Cellular transit system gets meter reading

Using laser-beam "tweezers" that function like Star Trek tractor beams, scientists have measured the forces generated by tiny biological engines inside living cells. The study – in which researchers put the brakes on cell components that normally zip around within cells – provides the first direct measurements of the mechanical energy exerted by this basic machinery of life.

The investigators focused on a miniature monorail system found in many cells. The "rails" consist of protein strands called microtubules. Along this network run specialized cell components called organelles – including mitochondria, the mobile mini-reactors that generate and deliver energy to the farthest reaches of intracellular space. Mitochondria and other organelles move along the microtubules by latching onto one or more "motor proteins" such as kinesin or dynein. These locomotive proteins pull themselves and their cargo along the microtubule railways.

Until now, researchers had only rough estimates of the forces generated by locomotive proteins. The new work, led by physicist Arthur Ashkin of AT&T Bell Laboratories in Holmdel, N.J., and cell biologist Manfred Schliwa of the University of California, Berkeley, replaces those estimates with direct measurements made within living cells.

The team applied a gradient-force optical trap, or "optical tweezers," to mitochondria cruising along microtubules within an amoeba. The tweezers use beams of photons to push around tiny objects or hold them in place (SN: 3/10/90, p.148). First, the researchers applied enough force to bring individual mitochondria to a screeching halt. Then they noted how much they had to tone down the laser before the organelles started moving again, figuring that the minimum amount of force needed to keep the organelles stationary must equal the force of the motor system itself. That comes to about 2.6×10^{-7} dynes per motor, they report in the Nov. 22 NATURE.

"On an absolute scale, it's not a lot of force," Ashkin says. "But on the scale of these beasts, it's quite impressive." He calculates that from a mitochondrion's point of view, that's about 1,000 times the force of gravity. Seen another way, it's enough force to propel an average-size bacterium through water at about 1 millimeter per second. With most mitochondria pulled along by two or three motor molecules at once, the forces create a powerful transport system that can maintain constant mitochondrial velocities over the wide range of viscosities encountered within cells, Ashkin says.

Steven M. Block, a motor-molecule specialist at the Rowland Institute for Science in Cambridge, Mass., comments that the work foreshadows a future when scientists will understand the mechanical details of biological motility on a molecular level. "How chemical energy in cells gets transduced into mechanical displacement remains completely obscure," Block says. "Optical tweezers provide an exciting new tool that may at last make that understanding possible."

For now, the research remains very basic. Block points out, however, that molecular motors play critical roles in such diverse processes as cell division and muscle contraction, and that motor defects may underlie a variety of diseases or cellular abnormalities. – *R. Weiss*

Smoking silences critical pain messages

Cigarette smoking, already known as a heart-disease villain, may also blunt the perception of pain, preventing smokers from noticing potential warning signs of an impending injury. This new finding might help explain previous indications that smokers with coronary artery disease, compared with nonsmokers with similarly clogged arteries, appear less likely to experience chest pain during episodes of ischemia – a reduction in blood flow to the heart that can lead to a sudden heart attack.

Scientists can't explain the smoking-related masking of pain, but animal studies hint that nicotine may block transmission of pain impulses.

Paula F. Miller and David S. Sheps at the University of North Carolina School of Medicine in Chapel Hill focused on 20 healthy men aged 19 to 44 who smoked an average of 23 cigarettes daily, and five nonsmoking men in the same age range. The researchers instructed volunteers not to smoke for 12 hours prior to the study's start. Then they applied a heat probe to each volunteer's forearm, letting the probe heat up gradually, and recorded the individual's pain threshold – the temperature at which he first felt pain. Smokers and nonsmokers showed similar pain thresholds on this initial test.

Having gathered their baseline data, the investigators next instructed smoking volunteers to smoke three cigarettes of their usual brand, with a 10-minute wait after the first cigarette and a 30-minute wait after the second. Repeats of the heat probe test revealed that the smokers had become less sensitive to pain from the heat. On average, this group's "ouch" threshold rose from 44.9°C (112.8°F) before smoking to 45.5°C (113.9°F) after two or three cigarettes – a small but statistically significant difference, says Miller, who described the results in Dallas last week at the American Heart Association's 63rd Scientific Sessions. The maximum pain the 20 men could tolerate increased after smoking, Miller notes, whereas nonsmokers showed no change in pain threshold or tolerance.

While these findings suggest that healthy male smokers tolerate pain better than their nonsmoking counterparts, Sheps says further research must demonstrate this effect among male and female smokers with coronary artery disease. As for the pain-subduing mechanism underlying "silent" ischemia, he speculates that nicotine blunts pain messages by binding with nerve cells.

If studies confirm that suspicion, the implications may extend beyond silent ischemia. Nicotine's proposed pain-masking effect, says Sheps, may help explain why smokers have such a tough time kicking the habit. –*K.A. Fackelmann*

Boreal lake offers preview of warming

While scientists remain uncertain whether the expected global warming has begun, a lake in the boreal forest of Ontario offers a disturbing glimpse of ecological changes that may lurk around the century's corner.

The portentous findings emerge from a unique, long-term project in which researchers have been monitoring conditions within many small lakes in northwestern Ontario over the past 20 years. Because the region has warmed considerably during that time, the project provides an in-depth look at the kinds of changes that could accompany a global greenhouse warming, assert David W. Schindler of the University of Alberta in Edmonton and his colleagues at the Canadian Department of Fisheries and Oceans in Winnipeg, Manitoba. They discuss their observations of one particular lake, known simply as #239, in the Nov. 16 SCIENCE.

"This is going to be an absolutely vital data set for looking at the effects of global warming on aquatic ecosystems in lakes. I don't know of any other region where they have that kind of long-term record," says Eville Gorham, an ecologist and lake expert at the University of Minnesota in Minneapolis.

The Canadian team found that the average air and lake temperatures in this part of Ontario have risen a significant 2°C since 1970. Snowfall and rainfall have dwindled slightly and evaporation has increased dramatically, causing a general drying of the watershed. In the driest years, large fires have swept through the region. The scientists also note that winter ice on Lake 239 now melts several weeks earlier in the springtime than it did at the beginning of the project.