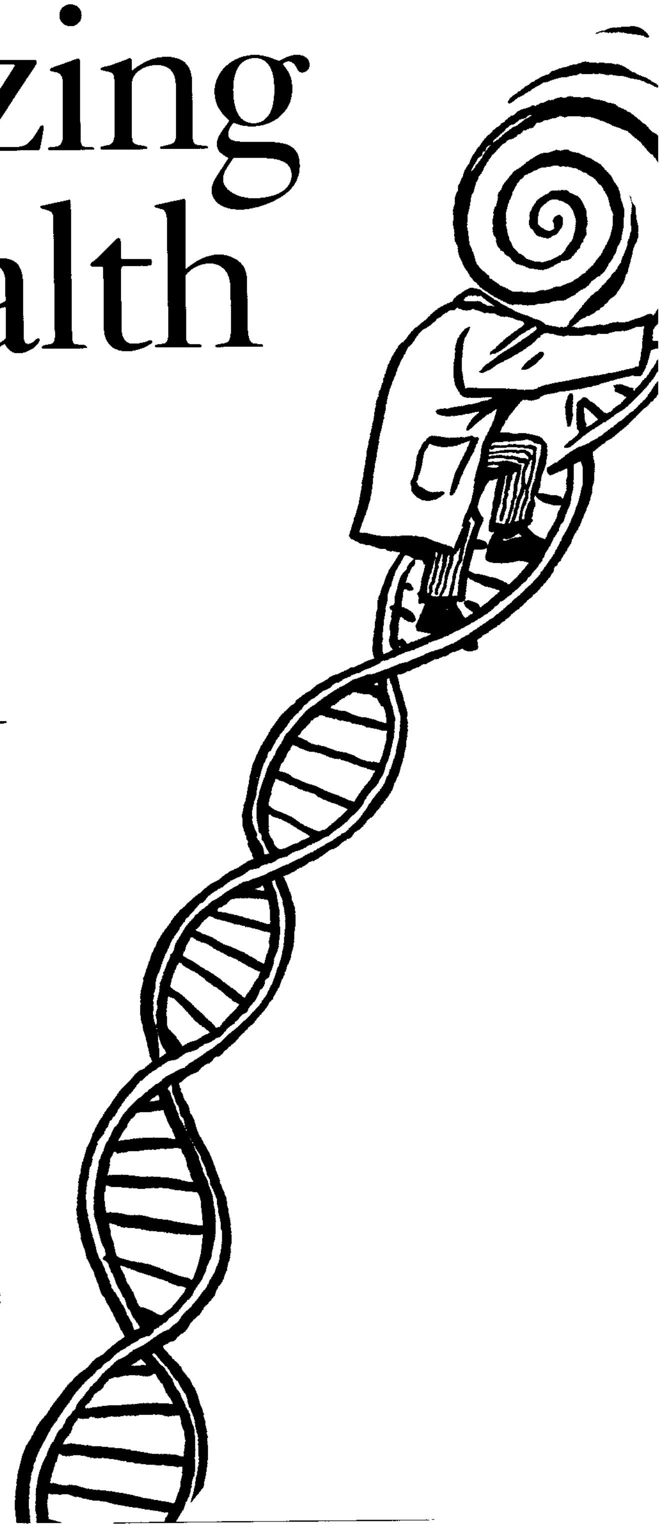
Scientists and engineers together

Revolutionizing Human Health



THE COMING TOGETHER OF BIOLOGY AND engineering, with vital assists from chemistry and physics, has raised the prospect of extraordinary health advances. The possibilities include hearts and livers grown on biodegradable scaffoldings in the lab and then implanted in patients; synthetic muscles that can supplement or replace those weakened by injury or illness; therapies for cancer and other ailments that devastate disease-harboring cells while leaving healthy ones completely untouched...treatments that would allow new cell growth — and restored capabilities — in patients afflicted by illnesses like Alzheimer's, with no need for surgery.

MIT scientists and engineers have had a major role in turning such ideas from dreams into goals. Yet as the Institute expands its already pace-setting capabilities in biomedical science and engineering, MIT researchers know that there are many barriers to breach before such goals can be realized.

Happily, these men and women work in an institution where solving problems is as much a part of the landscape as the Great Dome. What follows are snapshots of some of the people who are helping to change the face of medical science.

