tum dots or other electron-confining structures. However, they have always relied to some extent on a classical-physics effect, the mutual electrostatic repulsion of electrons, to control flows in and out of the device. Pumps employing that effect can give electrons extra energy, causing undesired heating.

The new pump works by varying the probability that an electron is present at any particular location, Marcus explains. A fluctuating pattern of probabilities arises from interference between electron waves.

Marcus and his colleagues at Stanford and the University of California, Santa Barbara fabricated their micrometer-square dot in a sandwich of gallium arsenide and aluminum gallium arsenide. They describe the device, which operates at a frosty 330 millikelvins, in the March 19 SCIENCE.

Electrodes plated on the top and bottom surfaces of the semiconductor structure allow the researchers to apply voltages. Some act as confining walls to electrons. Other oscillating signals, intentionally out of sync with each other, drive the pump. When they are on, "it's as if the walls start to shake," Marcus says.

The shuddering of the walls shifts the pattern of probabilities that an electron is in a given location, making it possible for electrons to enter the dot from outside and for others to be ejected.

The research team does not make direct heat measurements on the new device but draws on other experimental indications, as well as theory, to argue that heating is minimal. "Inside the device, it's reasonable to assume there is a dissipationless current flowing," Marcus says. *—P. Weiss*

Microscopic vessels merge to mix molecules

A new technique that blends minuscule amounts of chemicals can help researchers study the biochemical reactions that occur inside cells.

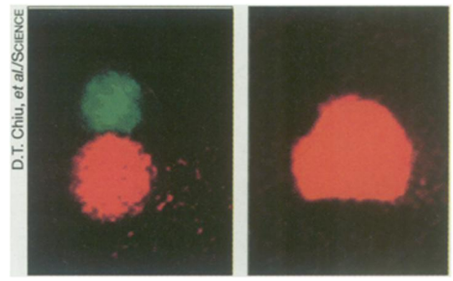
Richard N. Zare of Stanford University and his colleagues encapsulate solutions in tiny spheres, or vesicles, less than 5 micrometers in diameter. By fusing the vesicles, the researchers allow the solutions to combine and react.

Clyde F. Wilson of Stanford described the new technique last week at the Pittsburgh Conference in Orlando, Fla. The Stanford researchers and their collaborators from Göteborg University in Sweden and Pomona College in Claremont, Calif., also report their results in the March 19 SCIENCE.

"This technique comes closer to mimicking what goes on in cells as opposed to in free solution," says Zare. In a cell, molecules repeatedly bump into the cell membrane, which affects the reaction rate. "These [vesicles] are the tiniest test tubes you've ever heard of," he says. Each can hold as little as a billionth of a trillionth of a liter (10^{-21} l).

The researchers make the microscopic containers out of phospholipids, long molecules that assemble into a double-layer membrane. With a laser beam or a thin glass tube, Zare and his colleagues trap the vesicles and move them around. If they bring a pair close together and then zap them with several electric pulses, the two vesicles unite into one.

To demonstrate this fusion, the researchers made containers containing green and red fluorescent dyes and joined them. The contents mixed together, and the resulting single sphere glowed bright orange. They also combined calcium ions in one vesicle with an organic compound in another.



Two vesicles, about 5 micrometers in diameter, contain green and red fluorescent dyes (left). After a series of electric pulses, the vesicles fuse together, and the blended dyes appear orange (right).

"I think the work is truly amazing," says Zeev Rosenzweig, a chemist at the University of New Orleans. In a standard test tube, what limits the reaction rate is how fast the molecules can drift toward each other, he notes. In vesicles, however, the reactants don't have far to travel, so other factors influence the rate.

Rosenzweig thinks that this technique could eventually be used to study reactions between individual molecules. "Try to take two molecules and react them in a beaker, and they will never make it," he says. In the microscopic test tube, however, one single molecule would have no problem meeting another. *—C. Wu*

Drug blockades blood vessels' energy

Last year, a media frenzy over a new class of drugs raised hopes of a cure for cancer. Researchers have now discovered how one of these drugs may work. This knowledge could guide the development of smaller, more easily produced agents to eradicate tumors.

Angiostatin, one of the promising anticancer drugs, starves mouse tumors by blocking the growth of blood vessels that sustain them (SN: 5/2/98, p. 286). Scientists didn't know the cellular mechanism underlying the drug's action. The new discovery suggests that angiostatin deprives blood vessel cells of the energy that they need to proliferate.

Angiostatin sticks to and gums up an enzyme on the cells that line blood vessels, researchers from Duke University Medical Center in Durham, N.C., and their collaborators report in the March 16 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES. This enzyme produces adenosine triphosphate (ATP), the compound that cells break down to obtain energy.

Until now, the enzyme, called ATP synthase, had been found only in mitochondria, the energy-generating capsules that reside within cells. The scientists double- and triple-checked their results to make sure that the enzyme indeed coated the blood vessel cells, which they had extracted from human umbilical cord blood.

"I'd wager no one would have guessed that," says Duke biochemist Gordon G. Hammes, who studied the enzyme when it was first examined 30 years ago.

Although surprising, the finding "fits what's going on in the tumor microenvironment," says the study's lead author, Tammy L. Moser from Duke. Blood vessel cells are able to grow and multiply even in the harsh, oxygen-depleted environment of a cancerous tumor. By creating their own pools of ATP, says study collaborator Salvatore V. Pizzo of Duke, the blood vessel cells survive where other cells die.

Angiostatin, by putting the squeeze on the blood vessel cells' source of energy, starves the vessels, whose absence in turn starves the tumor.

Although the drug has raised many hopes, it's difficult to produce. The business end of angiostatin is folded up in pretzel-shaped "kringles," named for their resemblance to Danish sugar cookies, says Pizzo. "The problem is that it's very difficult to produce angiostatin in its native [structure]."

Knowing angiostatin's target enzyme, researchers may be able to create less contorted drugs with the same power. "Anytime you find a binding protein for a therapeutic agent, you immediately think: Could you engineer a smaller molecule that . . . could substitute for or mimic the agent?" says Judah Folkman of Children's Hospital in Boston, who pioneered the study of blood vessel–growth inhibitors to combat cancer.

This class of drugs continues to gain new members. Other Boston researchers report in the same issue of PNAS that they isolated a compound from human cartilage that inhibits blood vessel growth in mice. *—L. Helmuth*