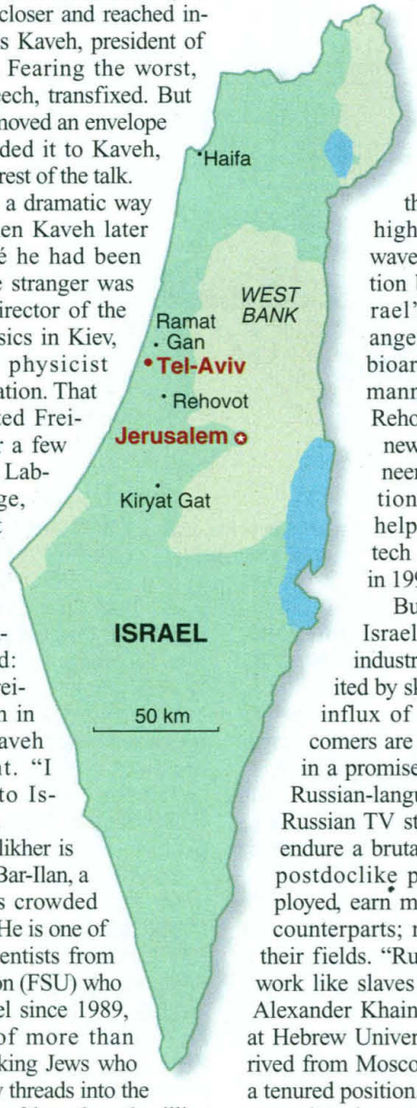
Ten years after Jews began arriving in droves from the former Soviet Union, newcomer researchers are transforming Israeli academia and turning the country into a high-tech heavyweight

Israel Hits Rich Seam in Ex-Soviet Immigrants

RAMAT GAN—In the middle of delivering a lecture to several hundred physicists in London in 1994, Moshe Kaveh spotted a stranger striding purposefully toward him down the center aisle with an intense look in his eyes. "He came closer and closer and reached inside his jacket," recalls Kaveh, president of Bar-Ilan University. Fearing the worst, Kaveh paused his speech, transfixed. But the stranger simply removed an envelope from his pocket, handed it to Kaveh, and took a seat for the rest of the talk.

It turned out to be a dramatic way to ask for a job: When Kaveh later looked at the résumé he had been given, he realized the stranger was Valentin Freilikher, director of the Institute of Radiophysics in Kiev, Ukraine—a fellow physicist Kaveh knew by reputation. That evening, Kaveh invited Freilikher to join him for a few days at the Cavendish Laboratory in Cambridge, learning later that Freilikher had trouble scraping together the fare for the short train ride. Fortunately, he succeeded: After talking with Freilikher and seeing him in action in the lab, Kaveh recognized a talent. "I want you to come to Israel," Kaveh told him.

Five years on, Freilikher is a tenured professor at Bar-Ilan, a tranquil haven in this crowded town outside Tel Aviv. He is one of more than 13,000 scientists from the former Soviet Union (FSU) who have surged into Israel since 1989, part of an exodus of more than 900,000 Russian-speaking Jews who are weaving many new threads into the fabric of this country of less than 6 million people. Bar-Ilan has welcomed the new blood. Known more for Judaism studies than for science, the university has recruited about 100 top "newcomer" scientists, setting many of them up in a gleaming new laboratory facility on campus. "For the price of a plane ticket, we are getting professors who would have cost us $1 million to bring to their present level of knowledge" if they had been trained in Israel, says Absorption Minister Yuli Edelstein, whose ministry spent $30 million last year on stipends and other support for immigrant scientists.



Even more stunning is the rapid growth of Israel's high-tech industry since the wave of post-Soviet immigration began. "In the 1970s, Israel's major export was oranges," says Steve Weiner, a bioarchaeologist at the Weizmann Institute of Science in Rehovot. Now, with the help of newcomer scientists and engineers, computer and information technology firms have helped double Israel's high-tech exports from $4.5 billion in 1990 to $9 billion last year.

