. Its primary function is to "bring foreign and Russian mathematicians back to Russia" for meetings, seminars, and sabbaticals, says the institute's scientific secretary Anatoly Lanin. The hope is that the visiting scholars will provide an intellectual lifeline to mathematicians remaining in Russia, helping to keep Russian mathematics at the cutting edge. It will be a tough task.

So many top mathematicians have left Russia in the past 5 years that its math communities are eroding like sandcastles at high tide. Many math institutions have been decimated, and a once-formidable math education system is crumbling. "If things continue on the same course, the Russian mathematics tradition will be dead in 10 years," predicts Massachusetts Institute of Technology (MIT)'s Dan Stroock, a probability theorist who traveled to Russia last year with MIT colleague Robert MacPherson to assess how the American Mathematical Society (AMS) might help Russian researchers.

For now, the international mathematics community is hoping that a viable math culture can be sustained in Russia through the current crisis; foreign assistance is playing a key role in supporting mathematicians who remain. And, in the best traditions of Russian survival during hardship, some promising alternative institutions are beginning to take shape.

A mere 5 years ago the Soviet Union could claim a formidable math community. It began to flourish in the 1930s and '40s, when political forces began shaping many other scientific disciplines: Soviet biology, for instance, was warped by Trofim Lysenko's pseudoscience, while physics was swelled by military funding. Mathematics, on the other hand, was for years "ideologically unimportant," says algebraist Alexei Rudakov, a professor at the Independent University of Moscow, and it became a safe harbor for many of the country's finest scientific minds, particularly Jewish researchers.

A strong math education system also played its part. Schools in the Soviet Union had a long tradition of good mathematics instruction, and in the early 1960s, prominent mathematicians pushed through changes designed to encourage math prodigies. They took advantage of a lull in Soviet oppression and anti-Semitic policies—the "Krushchev spring"—to launch new institutions with a math bent, recalls A.B. Sossinsky, a senior researcher at Moscow's Institute of Electronics and Mathematics. In Moscow, for example, mathematicians supercharged four city high schools with enhanced math curricula, and math boarding schools were established in Erevan, Kiev, Leningrad, and Novosibirsk. And just in case promising students were unable to enroll in those math schools, one of Russia's star mathematicians, Israel Gelfand, set up the All-Union Mathematics Correspondence School in 1964 to get high-schoolers doing extracurricular math work.

But this burst of enthusiasm soon ran into a major obstacle: an ideological crackdown in 1968 that resulted in the re-establishment of anti-Semitic policies throughout the Soviet system, says Vladimir Arnold, a prominent mathematician at Moscow's Steklov

Institute. Because disproportionate numbers of Jews had been drawn into math, the crackdown hit the discipline particularly hard, says algebraist Sergei Gelfand, Israel Gelfand's son. The famed Department of Mechanics and Mathematics at Moscow State University (known as Mech-Mat) stopped offering faculty positions to highly qualified Jewish mathematicians after 1968. "Jews were not allowed to get teaching jobs," recalls Vadim Schechtman, a mathematical physicist who in 1990 left the Institute of Microelectronics and High-Purity Materials near Moscow to join the State University of New York at Stony Brook. The Steklov Institute—the main math center in Moscow run by the Russian Academy of Sciences—has offered only one position to a Jewish mathematician in the last 25 years.

Ironically, the oppressive policies of the 1970s and early 1980s did have an up-side: Restrictions on travel kept the math community together. Jews in particular were barred from attending conferences abroad, and for years emigration was nearly impossible—"a math capability that was artificially sustained," says mathematical physicist Leon Takhtajan, who left Russia in 1990 to join Stony Brook. No wonder that mathematicians young and old began heading West in droves after Mikhail Gorbachev raised the Iron Curtain. Of the top 200 mathematicians in Moscow 5 years ago, at least half are now abroad, estimates mathematical physicist Sergei Novikov, president of the Moscow Mathematical Society. "Certainly there is a general feeling that there's no chance to do mathematics in Russia—you don't have enough resources to survive," says another Stony Brook expatriate, Mikhail Lubich, a specialist in dynamic systems who left St. Petersburg's Arctic and Antarctic Research Institute in 1990. Adds Schechtman, "It's hard to work if you can't eat."

