▶ LIFE

By Kirsten Weir

Cell Shock

Surprised scientists are finding new structures in cells.

Open any biology textbook to the chapter on cells and you'll see a diagram like the one on the next page. You'll see a nucleus, ribosomes, and many other *organelles*—tiny structures with distinct functions inside the cell.

The standard diagram of the cell has looked pretty much the same since the 1800s. Any biologist knows it like the back of his or her hand. Lately, however, scientists have discovered all sorts of mysterious new structures inside cells. Is it time to update the diagram?

"Everything in the textbook is established and correct, but there's a lot more going on," says Daniel Davis, a biologist at Imperial College London. "It's clear we're at a revolutionary moment for cell biology."

STRINGS AND SACS

Jim Wilhelm, a cell biologist at the University of California, San Diego, and his students have discovered dozens of new formations in yeast cells. "We seem to find a new one every few weeks," he says. In some cases they've found matching structures in mammal cells too.

Some of those structures are long, threadlike strands studded, like beads on a string, with hundreds or thousands of *enzymes*. Enzymes are proteins that drive the chemical reactions in cells. The stringy structures might help cells switch enzymes on and off all at once, Wilhelm suggests.

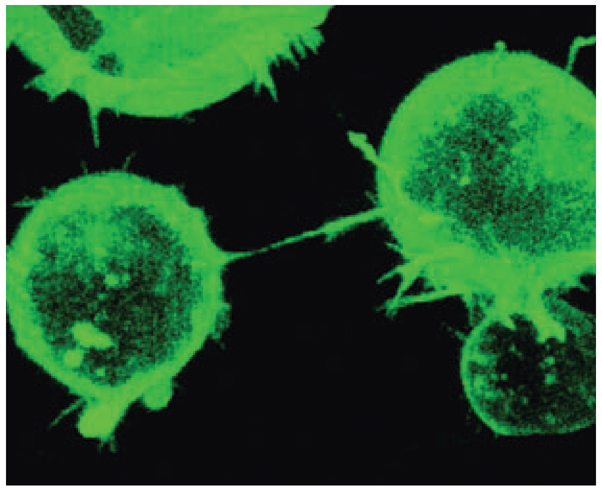
Other researchers have zeroed in on little membrane-enclosed sacs that form inside the cells of many organisms, including our own. After the sacs materialize, they're cast out of the cell. Scientists discovered those structures, called *exosomes*, in the 1980s and mostly ignored them after that. Now exosomes are getting a second look. Some, it appears, carry *messenger RNA*—molecules that contain the chemical blueprints for the construction of proteins. Exosomes might play a role in the important job of protein production.

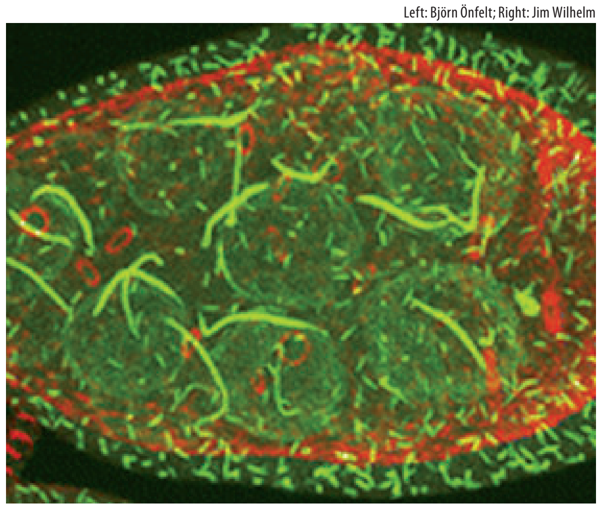
KILLER TUBES

Another intriguing discovery is *nanotubes*—long, thin tubes that stretch between cells and are up to 10 times longer than the cells themselves, says Davis. He studies nanotubes in human *white blood cells*—immune cells that destroy cancer cells or harmful intruders such as bacteria and viruses.

Scientists have always thought that white blood cells are like most other cell types: They communicate with one another by secreting molecules that act as messengers. Nobody thought that cells connect structurally with one another over long distances, Davis says. But when he took a closer look at white blood cells, he found nanotubes connecting them. "Immune cells aren't supposed to do that," he says. Turns out they do.

