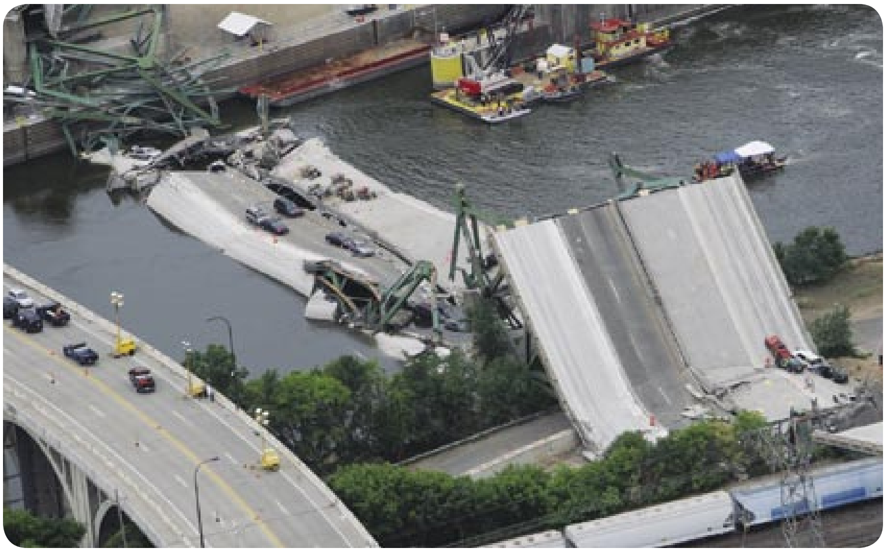


ALL FALL DOWN: The collapse of the I-35W bridge in Minneapolis this past August has sparked concerns about the integrity of other spans.

MANDEL NGAN AFP/Getty Images

ing at the University of Arizona. Saadatmanesh developed the material, called CarbonWrap, about six years ago and now sells it through CarbonWrap Solutions.

The polymer is made of woven filaments of glass, carbon and Kevlar, which are placed in a resin matrix. Its tensile strength—the force required to pull it apart—is about 200 tons per square inch, 10 times stronger than steel. The fiber costs $16 a pound and is attached to the bridge girders with a special epoxy. Patching a small girder crack would only cost about $200, including labor; doubling the layers increases the strength by about 30 percent.

"You don't need to drill holes," which can further weaken a structure, Saadatmanesh says. "Instead of taking eight hours" for a traditional patch, he adds, "you can do this in half an hour." In laboratory testing, Saadatmanesh says that CarbonWrap has held through the equivalent of about 10 million trips by a 35-ton truck. It resists corrosion, an important consideration given the galvanic currents that can be generated between metallic components on a bridge, and has withstood a pH 2.5 solution for two years. Steel would melt in just a few hours in such an acidic bath.

CarbonWrap has shored up water pipes and light poles, but it has yet to patch bridges—engineers are conservative by nature. "It takes a while to adopt a new thing," explains Taichiro Okazaki, a civil engineer at the University of Minnesota who is heading a team of researchers to examine the Minneapolis collapse. "New materials have to be very reliable, and it takes many years to develop trust." Bridge engineers have begun talking to Saadatmanesh's company, and Okazaki suggests that the first applications for CarbonWrap might be on small, lightly trafficked bridges, such as those found on golf courses. Such novel materials may play a crucial role in addressing the nation's aging infrastructure, although ultimately they cannot replace commitments to timely inspections, better designs and new bridges.

David Appell is based in Portland, Ore.

NANOTECH

A Simple Mimic

Water droplets encased in fat simulate cell membranes BY GARY STIX

A double layer of fat marks the property line that separates DNA, mitochondria, the endoplasmic reticulum and the rest of the elaborate internal machinery from everything that exists beyond the confines of a cell. Molecules of protein that poke through this lipid bilayer serve as communication channels for incoming and outgoing messages that regulate the body's most basic activities.

Biologists have tried for decades to produce a simple model of the cell's plasma membrane, particularly the openings to the outside world known as ion channels. The goal is not just academic. More than 60 ion-channel gene mutations have been linked to human diseases. Some drugs that target ion channels have achieved blockbuster status. Pharmaceutical companies could deploy such a model to simulate how new drugs interact with membrane proteins.

An ideal model has remained elusive. Some laboratories have focused on producing protocells—empty shells that are filled with cellular machinery that makes proteins or causes a fake cell to divide. Others have just created imitation cell membranes that simulate the electrical and chemical traffic at the cellular gateway. The most ambitious of these endeavors points toward a marriage of the work on protocells with membrane mimicry. It involves research at the University of Oxford and Duke University in which water droplets enveloped in a layer of fat come together to form bilayers into which membrane channels or pores can be inserted.

