pital in Memphis, Tennessee, dismisses her doubts, however: "We don't have any evidence whatsoever that [killer] T cells can stimulate each other."

The Emory team also showed that, far from being nonfunctional look-alikes, the long-lived memory T cells were in a "ready-to-hit" mode. When he and his colleagues restimulated the cells with viral antigens in a petri dish, they churned out the immune messenger interferon γ, an early step in the immune response, just as fast as their counterparts from MHC-bearing recipients.

The memory T cells also seemed to renew themselves continually, as more than 20% divided within a 1-week period in both MHC class I–positive and deficient mice. "That tells us that unlike naïve T cells, memory T cells have developed a new way of proliferation that is independent of either antigen or MHC," says Ahmed.

Swain's team studied another kind of immunologic memory, that of T helper cells, so-called because they help jump-start other immune cells, including the antibody-producing B cells. Working with a genetically modified mouse strain in which almost all T cells were specific for the same antigen, Swain and her colleagues extracted spleen cells and activated them with the appropriate antigen. Four days later, presumably before memory cells had developed, they transplanted the cells into hosts that lacked MHC class II molecules, which are needed to present antigen to T helper cells.

There, the T helper cells gave rise to memory T cells that again persisted. And because the memory cells seem to have developed after the helper cells were transplanted to antigen-free mice, Swain thinks that memory is only established once the antigen has been cleared from the body. "A persisting antigen might be counterproductive" for generating T cell memory, she says, because it could push T cells into overdrive and ultimately trigger cell suicide. If so, says Beverley, promising vaccines should be designed to degrade rapidly, or else memory might not develop.

In contrast to the slow renewal of memory T cells that Ahmed's group observed, almost all of the transgenic T helper memory cells were quiescent. "They seem to persist mainly as nondividing cells, similar to the long-lived neurons of the brain," suggests Swain.

But even though the two findings don't agree on every point, most experts are convinced that memory T cells don't need constant stimulation by either antigen or MHC molecules to stay in shape. The great unknown now is the nature of the signal—if there is one—that keeps memory T cells alive and kicking, says Ahmed: "My guess is that this work will set the stage for the next 5 years of T cell memory research."

–MICHAEL HAGMANN

NUCLEAR CITIES

U.S. Cuts Retraining of Russian Weaponeers

Congress has slashed by 75% a planned expansion of an effort to produce 20,000 civilian jobs for weapons scientists and engineers in 10 closed cities in Russia. But while the Department of Energy (DOE) is reeling from the blow to its 1-year-old Nuclear Cities Initiative (NCI), European countries hope to start their own program next year to keep nuclear scientists employed—and perhaps avert a brain drain to rogue countries.

During the Cold War, the Soviet Union set up a secret network of cities to build the country's nuclear arsenal. Soon after the superpower fissioned in 1991, Russia and the United States began allowing their nuclear scientists to strike up collaborations. The pace picked up last year, after Russia's Ministry of Atomic Energy announced that as many as 50,000 workers in the nuclear cities would need new jobs in the next several years. "The cities are in desperate shape and suffering terribly," says Jack Segal, director for nonproliferation and export controls at the U.S. National Security Council.

NUCLEAR CITIES PROJECTS

Project	City	Jobs created	Workforce in 2004
Expanding			
Advanced Computing Ctr.	Sarov	90	500 to 600
Nonproliferation Ctr.	Sarov	30	50
Advanced Computing Ctr.	Snezhinsk	50	500 to 600
Intl. Development Ctr.	Zheleznogorsk	3	3–4
Delayed			
Mercury lamp recycling	Sarov, Snezhinsk		
Rare earth metals plant	Zheleznogorsk		
Start projects in weapons production facility	Zarechnyy		

To stimulate job creation, DOE launched NCI last fall with $15 million. The agency modeled the effort after a program it began in 1994, the Initiatives for Proliferation Prevention (IPP), which matches U.S. national labs and companies with former Soviet weapons scientists engaged in peaceful work with commercial promise (*Science*, 8 January, p. 160). In February, however, the General Accounting Office reported that the $25 million IPP program was spending only 37% of its funds on former Soviet institutes and pouring the majority into the U.S.–based collaborators. More damning, the report charged that the IPP "has not achieved its broader nonproliferation goal of long-term employment" for weapons scientists but rather is keeping them afloat on R&D contracts. Given IPP's lack of success, the report concluded, the NCI "is likely to be a subsidy program for Russia for many years." The current NCI program "is not selling and may not even be working," says Kenneth Luongo, director of the Russian-American Nuclear Security Advisory Council (RANSAC), a private research group focused on the Russian nuclear complex.