Left: Björn Önfelt; Right: Jim Wilhelm

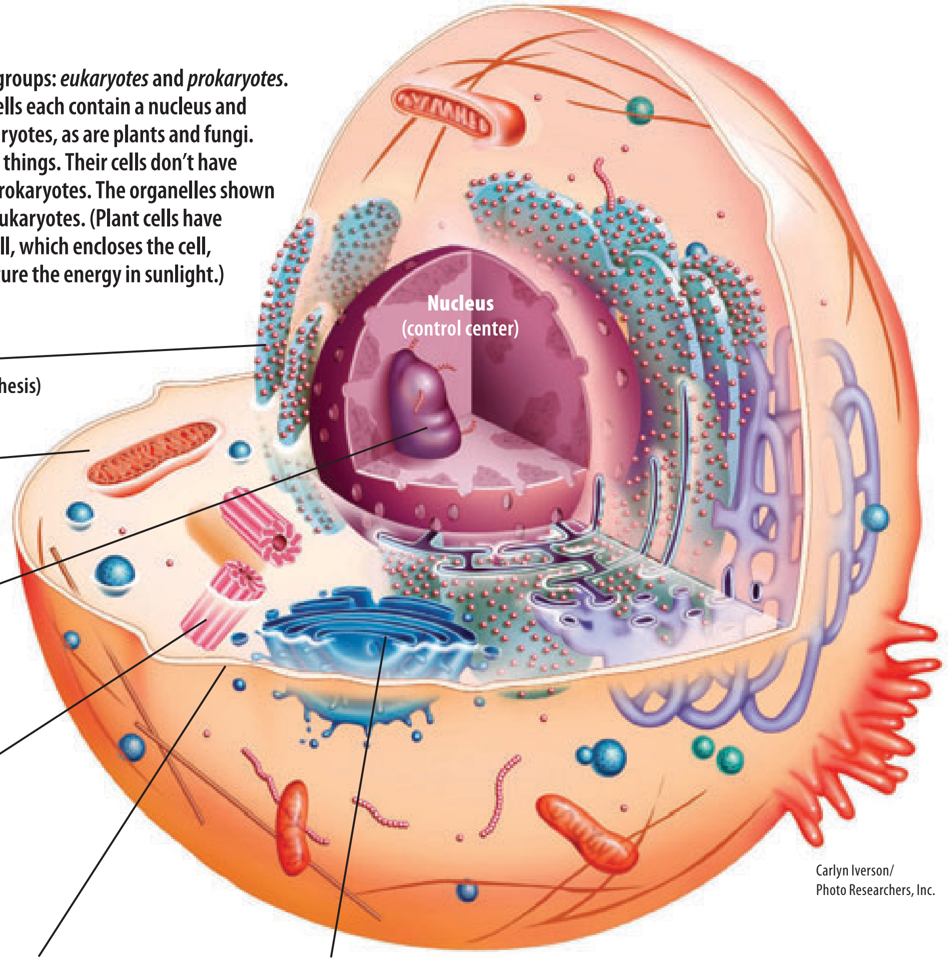




Extreme close-ups of two immune cells connected by a nanotube (left) and threadlike structures that carry enzymes inside a cell (right)

An Inside Look

Living things can be split into two groups: *eukaryotes* and *prokaryotes*. Eukaryotes are organisms whose cells each contain a nucleus and many organelles. Animals are eukaryotes, as are plants and fungi. Prokaryotes are the simplest living things. Their cells don't have nuclei or organelles. Bacteria are prokaryotes. The organelles shown in this animal cell are found in all eukaryotes. (Plant cells have some extra features: a rigid cell wall, which encloses the cell, and green chloroplasts, which capture the energy in sunlight.)



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So far, it isn't clear what goes on in the nanotubes in white blood cells. Davis believes cells use them to communicate with one another. They also seem to play a role in fighting illness. White blood cells decide whether other cells are diseased or harmful by sticking to them. If they are, the white cells attack. "These long tethers allow that to happen over long distances," Davis says. He has watched a white blood cell send its nanotube tether out to a tumor cell and kill it.

Nanotubes appear to have a downside too. Davis found that viruses such as HIV, which causes AIDS, can use the tubes like zip lines to whiz from cell to cell. The tubes enable the virus to be highly efficient, infecting many cells in a short amount of time.

Scientists studying new cell structures are driven by a desire to understand the basic units of life itself. But Davis's findings highlight another good reason to study each detail of the cell. Understanding the tiny structures might someday help scientists develop better ways to fight diseases such as AIDS and cancer.

NEW TOOLS

People have been peering through microscopes for hundreds of years. How did the newfound cell structures stay hidden for so long? New, more powerful microscopes deserve some of the credit. So do new lab tools and techniques such as *genetic engineering* and *green fluorescent protein* (*GFP*). Genetic engineering is the direct manipulation of an organism's DNA using modern technology. GFP is a glow-in-the-dark protein that occurs naturally in jellyfish.

Today, scientists can take the gene that codes for GFP from jellyfish and insert it into the DNA of another organism. That procedure makes any proteins or structures of interest in the cells of the other organism glow brightly, rendering them visible to the human eye.

"That was a breakthrough," Davis says. "You can make a green, glowing version of any protein you want to follow around the cell."

New technology isn't the only reason why new cell structures are coming to light. Just as important, Wilhelm says, are the questions that curious researchers are asking. "I always suspect there's more unknown than known at any given time," he says. "It's just a matter of rephrasing the questions that people are used to asking, or looking at them in a slightly different way." **CS**