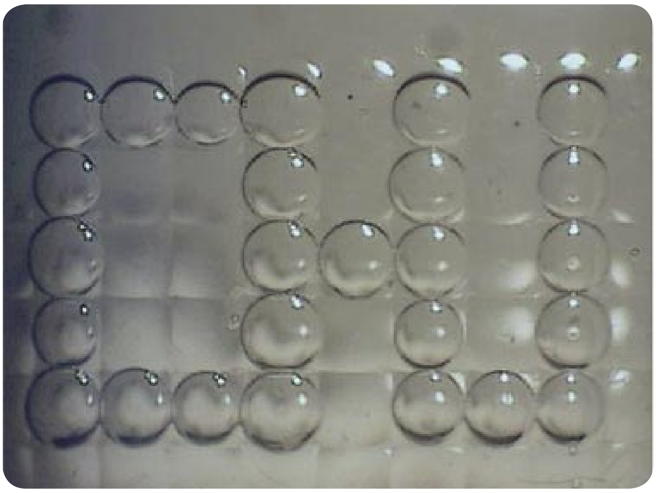
The droplets are manufactured by dissolving lipids in a small reservoir of oil. Water droplets measuring less than a millimeter across join the mix, causing the lipids to form a coating on the droplets of no more than half the thickness of a cell membrane. "These systems are very stable, like a robust soap bubble with a skin that's a biological surface," notes Matthew Holden, a postdoctoral fellow at the Oxford laboratory of chemist Hagan Bayley, where much of the research took place [see "Building Doors into Cells," by Hagan Bayley; SCIENTIFIC AMERICAN, September 1997].

Dubbed "liquid Lego," the droplets are intended to be a test bed for exploring the workings of not just a single cell membrane but an entire network of protocells. When a droplet joins with one of its neighbors, the two form the equivalent of a complete membrane. Ultimately, the team would like to engineer droplets with different characteristics, varying the pH of the water inside a droplet or the types of membrane channels used. Alternatively, different droplets may contain different drugs. The objective is to demonstrate how cells that constitute heart, brain or lung tissues communicate among themselves. "The new preparation of nanodrops holds enormous promise," says Bob Eisenberg, chairman of biophysics and physiology at Rush University Medical Center in Chicago. "It will allow manipulation of ion channels in new ways; it will allow systems to be built from arrays of drops that show interesting properties."

For the moment, simulating the pulsations of a heartbeat on a chip remains a dream, although the necessary tools are starting to come forth. In the June 16 online *Journal of the American Chemical Society,* Holden and his colleagues recount how they sent current through a chain of 16 droplets by plugging electrodes into various droplets along the network. They inserted bacterial pores (surrogates for ion channels) into the lipid protomembranes and also showed how electrodes could be used to add or remove droplets while keeping the network intact.

Two droplet experiments demonstrated the prospect of one day building autonomous systems that power themselves or make their own components. The paper describes a battery devised by infusing droplets with differing concentrations of ions and, separately, a current generated when droplets were infused with a membrane protein (bacteriorhodopsin) that causes protons to flow when exposed to green light.

The last unrealized step, of course, would be to insert DNA and organelles from a cell that could encode the desired ion channel from within the droplet. Then all scientists might have to do is just turn on the lights and watch the show.



LIQUID LEGO: Fat-covered droplets snap together to form the initials for the University of Oxford, where these imitation cells, each of which holds 200 nanoliters of water, were first concocted.

WILLIAM HWANG *University of Oxford*

HEALTH

Scared Off Silicone

Liability fears trump science for ulcer-beating injectable silicone BY MELINDA WENNER

Of the 20 million Americans suffering today from diabetes, one million will probably be killed by their feet. A diabetic foot ulcer and its attendant complications constitute a surer death sentence than colorectal cancer—just over half of all diagnosed patients survive for five years. More startling than these statistics, however, is that for 40 years, physicians have known about a safe medical procedure to prevent these ulcers. But the U.S. Food and Drug Administration has yet to approve the treatment.

Diabetics develop foot ulcers because of nerve damage. Injury to motor neurons deforms the feet, creating pressure points that are susceptible to harm during walking, and damage to sensory neurons prevents patients from feeling anything. "They lose the gift of pain," explains David Armstrong, a surgeon and a podiatric medicine expert at Rosalind Franklin University in Chicago. Unaware that anything is wrong, patients continue to walk and end up wearing out the protective fat pad between the skin and the bone in those areas. Eventually the skin erodes away, and an ulcer forms. They "wear a hole in their foot just like you or I might wear a hole in our shoe," Armstrong says. Left untreated, an ulcer can become infected or gangrenous and can lead to foot or leg amputation—if it does not cause sepsis, a blood infection, first.

The best way to prevent ulcers is to relieve pressure on the exposed parts of the feet. Doctors have historically prescribed