The challenges of subsisting in Russia have had an unfortunate impact on the intellectual life of those who have chosen to stay. "All major seminars have stopped," says representation theorist Alexander Kirillov, a highly respected professor at Moscow State University who has spent the last four spring semesters in the United States. Kirillov himself is considering offers from two American universities and is likely to move permanently to the United States this fall.

Many of those leaving Russia, including Kirillov, say one of their biggest concerns is where the next generation of Russian mathematicians will come from. Some students and postdocs have left the field to go into business, says Novikov, and many others are pursuing math "only because they know it's easy to go to graduate school in the United States," he says.

Indeed, preserving the math pipeline tops the agenda for many mathematicians who remain in Russia. For some, this has meant circumventing the crumbling Soviet system to create completely new institutions. One of these is Moscow's Independent University, whose math department admitted its first students in fall 1991. Independent University has no campus—classes meet in a high school during the evening—and scant money, so teachers must donate their time. But the privations haven't discouraged good students. After teaching an algebra class at Independent in February 1992, MacPherson says, "I would wager that never has a mathematics department been created with so much faculty and student talent."

ZAMIR USMANOV/AGENCE FRANCE PRESSE

Math magnet. The Euler Institute hopes to attract overseas researcher for seminars and sabbaticals.

Last fall, Independent added a graduate school, says Rudakov, that now has eight math grad students. But at Independent too, some students are using math as a gateway to the West. "We have not reached the point where all young people want to leave no matter what," Rudakov says. "We're still at the point where it's half and half." In fact, while many of the major seminars or study groups ended with the departure of the masters who led them, some younger mathematicians are starting new seminars that are garnering international attention. "Some of these are the most exciting in the world so far as their mathematical content and level is concerned," MacPherson says.

To inspire young mathematicians, of course, older, accomplished mentors are needed. It is here that foreign organizations are playing a big role in trying to make life as hospitable as possible for mathematicians so they'll stay put. The AMS has raised $700,000 from its members, the National Science Foundation, the Sloan Foundation, and the Soros Humanitarian Fund to aid math throughout the former Soviet Union. Some of the money goes to help Moscow's Independent University as well as Russian math high schools. The organization's primary program, however, is to provide subsistence grants—$40 per month for graduate students and $80 per month for Ph.D.s—for up to 3 years to mathematicians selected in a peer-reviewed competition. So far, of 5000 former Soviet mathematicians in the AMS database, 374 have received grants. "The main idea is not to help special individuals, but to preserve the possibility of doing mathematics in Russia," says Sergei Gelfand, who's assisting the AMS aid program. In addition, 125 of the long-term research grants—averaging $10,000 each—from George Soros' International Science Foundation have gone to mathematicians.

Then there's the Euler Institute. It was established just as travel restrictions were being lifted, when Russian mathematicians foresaw the impending exodus. In outfitting the institute, the Russian Academy of Sciences got plenty of international help: The Japanese Mathematical Society donated a minibus and a car, German mathematicians chipped in for furniture, and UNESCO footed the bill for photocopiers. The result is the very model of a modern major math institute. The international seminars it hosts are said to be first-rate, but when the visiting scholars depart, its halls are almost empty. "There's not much feeling of mathematical activity in the building," MacPherson says. "For now it has not achieved its goal," adds one Russian expatriate. Still, many mathematicians see the possibility that the Euler Institute may someday play a dominant role in mathematics. "I certainly would want to go to [the Euler Institute]," says Peter Lax, a specialist in differential equations at New York University's Courant Institute. "Unless everything collapses, I think it will become one of the world's top institutes," Lax says.

While collapse may not be imminent, Russian mathematics is certainly evolving: Just as the Steklov Institute and Mech-Mat are yielding gradually to the Euler Institute and Independent University, some of the country's top mathematicians are trying to straddle both worlds by dividing their time in Russia and abroad. One of these is Alexander Beilinson, a prominent algebraic theoretician who shuttles between MIT and the Landau Institute of Theoretical Physics. Beilinson says that "any mathematician who comes to Russia and gives a series of good lectures will do a great service."

"It was a difficult decision for many mathematicians to emigrate," says Sergei Gelfand, who came to the United States in 1990 but still maintains ties with the Institute for Problems of Information Transmission in Moscow. "There's a group of mathematicians who have emigrated who are looking back, who believe in the future of Russian mathematics," he says. And many of them are keeping the option of returning open. "I haven't done anything to prevent me from returning," says one.

–Richard Stone

With reporting by Daniel Clery in St. Petersburg.