(BMP-2), which stimulates bone growth. Only one compound had the desired effect. This was lovastatin, a molecule derived from a strain of the fungus *Aspergillus terreus* that Merck sells under the brand name Mevacor in the United States.

To find out if lovastatin's ability to stimulate BMP-2 production by cultured cells translated into increased bone formation in live animals, the team injected the drug into the tissue above the skullcap bones of young mice. After injecting the animals three times a day for 5 days, the researchers found that treated bone was nearly 50% larger than that in mice injected with a salt solution.

Another statin, called simvastatin (trade name Zocor), also had promising effects, this time in female rats whose ovaries had been removed to mimic the hormonal changes of menopause, when many women start to lose bone density. In rats that received oral doses of the statin for 35 days, the leg bones and vertebrae were nearly twice as dense as in rats that received a placebo.

Mundy and his colleagues don't know how the statins encourage bone growth. But cardiologist James Liao of Brigham and Women's Hospital in Boston, who has studied the molecular effects of statins on the cells that line blood vessels, suggests one possibility. He notes that by blocking HMG Co-A reductase, the statins also block the production of other lipids that attach to signaling proteins in the cell, allowing them to function properly. Disrupting these proteins might somehow trigger the cells to make BMP-2, he says.

It's also far from clear what the findings mean for people who take statins, which can cost hundreds of dollars a year. A few scientists who have conducted clinical trials on statins have searched their databases for signs that the drugs improved bone density. They saw some intriguing hints: Clinical researcher Steven Cummings of the University of California, San Francisco, for example, says patients taking statins seemed to have lower risk for bone fractures. But the numbers were too small to produce statistically significant results.

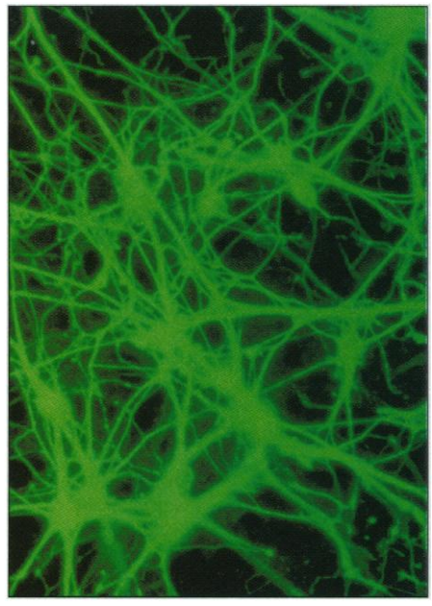
Indeed, the doses used to lower cholesterol levels may be too low to have much effect on bone density. Mundy and his colleagues gave their rats doses about 10 times higher than those typically taken by patients. The high doses may be needed, Mundy says, because the statins currently on pharmacy shelves were chosen for their ability to target the liver, the body's main site of cholesterol synthesis, rather than the bones. He and Cummings both think that similar compounds chosen for their ability to target bone would likely be more effective. "My guess is that the statins given for lipid lowering are not necessarily going to be ideal" for treating osteoporosis, Mundy says. But they might point to similar molecules that could encourage bone formation more effectively, he says—perhaps with the side effect of lowering high cholesterol levels. **–GRETCHEN VOGEL**

STEM CELLS

Rat Spinal Cord Function Partially Restored

Behind the controversy over research on primordial cells from early human embryos is a dream: using these versatile cells to repair a wide range of injured tissues in adults. Researchers at Washington University in St. Louis have now brought this dream a step closer to reality for the spinal cord.

In the December issue of *Nature Medicine*, neurologists Dennis Choi, John McDonald, and their colleagues report that when they injected immature nerve cells derived from mouse embryonic stem cells into rats whose hindlimbs had been paralyzed by blows to their spinal cords, the animals regained some mobility. What's more, because the animals were treated 9 days after they were injured, the results suggest that stem-cell therapies might someday lead to treatments for the hundreds of thousands of patients worldwide with spinal cord injuries they received long ago.



Spinal patches? Neurons such as these, grown from mouse embryonic stem cells, may help repair damaged spinal cords.

CREDIT: J. W. MCDONALD

Oswald Steward, a spinal cord researcher at the University of California, Irvine, College of Medicine, calls the work "compelling" and "an obligatory first step toward a transplantation therapy for spinal cord injury" based on embryonic stem cells. Still, he and others caution that no such therapy is anywhere near the clinic. The Washington University researchers do not yet understand how the transplants worked, and until they do, it will be hard to improve upon the results.