But there is a darker side to Israel's transformation: While industry and academe have profited by skimming the cream off the influx of immigrants, many newcomers are struggling to find a niche in a promised land that now offers 50 Russian-language newspapers and two Russian TV stations. Most new arrivals endure a brutal competition for tenuous postdoclike positions and, once employed, earn much less than their Israeli counterparts; many fail to find jobs in their fields. "Russian immigrants have to work like slaves late into the night," says Alexander Khain, a tropical meteorologist at Hebrew University in Jerusalem who arrived from Moscow in 1991 and now holds a tenured position. Israelis acknowledge that some immigrants are falling through the cracks. "Statistically, I think we are doing fine" in absorbing newcomers, says Tel Aviv University (TAU) chemist Eliezer Gileadi, architect of a key program for employing immigrant scientists. "The trouble is, people are not statistics. Either you have a job as a scientist or you don't."

Despite the hardships in their adopted country, émigrés say they have no desire to return to Russia or other former Soviet countries, where life for researchers grows harder by the day and anti-Semitism is making a comeback. And although some Israelis resent paying higher taxes to support immigrant welfare programs, they do enjoy the benefits of the economic boom fueled by the highly educated newcomers. Post-Soviet immigration is "the best thing that's happened to our country in the last 25 years," says Weizmann president Haim Harari. And it could get even better. "We have a generation that is getting the best of both systems," Harari says, referring to young émigrés who studied in Russia's superb high schools and now, in Israel, are learning Hebrew, serving in the army, and attending university. "The next decade will bring a fantastic wave of successes," he predicts. "This is a whole new story beginning to unfold."

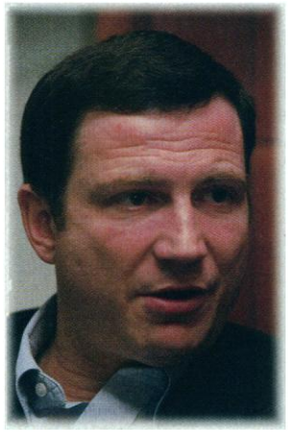
Stateless scientists

Israeli science began just 75 years ago, in 1924, when the Jewish community in British-ruled Palestine established the Technion-Israel Institute of Technology in Haifa, a university now recognized as Israel's Massachusetts Institute of Technology. Two other institutions—Hebrew University and the Daniel Sieff Research Institute, later renamed after Israel's first president, chemist Chaim Weizmann (see sidebar on p. 896)—were founded before the state of Israel was created in 1948. During the next 25 years, Israelis fought three wars with their Arab neighbors and eked out a meager existence in a land that was mostly desert, with scant natural resources. Consequently, the country's two main scientific priorities were defense and agricultural research. Foreign aid, mainly from the United States, kept basic science afloat until 1972, when the government established the Israeli Science Foundation and set up an independent council to oversee the universities.

By definition a land of immigrants, Israeli science got its first big injection of Russian blood in 1973, when Soviet authorities

opened the door a crack for Jews to leave; about 150,000 came to Israel in the 1970s. But the Soviets did not make it easy: Jews first had to declare their intent to emigrate, a wrenching action that often turned them into pariahs. "It was a scandal when I applied to leave for Israel" in 1975, recalls Edward Trifonov, then a biophysicist at the prestigious Kurchatov Institute in Moscow, whose father and adopted father had been prisoners in Stalin's *gulags*. In retaliation for applying for an exit visa, Trifonov says, at a public meeting trade union officials "accused me of concealing my ethnicity for career purposes." Trifonov spent the next year as a *refusnik*, locked out of his lab and waiting for an exit visa. He finally emigrated to Israel in 1976 and landed a professorship at the Weizmann Institute, where he is now one of about a dozen former Soviet professors.

Trifonov was one of the lucky ones. Mathematician Victor Brailovsky applied for his visa in 1972, then spent the next 15 years as a *refusnik*, including a year in prison in Moscow and 4 years in internal exile in Kazakhstan. He and physicist Natan Sharansky—now Israel's minister of industry and trade—became causes célèbres among their Western colleagues. Among their vocal supporters were TAU president Yuval Ne'eman, a theoretical physicist, and TAU mathematicians Dan Amir and Vitali Milman, who petitioned Soviet authorities to release *refusniks* and helped newcomers find jobs in Israel. "Milman is an avid collector and connoisseur of fine art, and no doubt he used the same impeccable judgment in bringing together the first-class mathematicians of our school," says TAU's Leonid Polterovich. TAU awarded Brailovsky an honorary doctorate and kept a vacant faculty position waiting for him, but it wasn't until 1987, the era of Mikhail Gorbachev's *glasnost*, that Brailovsky was released. He now teaches at TAU.