Such doubts spelled trouble for NCI, which hoped to see its budget double, to $30 million, in 2000. Picking up on the report, the House committee that oversees DOE's budget declared "it is not clear that [DOE] is the best agency to implement this program since the most important training needed in these cities is marketing and business expertise"—not traditional strengths of the U.S. national labs. NCI was launched "with a lot of money, a lot of fanfare, and not a lot of programmatic planning," says Madelyn Creedon, counsel for the Senate Armed Services Committee, which reviews Defense Department efforts to reduce the former Soviet nuclear threat. The House wanted to nix all but $1.5 million for NCI, but House-Senate conferees agreed to provide $7.5 million, half the current level, in 2000. "This reduced funding is absolutely insufficient to support business activity in even a single city," says Olga Vorontsova, deputy director of international relations at the nuclear center in Sarov. Unless the program expands, she predicts, NCI will "contribute little to the reduction of the nuclear weapons workforce."

Fewer cities. DOE will limit aid in 2000 to existing Russian sites, such as Snezhinsk, home of the largest hydrogen bomb ever made.

CREDITS: (TOP TO BOTTOM) DOE; SNEZHINSK NUCLEAR CENTER

The funding cuts mean that DOE will have to postpone plans to expand NCI beyond its three current sites (see table). DOE officials, meanwhile, have stepped up their outreach to Congress and also hope to win support from the seven other federal bodies on NCI's advisory board. "I would applaud and encourage facilitation of a team approach," says NCI senior adviser Terry Plummer. But DOE and the national labs "have built trust and confidence with the nuclear

cities," so the agency is "the logical home" for the NCI, says another NCI official.

In the meantime, Europeans are forging ahead with their own plans for an initiative that would plow $10 millon or more a year into the cities. At a meeting later this month in The Hague, Netherlands, they will join with U.S. and Japanese representatives to identify potential projects. "It will be an attempt to prioritize unmet problems," says Segal, and "to try to get countries to commit money." Leading the charge for a European NCI, announced last week at a RANSAC-sponsored meeting in Washington, D.C., is the Landau Network–Centro Volta in Como, Italy, a nongovernmental organization that supports scientific cooperation with the former Soviet Union. The Landau network will follow up discussions at The Hague with its own meeting with nuclear city officials next month in Rome.

If the European effort gets off the ground, it could play a vital role in supporting the nuclear cities until NCI recovers. "It's a daunting agenda," says Segal, "but one for which we'll never be forgiven if we fail."

–RICHARD STONE

GENETICS

Gene Skews Patterns Of Inheritance

In the eyes of Mendelian geneticists, all chromosomes are created equal. In anticipation of sexual reproduction, paired chromosomes split up so that each developing egg or sperm ends up with just one of the partners. In theory, both partners have the same chance of making it into the next generation. But in mice and some fruit flies, reality is not so egalitarian. Sometimes one chromosomal partner consistently wins out over the other, seemingly breaking one of the basic rules of genetics.

Last March, researchers at the University of Wisconsin, Madison, solved part of that mystery in fruit flies. They showed that early in sperm development, while partner chromosomes are still close together, a truncated protein encoded on one copy somehow prevents pre–sperm cells carrying the other from maturing (*Science*, 12 March, pp. 1651 and 1742). Now mouse geneticists have fingered the gene responsible for a similar phenomenon in mice.

Last week at the 13th International Mouse Genome Conference in Philadelphia, Bernhard Herrmann, a geneticist at the Max Planck Institute for Immunology in Freiberg, Germany, described a mouse gene, located on chromosome 17, that can also skew chromosomal inheritance patterns. This gene, which codes for a protein kinase enzyme, apparently works by altering the ability of mature sperm to swim to their target, the egg. (The results also appear in the 11 November issue of *Nature*.)