ILLUSTRATIONS BY CHRISTOPHE VORLET

Biological materials and health

SHUGUANG ZHANG'S MOVE from exploring genes — a traditional focus for someone with a molecular biology Ph.D. — to the new and chancier field of designed biological materials was triggered by an experience in Alexander Rich's lab at MIT 12 years ago.

Zhang was probing a yeast protein that binds to DNA. A tiny stretch of the protein, he found, had an unusual, and intriguing, molecular structure. Zhang, then a postdoctoral fellow, asked brain and cognitive sciences grad student Todd Holmes to help him explore the segment, known generically as a peptide.

"One day Todd called. 'Something strange is going on,' he said," recalls Zhang, now associate director of MIT's Center for Biomedical Engineering. "I went over and looked through the microscope. We had put

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Twelve years ago, Shuguang Zhang, associate director of MIT's Center for Biomedical Engineering, switched from exploring genetics to the new, chancier field of biomaterials after probing unusual protein segments. What he observed was self-assembly, a process which could lead to nano-structures and even microscopic machines.

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variants of these peptides in different conditions in a dozen petri dishes. In two of the dishes, there was a membrane over the surface that looked like Saran Wrap."

It took Zhang a year-plus to figure out what that odd substance was: a biological material that had undergone molecular self-assembly to form what's now called a hydrogel matrix.

Self-assembly happens all the time in nature. Spider webs and hair are examples of structures created by fibrous proteins interwoven with each other. Nature also demonstrates self-assembly's powers: a silk fiber more than a mile long can come together in the fiber-forming glands of a silkworm in a mere two to three days.

Zhang recognized that self-assembly in the lab could lead to "nano-" structures — structures with dimensions measured in billionths of a meter — and maybe molecular machines, too. But it took a decade of experimenting with materials and techniques for potential uses to come into focus.

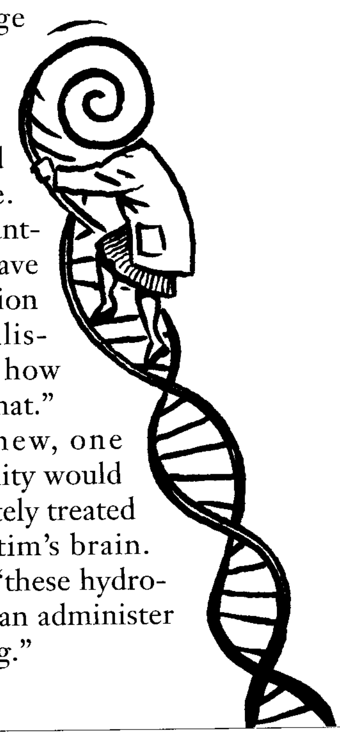
While the self-assembling peptide materials incorporate amino acids — the building blocks of proteins — they're mostly water (hence the name "hydrogel.") They can self-assemble into a range of shapes, from nanotubes to fine 3-D nanofiber webs. Their dimensions are tiny: a tubule is 30 to 50 nanometers wide, or about a thousandth the diameter of a human hair. And, they're biodegradable.

What do such traits make them useful for? One application is as scaffolds for new tissues. "The dimensions of the individual strands in a hydrogel web are the same as the components of the matrix that surrounds most cells," explains Zhang.

MIT's Alan Grodzinsky has already grown cartilage cells on hydrogels. And Zhang and Holmes — the latter now on New York University's faculty — have shown that the nervous-system cells called neurons readily grow new extensions on hydrogel scaffolds, which may point to a role for such scaffolds in treating conditions like stroke.

Vision can be eliminated by a stroke. Gerald Schneider, an MIT professor of brain and cognitive sciences, has restored sight to lab rodents by implanting nerve fibers from elsewhere in their bodies into their brains. But hydrogel-based "bridges" could work better yet.

Hydrogels, notes Rutledge Ellis-Behnke, a grad student in Schneider's lab, can harbor extremely useful "passengers" — the cell stimulators called growth factors, for example. "From our work with transplanted nerve fibers, we already have a benchmark for the restoration of visual function," says Ellis-Behnke. "Now, we can see how hydrogels match up against that."



Although the effort's new, one intriguing long-term possibility would be to simply inject appropriately treated hydrogels into a stroke victim's brain. "Remember," notes Zhang, "these hydrogels are mostly water. You can administer them just as you would a drug."