CREDITS: (TOP TO BOTTOM) MUTSUMI STONE; SHARON ABBADY/BLACK STAR

The dam breaks

The year Brailovsky finally got his visa, the Israeli Academy of Sciences and Humanities made a bold prediction to then–Prime Minister Shimon Peres: With the Cold War thawing, Israel could expect 500,000 Jews to emigrate from Russia. "People at the time thought it was crazy," says academy director Meir Zadok. In a paper suggesting how to respond to the deluge, the academy pointed out that headhunters from many countries—including Israel's enemies—would be going after talented researchers. "We thought we should be a part of this," says Zadok. "We wanted to ensure that first-class scientists would not be neglected."

Two years later, the academy was proved right when the trickle of immigrants became a torrent with the arrival of 24,000 Jews, mostly from the Soviet Union. The following year, 1990, saw almost 200,000 newcomers, pouring in at a rate of more than 500 a day. The timing was not propitious: Israel's economy was mired in recession, with unemployment running at about 9%. "We were flooded by immigrants at a time of economic crisis," says Joseph van Zwaren de Zwarenstein, director of exact sciences at the Ministry of Science. For the most part, Israelis were unprepared for the onslaught. "Many Russian scientists were hoping that after all their suffering, they would be treated like heroes," says van Zwaren. "Unfortunately, that was not the case."

"It was more difficult to convince [Israelis to accept the Russians] than it was to convince the scientists to come."

—Moshe Kaveh

Israelis, in fact, were increasingly distracted by events elsewhere. Iraq invaded Kuwait in August 1990, near the height of the immigration. "We were given gas masks at the airport," remembers Elena Litsyn, an expert on differential equations from Perm, Russia. And in an ironic twist of fate, a week after arriving in Israel, Yuri Feldman—trained to fire scud missiles in the Russian army—watched from his new home as Iraqi scuds fell on nearby Tel Aviv. "I decided it was better to move and took my family to Jerusalem," says Feldman, who within days had landed a position at Hebrew University.

Most newcomers were not so fortunate. "Some had been in *gulags* for years, not reading the literature," says molecular biologist Etana Padan, who heads the immigrant absorption program at Hebrew University. Many émigré scientists were in their 40s or older, she says, and could not compete for entry-level jobs with Israeli postdocs in their 30s. At the height of the deluge, newspapers and TV shows ran poignant stories of immigrant scientists sweeping streets or waiting tables. In some cases, the newcomers had skills for which Israel had little need. "Some were mine engineers. But we don't have any mines; what were we going to do with them?" says Science Minister Silvan Shalom.

Others, however, simply could not deal with the combined stress of adapting to Israel—having to learn Hebrew, for instance—and adapting to Western science. "Many of the scientists who came here were under the impression that they could just sit back and some talent hunter from General Motors or wherever would say, 'Here's a check for $10 million, just give me that invention of yours,' " says Edelstein. "For some strange reason it didn't happen."

"For the price of a plane ticket, we are getting professors who would have cost us $1 million to bring to their present level of knowledge."

—Yuli Edelstein

Edelstein's ministry has tried to help. It put together a raft of programs to keep immigrants above water, from the Shapiro fund, which pays scientists a subsistence wage to get them into labs at no expense to their hosts, to Kamea, a highly competitive program that funds permanent positions as research associates. Unrest among the ex-Soviet researchers, however, spawned the Immigrant Scientists Association of Israel, which claims to represent more than 100,000 scientists and engineers. It has lobbied hard for the creation of new programs and for pay increases in existing ones, winning modest concessions. But many newcomers say they are far from satis-

In the R&D Sweepstakes, the Lure of a Quick Shekel Prevails

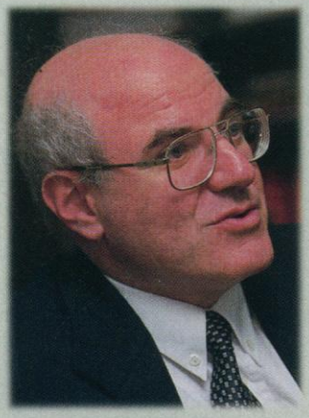
JERUSALEM—The science adviser to the prime minister can't exactly claim a choice spot along Israel's corridors of power: Molecular biologist Israel Hanukoglu's cramped office sits at the far end of the building from where Prime Minister Benjamin Netanyahu holds court. The physical distance roughly sums up the clout Hanukoglu has had with the embattled prime minister, who is fighting for his job in elections to be held on 17 May.

