that they could restore class I expression to the mutant cells by replacing a mutant transporter gene with a good one.

In addition to finding the components for peptide transport, immunologists are also identifying the structures that produce the peptides in the first place. Just last fall, researchers in Monaco's and Trowsdale's laboratories independently produced evidence suggesting that the production occurs on a structure called a low-molecular mass polypeptide (LMP) complex, which resembles a proteasome, described by Monaco as a "big ball of degradative enzymes."

Now that immunologists have a good idea of how both intracellular and extracellular antigens are prepared for display on the cell membrane, they are moving ahead to try to understand why some antigens elicit stronger immune responses than others—information that could help produce more effective vaccines. And other immunologists, like McMichael, are exploring the connection between antigen processing and human disease. The story, says McMichael, is becoming remarkably clear. "Molecular structure is fitting together with cell biology and old fashioned immunology and virology. It's all coming together to give the same picture." ■ MICHELLE HOFFMAN

ADDITIONAL READING

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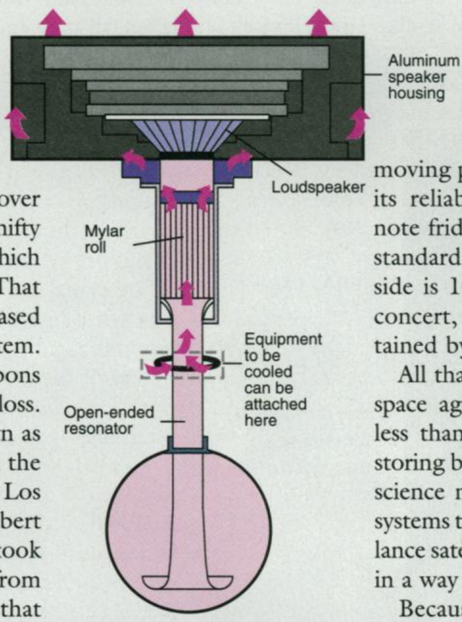
Acoustic Fridge Takes to Space

Rock and roll loudspeakers have always been used to make the coolest music around. Until now, however, they've never been thought of as actual cooling devices. But that's all changed, thanks to the work of Steven Garrett and his colleagues at the Naval Postgraduate School in Monterey, California. Building on work done over the past decade, Garrett's team has designed a nifty refrigerator powered by a standing sound wave, which flew this week on the space shuttle Discovery. That flight was a test, but in the future refrigerators based on this concept could become a hot commercial item. And, since they contain no chlorofluorocarbons (CFCs), they might even help slow global ozone loss.

The principle behind the space cooler, known as thermoacoustic refrigeration, was developed in the 1980s by a team that included Garrett and Los Alamos scientists Gregory Swift, Tom Hofler, Albert Migliori, and the late John Wheatley. They took their inspiration from the laws of acoustics and from the centuries-old observations of glass blowers that when they heat one end of a glass tube while keeping the other cool enough to touch with their lips, the temperature gradient sometimes sets up a sound wave, causing the tube to "sing." The thermoacoustic refrigerator does just the reverse: It exploits sound waves to create a temperature gradient.



It's a gas. *Expansion and compression of a helium-xenon mix* (pink) *causes heat flow* (arrows) *out of the acoustic fridge.*

SOURCE: STEVEN GARRETT ILLUSTRATION: J. CHERRY

The new fridge is decidedly low-tech—and true to the spirit of garage rock. Its 4-inch JBL loudspeaker plays one note—roughly concert A—very loud. The note is just the right frequency to set up a standing sound wave in a cylindrical tank filled with a mixture of helium and xenon at a pressure of 10 atmospheres. The sound wave causes the gas at each spot in the tank to go through cycles of compression and expansion. That's the key to the device, because gas heats up a bit when compressed and cools as it expands.

The refrigerator capitalizes on that heating and cooling cycle with a low-tech heat absorber: a rolled-up sheet of mylar that fills the upper end of the chamber that holds the gas. Spacers made of fishing line create gaps that allow the gas to permeate the mylar jellyroll. When a compression phase of the sound wave comes along, the gas molecules collide with the mylar and transfer some of their heat to it. The mylar in turn passes the heat to the speaker-casing, from which it radiates away. Then, when the gas expands, it cools further than it would otherwise, since some of its heat has been drawn off. The process causes a progressive cooling, which can be exploited for refrigeration.

The result is a fridge that uses no ozone-eating CFCs and has only one moving part (the speaker), which should boost its reliability. Remarkably enough, the one-note fridge is also quieter on the outside than standard models; although the noise level inside is 10,000 times that of a Rolling Stones concert, the high-frequency sound is easily contained by the chamber walls.

All that piqued NASA's interest, because the space agency's other refrigeration options are less than ideal. A freon-based refrigerator for storing biological samples failed on a shuttle life-science mission last year, and the refrigeration systems that keep the equipment cool on surveillance satellites are also problematic: They vibrate in a way that disturbs imaging equipment.

Because of these problems, General Electric, which provides NASA with its life-science refrigeration, and the Department of Defense have contracted with the Navy group to develop the thermoacoustic alternative. The model being tested for the first time on the Discovery is a cryo-cooler, designed to maintain equipment at very low temperatures such as those required on surveillance satellites. But the next generation—for which Garrett's group already has a G.E. contract and a future shuttle berth—will run at the temperatures of a home refrigerator.

Speaking of home refrigerators, the rock and roll fridge's advantages could play well on terra firma as well; Garrett says it could be less expensive to produce than today's models, and just as durable. In fact, he says the only thing keeping the acoustic fridge out of American homes is a lack of interdisciplinary talent: "The people who do refrigeration don't know acoustics."

Maybe that's the reason why there's been so little interest from terrestrial refrigerator manufacturers. Whatever the reason, Garrett thinks "it's a sin that it has to be tested in space. It should be tested in Whirlpool's home-economics lab." That's not to say that there are no cool companies: Volvo has inquired about the possibility of developing an acoustic car air conditioner. But Garrett and his team are, for the moment, spread too thin to give it much of their time. ■ MARCIA BARINAGA