synthesis of artificial materials with lessons from biology. That interface is very, very exciting," Wiesner says.

Researchers at the frontier of materials science have long looked to nature for inspiration in synthesizing complex materials. Bone has been among the most enticing to emulate because of its strength and structure. At its simplest level, bone is a composite made when proteins in collagen fibers coax calcium, phosphate, and hydroxide ions in solution to condense atop the fibers and grow into a rigid structure of tiny crystallites of hydroxyapatite all aligned in the same direction. Hydroxyapatite gives bone its toughness.

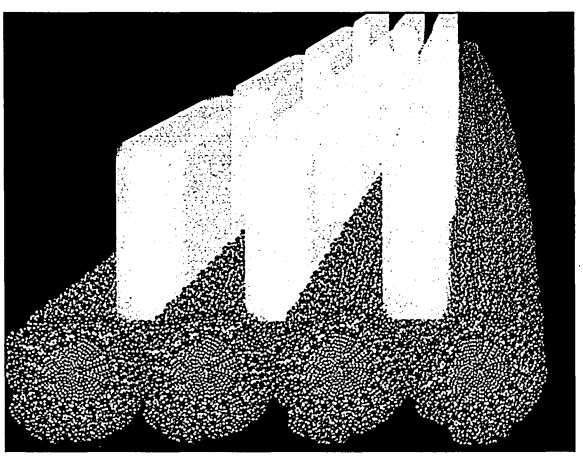
Over the years, several research teams have induced hydroxyapatite crystallites to grow atop other materials such as polymers. But they've never managed to align the crystallites with any material other than collagen, the protein fibers that nature picked for the job. So Stupp and his colleagues decided to see if they could design purely synthetic molecules to carry out the task.

From previous work in his own lab and others, Stupp knew that synthetic molecules could at least carry out the first task, assembling themselves into fibers. The trick was to make two-part molecules, with a water-friendly group at one end linked to an oily hydrocarbon at the other. When placed in water, these spontaneously assemble into loosely connected fibers called micelles as the hydrocarbon tails pack tightly together to avoid associating with water.

The Northwestern researchers designed two-part organic molecules called peptide-amphiphiles (PAs), in which the oily hydrocarbon chains were connected to a series of peptides, essentially short protein fragments. To carry out the second part of their task—growing the hydroxyapatite on top—the scientists had to design in a couple of other functions as well. First, they added peptides to their PAs that could form links with one another to lock the flimsy micelles into resilient fibers. Second, they added negatively charged peptides rich in phosphoserine groups, which previous biochemical studies had shown help collagen attract the positively charged ions that form hydroxyapatite crystallites.

Much to the team's surprise, the PAs not only formed fibers and slipped on a coat of hydroxyapatite crystallites, but also got the crystallites to adopt the same crystallographic organization as in bone. Stupp says the team is still trying to understand this bit of good fortune. "The bottom line is, we don't know the exact mechanism why our crystals end up aligned just as in bone," Stupp says. But it's clear the fibers play a vital role. "If we don't have the fibers [in solution], the crystals don't form," Stupp says. He suspects that the fibers are so small that they allow the crystals to grow in only one direction, along the length of the fibers.

Stupp says much more work is needed to understand the new bone-mimicking molecules. But his team is already looking beyond bone. In their paper, the researchers also describe how they added peptides with a trio of amino acids—arginine, glycine, and aspartic acid—which readily attract cells and encourage them to bind to a particular surface. Eventually, Stupp hopes, his team will be able to use PA fibers to repair damaged nerve tissue by coaxing neurons to attach and grow on the fibers. And by changing the peptides, Stupp believes, he and his colleagues will be able to assemble other types of crystals, metals, or even polymers to make everything from high-strength composites to nanowire circuitry for molecular-based computers. In that case, Stupp and his team may find themselves flattered with a little imitation of their own. –ROBERT F. SERVICE



Close copy. Synthetic molecules assemble into fibers that coax minerals into growing on top, a structure that mirrors bone.

CREDIT: J. HARTGERINK

ANIMAL WELFARE

Congress Clears Way For Rodent Rules

Animal rights groups have won the latest round in their long-running fight to force the U.S. government to more tightly regulate the use of mice, rats, and birds in scientific research. Congress last week approved an agriculture spending bill that allows the U.S. Department of Agriculture (USDA) to start developing the new rules, which biomedical groups blocked last year in an 11th-hour lobbying victory.

"Finally, we can get started [on regulations] that will be good for animals and for science," says lobbyist Nancy Blaney of the Working Group to Preserve the Animal Welfare Act, a coalition of animal rights groups. But Tony Mazzaschi of the Association of American Medical Colleges, which opposes the idea, says the decision is "disappointing; all this would do is create costly paperwork for research institutions."

The controversy stems from a 30-year-old USDA policy that exempts mice, rats, and birds—which account for 95% of all experimental animals—from regulation under the Animal Welfare Act (AWA). Last year, after several court battles, USDA signed a pact with animal rights groups and agreed to draft caging and care rules. The deal outraged biomedical groups, which argued that USDA regulation would duplicate existing government and voluntary rules and drain millions of dollars from research accounts. They quickly convinced Senator Thad Cochran (R–MS) to block USDA action by adding a ban to the 2001 agricultural appropriations bill (*Science*, 13 October 2000, p. 243).

This year, Congress seemed ready to continue the freeze after the House included the ban in its version of the agriculture measure. But the Senate balked after Democrats took control this spring. As a result of the switch, Senator Herb Kohl (D–MI) took over the subcommittee that oversees agriculture spending from Cochran. Lobbyists say Kohl—who is considered friendlier to animal rights groups—was instrumental in hammering out the compromise language included in this year's bill. It allows USDA to begin writing the regulations and seek public comment, but it bars the agency from finalizing any rules before 30 September 2002, when the annual measure expires. The open deadline gives lawmakers a chance to revisit the issue next year.

The lack of closure "won't have an effect on the process," however, because getting new regulations approved routinely takes years, says John McArdle of the Alternatives Research and Development Foundation in Eden Prairie, Minnesota. He has long pushed for AWA regulation because the law requires researchers to consider alternatives before using animals for experiments.

It's not clear how rapidly the USDA will push ahead, however. USDA officials were not available to comment, and Mazzaschi says the Bush Administration "isn't anxious to move forward." But Blaney expects the agency to "start work as soon as the president's signature is dry" on the funding bill, which could be this week. If it doesn't, both sides agree, the matter could end up back in court.

–DAVID MALAKOFF