But that hasn't stopped the soft-spoken Hanukoglu from arguing for a change of emphasis in Israeli science policy during his 18-month tenure as the country's first science adviser. He says the government's love affair with high-technology—stoked by the recent influx of thousands of skilled former Soviet scientists (see main text)—could imperil the country's basic research. "With all the rush toward technological development, we may be ignoring the need to strengthen the basic sciences," he says. Last fall Hanukoglu wrote a position paper calling for the government to double the modest $30 million budget of the Israeli Science Foundation (ISF), the country's main granting body. But so far, the plea has fallen on deaf ears. "Israel's strength is applied research," Netanyahu told *Science*. "The country is too small [to devote more resources to] basic research."

Size matters. Netanyahu says Israel is too small to spend more on basic research.

Many Israeli scientists share Hanukoglu's concern, arguing that conditions are deteriorating for cash-strapped basic researchers. But the impending election isn't likely to change things, no matter who wins. "Since science enjoys across-the-board support among the parties, it is in a way taken for granted," says Hanukoglu. Any shift in priority, he and others say, will have to come from steady grassroots pressure.

The Israeli government has always treated applied research as the favorite child, pouring most of its scant resources for science into defense and agricultural research. Haifa's Technion-Israel Institute of Technology and the Weizmann Institute in Rehovot (see sidebar on p. 896) managed to build strong research programs, in large measure thanks to donations from Jews abroad. But as the country grew wealthier, Israeli scientists agitated for more money for basic research. In response, the government set up the ISF in 1972. Since then, Israel, despite its small size, has grown into a major player on the world science stage: According to an analysis in *Science* (7 February 1997, p. 793), Israel ranks second behind Switzerland in papers per capita and third behind Switzerland and Sweden in citations per capita. The analysis also showed that Israel leads the world in the citation impact of its computer science papers.



Back to basics. Science adviser Hanukoglu wants more dollars for basic research.

In the past several years, however, "the pendulum has shifted from basic to applied research," says Meir Zadok, director of the Israeli Academy of Sciences and Humanities. The key factor is the government's decision to steer most former Soviet immigrant scientists into industry. The Ministry of Industry and Trade (MIT) established a series of technology incubators for turning raw ideas from former Soviet scientists into marketable inventions. Today, MIT spends about $500 million—16 times the ISF's budget—on incubators and other programs.

As MIT's R&D spending waxes, the Science Ministry's wanes. Its budget has shrunk from $60 million in 1995 to $50 million this year, amounting to about 8% of the share of civilian R&D. "This is one of the weakest ministries in the government," grumbles ministry comptroller Emanuel Mudrik, who says the ministry is taking steps to increase its share to 18% by 2005, mainly through the establishment of what it calls "mini–national laboratories" for strategic research in biotech, next-generation Internet, and other areas.

Partly accountable for the ministry's fading power is a revolving door at the top: There have been 11 science ministers in 16 years, many of whom have had their eye on other portfolios. And as Netanyahu has promised a cabinet shake-up if reelected, Silvan Shalom, the lawyer who has held the science minister post for 8 months, doesn't expect to be at the helm much longer. His most notable legacy—a program he launched called Flowers in the Desert—has won him few friends among scientists, with its aim, in Shalom's words, "to bring science to the community." The program funds research on such topics as the sociology of Bedouin life, and it sponsors efforts to acquaint disadvantaged youth with universities. However, scientists do credit Shalom with raising the profile of the government ministries' chief scientists, who under Shalom have become the main force for setting science policy.

With Hanukoglu planning to return full time to his lab at the College of Judea and Samaria in the West Bank town of Ariel after the elections, basic researchers will lose a valuable ally in their fight for funding—and it's unclear whether Israel's prime minister after the elections will appoint a successor. "We still have major difficulties to raise the kind of money that a U.S. lab does," says Weizmann molecular biologist Benny Geiger. ISF grants average about $40,000 a year. "After deduction of overhead, this sum is barely enough to maintain a lab with a single research worker," says Hanukoglu, who studies mitochondrial genes involved in steroid hormone synthesis. There are other funding sources: Israelis can apply for European Union research program money or to bilateral research funds co-sponsored by countries such as the United States and Germany.