Choi and McDonald started their stem-cell experiments back in 1996, upon hearing that a colleague at Washington University, neurobiologist David Gottlieb, had chemically coaxed mouse embryonic stem cells to become nerve cells in a lab dish. Initially, Choi and McDonald simply wanted to test whether Gottlieb's mouse embryonic stem cells would survive in the rat nervous system, as a first step toward a workable therapy. After Gottlieb coaxed the cells to develop into precursors of nervous tissue, Choi's team injected the cells into the spinal cords of 22 adult rats with 9-day-old spinal cord injuries. Several weeks later, the researchers examined the animals to see what had become of the transplants.

By using fluorescent antibodies that home in on mouse tissue, the researchers could see that many of the implanted cells had survived and spread throughout the injured spinal cord area. Using antibodies that stick to specific cell types, they also detected clear signs that those cells had matured to form both nerve cells and support cells known as oligodendrocytes and astrocytes. "We're confident that the cells survive and differentiate," Choi says.

Meanwhile, the researchers checked the rats for any behavioral benefits of the transplants, not expecting to find anything dramatic. After all, no one had ever seen any improvement in locomotion from an attempt to repair damage to the spinal cord more than 24 hours after an injury. But within a month of performing the transplants, the Washington University team noticed that the rats could lift their rear ends and step awkwardly with their hindlimbs. By contrast, rats that had received sham injections simply dragged their behinds wherever they went. "We didn't believe the behavioral recovery when we first saw it," McDonald recalls. But after seeing exactly the same result with a second group of rats, the scientists knew it was real.

Exactly what accounts for the improvement is still unclear, however. One possibility is that the new mouse neurons made functional connections with rat neurons, thus partially restoring the spinal cord's ability to transmit nerve signals between the brain and the rear legs. Another is that the mouse-derived oligodendrocytes rebuilt the insulating myelin sheaths around battered spinal cord nerves, enabling them to conduct impulses again. And a third hypothesis is that the implanted cells simply secreted chemicals that acted on damaged cells in the rat spinal cord, either preventing them from

dying or restoring their ability to function.

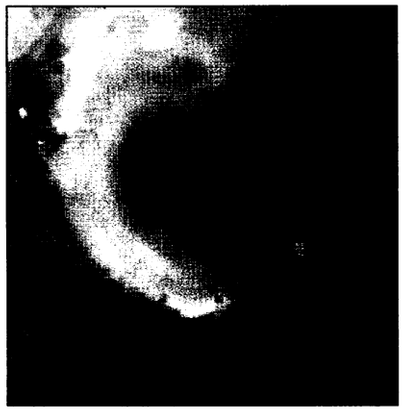
Choi's team is now examining the various possibilities so that they can determine how to get better results. "We've got to figure this out," Choi says. "Otherwise it's a random walk." They would also like to extend the delay before treatment from 9 days to a month or two, which would be a better test of prospects for fixing human spinal cord injuries that are years to decades old. Nevertheless, Choi is thrilled to have taken this first step. "We're breaking new ground," he says. –INGRID WICKELGREN

PLANETARY SCIENCE

Another 'Ocean' for a Jovian Satellite?

Oceans seem to be popping up everywhere among the satellites of Jupiter. First it was Europa's 100-kilometer-deep, ice-encrusted ocean, which might even harbor some life; then Ganymede and Callisto's deep waters turned up, buried deeper than Europa's. Observations from the ground and the Galileo spacecraft now suggest that it may be fiery Io's turn. But there are no tantalizing prospects for life in Io's proposed ocean. At something like 2000 Kelvin, the ocean seething beneath Io's volcanoes and lava lakes would vaporize the hardiest creature, for this ocean would consist of molten rock.

If Io's magma ocean is really there, it may be fueling geologic "processes we don't see on Earth and that haven't been seen in billions of years," notes geophysicist Susan Kieffer of Kieffer & Woo Inc., in Palgrave, Canada. The magma ocean that roiled Earth in the earliest days of the solar system left no geologic record, but Io could be a living example of how an infant planetary body shapes itself.



A hot spot. Io's volcano Pele glows at 1300 Kelvin (central red dot) in the infrared.