The finding solves "one of the oldest riddles in mouse genetics," comments John Schimenti, a molecular geneticist at The Jackson Laboratory in Bar Harbor, Maine. It might even have practical uses. Putting the gene on an animal's sex-determining chromosome can alter the sex ratio of its offspring, allowing farmers breeding dairy cows, for example, to produce almost all female calves. "You could save a lot of animals and at the same time enormously increase the productivity," Herrmann says.

Geneticists first noticed the unequal transmission of a then-unidentified chromosome in the 1930s while studying a mutation that produces tailless mice. Mendelian genetics predicted that when the males breed with normal females, 50% of the progeny should have short tails, as a result of inheriting one mutant and one normal copy of the gene. But the crosses produced far fewer short-tailed animals. "This was the first time people saw a distortion in the Mendelian ratio in mammals," Herrmann notes.

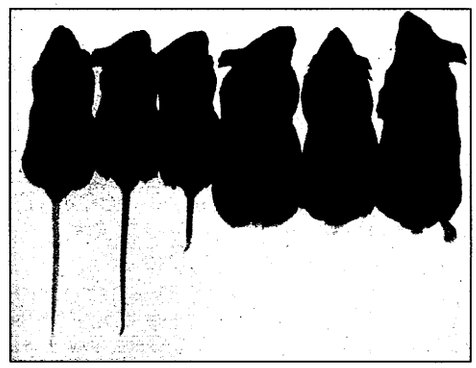
In 1984, Mary Lyon, a mouse geneticist at the Medical Research Council Laboratory of Mammalian Genetics in Harwell, England, took a stab at explaining this distortion after observing strange inheritance patterns of tail lengths in her breeding studies. She suggested that up to four genes had to be involved: one called the responder and as many as three others that she called distorters. She figured out that the responder reduced sperm fitness when not accompanied by distorter genes. As a result, both responder and the presumably closely linked tailless gene would be passed on less than 50% of the time. But when distorter proteins were present, Lyon predicted, the responder could counter their detrimental effects, skewing inheritance in favor of any chromosome carrying the responder. "It turns out that her model is correct," says Lee Silver, a geneticist at Princeton University.

Silver himself had gone looking for the responder gene, working with Schimenti. But although both they and Herrmann came up with candidates for the responder gene, neither panned out. Herrmann's gene, called *rsk3*, provided a lead to the right one, however.

The stretch of chromosome 17 where the *rsk3* gene is located has undergone several duplications and rearrangements. On a hunch, Herrmann decided to find out whether one of those rearrangements might have linked all or part of *rsk3* to the true responder gene. The hunch paid off.

The responder gene Herrmann found, called *Tcr*, consists of the partial *rsk3* gene fused to another gene that resembles genes for sperm-motility kinases, or Smoks. To make sure the new gene was the right one, the Max Planck group inserted it into various mouse chromosomes and showed that it does skew inheritance patterns. When present on the Y chromosome, for instance, the mice fathered far more than the normal 50% male progeny.

Herrmann thinks the responder gene handicaps sperm that carry it by causing their flagella to beat too slowly, while the distorter genes—whose identities are still unknown but which seem to be on the same chromosome—cause them to beat too fast. As a result, only the sperm lucky enough to get both



CREDIT: B. HERRMANN

Telltale tails. Less than the expected 50% short-tailed mice foretold the unusual inheritance pattern of mouse chromosome 17.

distorter and responder proteins move optimally and are able to beat out the sperm that lack either a responder or distorter.

The discovery in flies and mice of two very different genes that promote their own inheritance—and incidentally that of the chromosome they ride on—suggests that the evolutionary pressure to become such a self-promoter must be quite strong, says Silver. Successful transmission should lead to ever greater representation of that version of a chromosome in a population. Consequently, he adds, "there's probably thousands of examples out there that we can't see," perhaps even in people.

–ELIZABETH PENNISI

ANIMAL REGULATIONS

FDA Report Scores Chimp Research Lab

A federal investigation has found that the country's largest chimpanzee facility has violated dozens of regulations relating to good laboratory practices. The violations, described in a preliminary report detailing the results of an August inspection by the U.S. Food and Drug Administration (FDA), mostly involve inadequate record keeping, but they also include unapproved changes in experimental protocols. Animal activists who obtained the report claim that the irregularities raise questions about the integrity of trials involving potential new drugs and medical devices.

The Coulston Foundation, a private breed-