To give Israeli researchers a stronger voice in policy-making, Hanukoglu last year played a key role in establishing a permanent Science and Technology committee of the Knesset to discuss legislation and oversee government agencies involved in science. It will also be a target for lobbying—and Hanukoglu intends to use it to fight for basic biomedical research after he leaves the government. The way U.S. researchers lobby legislators on Capitol Hill, Hanukoglu says, "should set an example for us." **–R.S.**

CREDITS: (TOP TO BOTTOM) MUTSUMI STONE; SHARON ABBADY/BLACK STAR

fied with the status quo. "People in most of these programs receive no tenure. They are like marionettes—cut the strings and they fall," says association vice president Oleg Figovsky, R&D manager of Polymate Ltd., a research shop outside Haifa.

Newcomers say they feel intense pressures to compete for research appointments and to hold onto them. "During my first year in Israel, I slept only 4 hours a night and produced 25 papers," says Isak Beilis, a physicist from Moscow who now has a stable position at TAU. Adds Tel Aviv colleague Emil Ginsburg, a biologist from Novosibirsk, "I know a lot of people who are very productive—and are living cadavers." Many newcomers can endure this lab rat life—for which they receive on average about 40% of the salary of an Israeli scientist—for only so long before trying their luck in other countries. "The tragedy of Israeli science," says Trifonov, "is that plenty of good scientists had to leave."

Israeli officials confirm that for the newcomers, winning a permanent position in academia is a harsh lesson in survival of the fittest. "At many universities people were just used for 3 years, then they were told, 'You're a great guy, but we don't have money,' " says Edelstein. According to TAU's Touvia Miloh, associate dean of the engineering faculty, "only the very, very best survive."

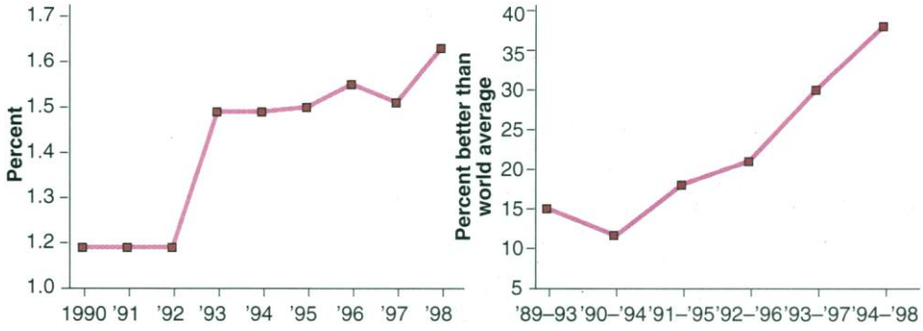
Carpe immigrantes

Despite the fact that more than 5300 scientists had registered with the Ministry of Absorption by the end of 1991, some Israelis took a more active approach to recruitment. Moshe Kaveh, for example, had strong links with many Jewish research heavyweights still in Russia and wanted to bring them out. In 1992 he approached Ne'eman, then the science minister, and asked for financial help to import 100 Russian scientists to Bar-Ilan, a university that, he says, "was basically established by immigrants." He argued that because Israel invests about $1 million in training each homegrown scientist, bringing 100 Russians amounted to "a gift of $100 million." Ne'eman agreed with the rationale but said the government couldn't afford to add 100 faculty to Bar-Ilan's payroll.

Nevertheless, Kaveh pushed ahead with his plan, in the process becoming dean of natural sciences, then university president. The biggest challenge was to find the millions of dollars needed to provide equipment and salary for the newcomers, but he also faced opposition from some of his colleagues. "It was more difficult to convince others at Bar-Ilan [to accept the Russians] than it was to convince the scientists to come," he says. "Israelis felt pushed aside a little bit." Nevertheless, Kaveh wasted no time bringing in a few dozen Russians, even before he had secured money for lab equipment or a building to house them. "It was a dangerous gamble," he says. The gamble paid off after a visit to philanthropist Pearl Resnick, a longtime donor to Israeli causes who was born in Okna, Russia, and now lives in New York. "I told Pearl this was a very unusual opportunity to bring to Israel our brothers and sisters, Jewish scientists of top caliber." She agreed and gave what one source calls "a few million dollars" for a new facility, the Jack and Pearl Resnick Institute for Advanced Technology, which opened in 1997.

House of Resnick. U.S. dollars helped build home for Russians at Bar-Ilan.