CREDITS: (TOP TO BOTTOM) SAM OGDEN PHOTOGRAPHY; JPL/NASA

When the Voyager spacecraft returned the first closeup images of Io in 1979, planetary scientists learned that it is outrageously active. More recent observations from Earth and now from the Galileo spacecraft have shown just how extreme its volcanism is. Io's huge calderas dribble lava onto the surface at temperatures exceeding 1500 K, when the hottest terrestrial lavas today are hundreds of degrees cooler (*Science*, 17 April 1998, p. 381). Such high temperatures implied compositions with high proportions of magnesium and iron, called ultramafic, which would raise the melting point of the rock. Hot ultramafic lavas were common billions of years ago when Earth itself was hotter but have been scarce since.

In the October issue of *Icarus*, planetary geologists Laszlo Keszthelyi and Alfred McEwen of the University of Arizona, Tucson, and Jeffrey Taylor of the University of Hawaii, Honolulu, consider what Io's surface might be saying about the satellite's interior. Jupiter's gravity kneads Io, driving heat through the interior. Keszthelyi, McEwen, and Taylor calculated that if Io is solid down to its liquid iron core, as Earth is today, Io should have thoroughly extracted silica-rich magmas from its rock to form a thick, silica-rich crust. In this scheme, the crust would now melt from place to place to produce lavas with a low melting point, just the opposite of what is seen.

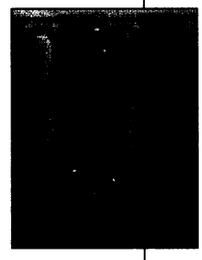
So Keszthelyi and his colleagues assume that Io never managed to extract much silica-enriched magma from its interior. In their preferred model, beneath a 100-kilometer-thick crust built of silica-poor lavas churns an 800-kilometer-thick magma chamber that melts away the bottom of the crust as fast as surface lavas build it. Their calculations suggest that the magma would be heavy with mineral crystals—more so toward the bottom as increasing pressure encourages their growth.

This mushy magma ocean must be global, the researchers conclude, to feed the volcanic hot spots that seem to be uniformly distributed over Io's surface—Galileo observations have yielded 100 of these so far and counting. Io's mountains, which range up to 10 kilometers high, are also evenly distributed, so they may be blocks of crust tilting as they founder into the magma ocean below. The early Earth or moon may have looked this way, says McEwen, before it cooled enough to solidify.

"The evidence for globally distributed magma plumbing is very good," says Galileo project scientist Torrence Johnson of the Jet Propulsion Laboratory in Pasadena, California. "That implies a global source." But short of dropping seismic stations onto the surface, he says, proof may be hard to come by. Still, McEwen suggests at least two ways Galileo might help. During its last scheduled flyby of Io, made on Thanksgiving Day, the spacecraft recorded magnetic observations that may show whether Io generates a magnetic

ScienceScope

Northbound MIT's dean of the school of science, Robert Birgeneau (below), will leave the Cambridge, Massachusetts, campus next summer to become head of his alma mater, the University of Toronto. That's causing jitters among the women faculty at MIT, who praise the physicist as their most important advocate in a long battle to address gender inequality (*Science*, 12 November, p. 1272). But Lotte Bailyn, an MIT management professor and former faculty chair, is optimistic that the issue won't die with the dean's departure. And Birgeneau himself says that the effort to address inequality issues "is in transition—but there's enough momentum" to ensure that the issue remains on the front burner. Both academics note that the other four MIT schools have already organized committees to examine the status of faculty women similar to the one Birgeneau helped create.



Who's No. 1? Japan's investment in research has reached record levels. According to new figures from the country's Management and Coordination Agency, total R&D spending was $122 billion for the year ending on 31 March, a 2.5% increase over the previous year despite an economy that shrank by 2.1%. Japan devoted 3.26% of its $3.7 trillion gross domestic product to research, well ahead of the 2.79% figure posted by the second-place United States for its $8.8 trillion economy (*Science*, 29 October, p. 881), although the countries use different accounting methods.

The 1998 numbers for Japan show that public spending grew by a robust 9%, to $27 billion, while spending by the recession-battered private sector edged up 0.7%, to $95 billion. "Given the severe [economic] conditions, the spending trend is very positive," says an official at the Science and Technology Agency.

The government's share of the spending pie rose to 21.7% in a deliberate effort to bring it in line with rates for other industrialized countries. Meanwhile, the U.S. government's contribution to R&D spending continues to drop, reaching a record low of 26.7% of a projected $247 billion in 1999. Ironically, many U.S. officials are wringing their hands at the declining federal contribution, caused largely by a surge of industrial R&D in conjunction with a booming economy.

Contributors: Robert Koenig, Dan Clery, Andrew Lawler, Dennis Normile