Another institution that kick-started its research effort with ex-Soviet brainpower is the College of Judea and Samaria (CJS) in Ariel. Opened in 1983, CJS is one of several colleges established by the Israeli government to widen access to higher education. Situated in the West Bank, the college stumbled a bit when it started reeling in Russians in 1991. "In the beginning, we were not mature enough to judge the capabilities of newcomers," says CJS executive committee chair Yigal Cohen-Orgad, who adds that the college didn't renew the contracts of several early arrivals. CJS soon brought in outside experts to vet potential faculty members and set a quality standard: "Those good enough to get external grants and teach in Hebrew will stay with us," says Cohen-Orgad, who foresees a big need for staff as the college grows from 2500 students today to a planned 7500 in 2005.



Post–Cold War dividend? During the 1990s, Israeli scientists have captured a growing percentage of the world's physics papers *(left)*, and their papers are getting cited more frequently than the world average.

CJS's policy is beginning to bear fruit. Russian specialists in functional differential equations have established at Ariel the country's first center devoted to the topic. The university also scored a success in recruiting Michael Tseitlin, a specialist in petrodite crystals for solid-state lasers, who arrived in 1991 from Dushanbe, Tadjikistan. Tseitlin started out at CJS growing crystals in an improvised oven made from a samovar. From this modest setup, he developed methods for cheaply churning out high-quality crystals. Investors last year sank $1 million into a factory to mass-produce the crystals.

Indeed, although academia has captured dozens of newcomers, the real winner has been Israel's high-tech industry. Edelstein makes no bones about his ministry's effort to pump up the country's 1800-odd technology firms. "We are trying to push as many [immigrants] as possible into the private sector," Edelstein says. Feldman says he has noticed the change at Intel's research center in Kiryat Gat: "When I visited in 1991, people spoke English. Now they all speak Russian."

This push toward industry was a necessity: In the early 1990s, many more scientists and engineers came to Israel than could ever be absorbed by academia. "We had only so many places in universities, so we set out to identify weak links in the technology development chain," says Rina Pridor, a lawyer who joined the Ministry of Industry and Trade in early 1991 to devise a program. The ministry funded the establishment of a dozen technology "incubators" across the country. These were places that any scientist could go to pitch ideas. If given the go-ahead, the scientist would get lab space, funds for a small staff and supplies, and 2 years to turn the concept

CREDITS: (TOP) INSTITUTE FOR SCIENTIFIC INFORMATION; (BOTTOM) MUTSUMI STONE

Science Stronghold Seeks the Big Prize

REHOVOT—The Weizmann Institute, an intellectual oasis in the desert south of Tel Aviv, is the very picture of a modern-day ivory tower: a quaint building housing the restored lab of the institute's founder, a futuristic 10-story particle accelerator tower, and glistening new facilities, all set among trees and luxuriant gardens. But as a research powerhouse, and perhaps Israel's best known scientific institution, the Weizmann has its own idiosyncratic way of doing science. Although the institute has 750 grad students, it is not a university, so "we have no obligation to cover every niche or field," says Weizmann President Haim Harari. In fact, the institute picks and chooses carefully, building expertise in a particular area before moving on to something else. "We don't have to be democratic," says Harari, whose 400 Ph.D. scientists include 14 professors in neurobiology but none in zoology.

Keeping a tight focus has paid off: Weizmann scientists claim honors ranging from the discovery of the *p53* cancer gene to the development of new encryption techniques. Former Soviet mathematicians, especially, have had "a profound effect" on the institute, says biochemist Maxine Singer, president of the Carnegie Institution in Washington, D.C., and a member of Weizmann's board of governors. Outside reviewers, she says, cite the computer science group as "one of the strongest in the world."

Thinking big. The Weizmann took root from the modest Sieff Institute.

But the Weizmann has even higher ambitions. Last November it launched a campaign to raise its endowment from $230 million to $500 million by the end of 2001. The institute's strategy is to forge strongholds in a few key disciplines, with the hope of one day capturing a trophy that has so far never been awarded to an Israeli: a Nobel Prize or a Fields medal. "There is a dilemma here," says Harari. "We have not succeeded in creating enough centers of truly high quality in a specific field or a specific place."

The Weizmann was founded in 1934 by an English couple, Rebecca and Israel Sieff, who named it in memory of their son, Daniel. But it did not have an easy early life. Founder Chaim Weizmann and the team of 10 scientists that made up the Daniel Sieff Research Institute, working in bacteriology, pharmacology, and agricultural science, were soon carrying out secret weapons research for the Haganah, the Jewish underground movement opposed to British rule. Weizmann directed the institute for 18 years, even during his tenure as Israel's first president. With the young state fighting for its life, Weizmann, a gritty fighter and shrewd diplomat, came under fire for having the temerity to spend some of his country's scarce resources nurturing his beloved institute, which was renamed after him in 1949, 3 years before he died.

In the late 1960s, with the security situation appearing more stable, Israel drew in more and more immigrants and the Weizmann began luring top-notch scientists from abroad. The institute set out to give a handful of disciplines the funds needed to compete internationally. In the 1980s it was the turn of heavy-ion research, then over the past decade Weizmann established a solar-energy research facility and a submicrometer materials science lab. Each center, Harari says, costs about $20 million up front and $2 million a year to run, a substantial chunk of the institute's $170 million annual budget. The latest pricey field that Weizmann is paying into is biological physics, to the tune of $10 million over 5 years. And next year it plans a major initiative on the genetics of cancer. "The flexibility to move in such directions counteracts the fact that it is a small institution," says Singer. This approach, however, has alienated researchers who don't fit the mold. "Some of the best scientists got ditched and later formed outstanding laboratories in other universities," says one prominent Israeli researcher.

Although the institute draws half its revenue from the state, it relies heavily on the generosity of Israel's philanthropists and Jewish patrons overseas. Fund-raising offices in 21 countries pulled in about $30 million last year, including the funds necessary to open an outdoor, hands-on science museum last month. At Weizmann, almost any building, lab, or stick of furniture can have a donor's name slapped onto it, for a price. Consider, for example, the Rosalind and Joseph Gurwin Laboratory for Vacuum Processing of the Joseph H. and Belle R. Braun Center for Submicron Research. According to one institute staffer, Weizmann officials one day asked a donor for money to renovate a building named after him. The donor refused, and the name came off.

Researchers cite some drawbacks of working at Weizmann, including the physical isolation of working in the Middle East and the struggle to attract talented students. Teaching, however, is voluntary. Being able to totally immerse oneself in research, says adhesion protein expert Benny Geiger, "makes Weizmann quite special." **–R.S.**

into a patent-protected, marketable proposal to industry. The funding package, Pridor acknowledges, is modest: Each project gets $300,000 from the ministry and must find a mandatory $50,000 from an outside investor. Industry savants viewed the program with distaste. "Investors wouldn't even talk to us a few years ago," says Pridor, and charged the ministry with setting up a welfare program.

The program encountered hard going at first: Newcomer scientists were skeptical about revealing details of their ideas. "They were afraid someone would steal their baby," Pridor says. And Russian scientists in particular had no clue how to run a company and how to divvy up equity. Incubator facilities tend to be modest: The Gat High Tech Center in Kiryat Gat, which specializes in intelligent highway projects, operates out of a nondescript concrete shed. "We draw a very low salary," says Amos Shaham, general manager of Road Safety Technologies Ltd., a start-up that is designing magnetic strips that can be embedded in roads and scanned by sensors under a car's bumper to warn drivers of intersections or dangerous curves.

The big test comes after the 2-year incubation, when the inventors have to make it in the real world. By the end of last year, Pridor says, half the companies that graduated from incubators were still alive, having accumulated in total more than $200 million in private investment. The incubator program "has been quite effective," says biochemist Maxine Singer, president of the Carnegie Institution in Washington, D.C. In the early 1990s, she points out, "people thought there

CREDIT: MUTSUMI STONE

wouldn't be any jobs for the Russian scientists." Success has expanded the program, which now supports 26 incubators nationwide and has funded 400 projects, about 200 of which are still in operation. All told, the heavy thrust into technology has paid off. "We're talking about billions of shekels contributed to the Israeli economy," says Edelstein.

Haim Harari. The real impact of the Soviet newcomers will come in the next generation.

Deep impact?

While Israeli science and industry are still riding this wave of new brainpower, some are beginning to consider the long-term impact of the newcomers. They have not stimulated all fields of science equally. "You don't need to do any survey to know we received, in general, very high-quality mathematicians," but newcomers have had "almost zero impact in biology," says Harari. Part of the reason for this discrepancy stems from Russia's traditional strength in the physical and theoretical sciences. Thanks to the Soviet influx, claims TAU's Amir, "Israel is now considered a superpower in mathematics." Sergei Gelfand of the American Mathematical Society agrees: The country's strong math community, he says, "is an achievement of Israeli immigration policy and practice."

Citation analysis suggests that the newcomers have lifted the overall standing of Israeli science. Over the last decade, Israeli physicists have captured a rising share of total papers published in the world's major journals, and citations per publication have been climbing, according to data compiled by the Institute for Scientific Information in Philadelphia. No clear trend could be discerned in math, although mathematicians generally take longer to publish their results and produce fewer papers on average than their colleagues in physics. "The beginning of this global influence we are starting to see only now," says Edelstein.

The new immigrants—perhaps not surprisingly—have also strengthened the country's scientific ties with colleagues in former Soviet countries. For example, the Weizmann Institute and the Landau Institute outside Moscow have established a Joint Center for Theoretical Physics on the Weizmann campus, and the prime minister's office has just established at Hebrew University a Center for Academic Ties between Israeli scientists and their counterparts in the FSU and the Baltics. In addition, Moscow space scientists last year helped a team of researchers at the Technion—14 out of 20 of whom are newcomers—locate a satellite after the Israelis had received incorrect tracking information from the United States.

In the long term, however, the jury is still out on the extent to which the Soviet immigrants will reshape Israeli science. Some newcomers stay in Israel only briefly before taking jobs abroad. "Many high-level scientists have left—here and there you find real losses," says mechanical engineer Avraham Shitzer, vice provost for research at the Technion, which has retained about 190 newcomers. But, says Harari, it's too early to say what kind of scientific talent will emerge from the students who studied science in Russian schools and are now being integrated into Israeli society. Government figures show that a third of all immigrants in the university system between 1989 and 1995 majored in mathematics and natural sciences, three times the proportion among all Israeli university students. "When you come as a 17-year-old," he says, "it's not as bad as coming as a 30-year-old who has to work as a janitor before finding a job."

"In Israel we have a philosophy that each family needs to raise a son, plant a tree, and have a house," says TAU geneticist Ben-David Yair, who came to Israel in 1973 and changed his name from Evgeny Kobylyansky to protect his family back in Moscow. "I would like to add one principle: We must also accept a new immigrant." For the most part, that philosophy seems to have taken root. "Step by step, Russian immigrants become a very important part of scientific directions, and they stop being slaves and begin to be colleagues," says Hebrew University's Khain. Adds Zadok of the Israeli Academy of Sciences, "You don't see any Ph.D.s sweeping the streets today."

—RICHARD STONE

CREDITS: (TOP TO BOTTOM) MUTSUMI STONE; (BOTTOM) WILHELMUS DEGROOT/JOHN H. GLENN RESEARCH CENTER AT LEWIS FIELD

TECHNOLOGY

Shoebox-Sized Space Probes Take to Orbit

Technological finesse and the search for cost savings are spawning a new generation of "nanosatellites," weighing only a kilogram or so

Peter Panetta is fond of passing around a model of a satellite he's designing. That's not unusual for a NASA engineer, but what is surprising is that the model, roughly the size of a hatbox, is a full-scale spacecraft mock-up.

The cylindrical prototype, 30 centimeters in diameter and 10 centimeters tall, represents a conceptual design for the first of NASA's nanosatellites—spacecraft with total launch masses of between 1 and 10 kilograms, or a mere one-thousandth the mass of a conventional satellite. A hundred or more of these tiny spacecraft, at a cost of half a million dollars apiece, will swarm through the magnetic fields and trapped particles near Earth during NASA's Magnetospheric Constellation (MC) mission, planned for 2007. Other NASA nanosatellites may soon hitchhike to Mercury on a macrosatellite, carry crystal-growth experiments in low Earth orbits, or fly in formation to study Earth's atmosphere from above.

These pint-sized satellites are the offspring of two converging trends: NASA's effort to develop faster and cheaper alternatives to the billion-dollar space science missions of the 1970s and '80s, and the promise of microelectronics and microfabrication for shrinking spacecraft parts, including sensors, power supplies, and even thrusters. The first nanosatellite has not yet flown, but NASA managers are confident that within 5 years, the technologies will be

Mighty mites. Tiny thrusters carved from silicon.