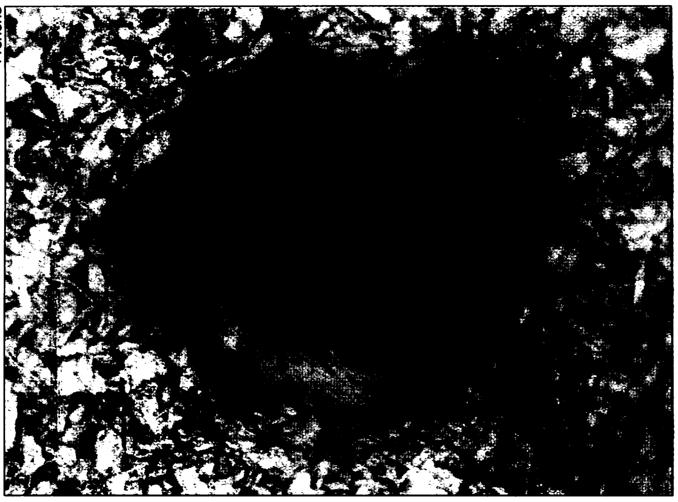
Frerichs



A hibernating ground squirrel curled up in its laboratory burrow.

hibernating animals rockets to four times that measured during nonhibernating periods. Moreover, the amount of ascorbic acid in the cerebrospinal fluid that bathes the central nervous system doubles during hibernation. "It seems an important strategy to build up this extracellular store of ascorbic acid," says Rice.

The researchers also noticed that when a squirrel roused temporarily from its torpor, a periodic occurrence for most hibernators, its vitamin C supply returned to normal within hours.

"When they go down into hibernation, ascorbic acid goes up. And as soon as they warm up, it goes away really fast," says Drew.

The investigators believe that the increased supply of vitamin C protects the squirrel's brain from the rush of free radicals that occurs when torpor ends, blood flow to the brain resumes, and cells begin vigorously generating energy. To confirm this hypothesis, the scientists plan to reduce the amount of ascorbic acid in the blood of hibernating squirrels and observe whether that induces any brain damage.

They hope that such experiments will ultimately lead to a way to curtail the brain cell death that follows a stroke's initial wave of destruction. "Some of the damage [from a stroke] is caused by the lack of oxygen and glucose during the reduced blood flow. Other damage is caused once the blood flow starts again," notes Drew.

This resumption of blood flow, known as reperfusion, apparently exerts fatal stress on some cells as they try to recover from the stroke. To combat this reperfusion-induced damage, physicians might infuse ascorbic acid or another antioxidant into a patient's blood, suggests Rice.

Seeking further clues to how squirrels withstand torpor and their periodic emergence from it, Drew also plans to examine another curiosity concerning hibernation: Reports dating back to the 1950s have noted that the blood of hibernating animals clots slowly.

Drew has confirmed those observations with her arctic ground squirrels. "Their blood didn't clot in 24 hours," she says.

She is now trying to identify the anticlotting factor, or missing clotting factor, that would explain this unusual phenomenon.

The investigators conducting this hibernation research can offer no guarantees that their results will one day help stroke patients, yet they note that the frustrating history of stroke treatment research argues that no potential line of inquiry should be ignored.

"My main interest is clinical. I want to see something end up in an IV bottle and dripping into patients. That's the ultimate goal," says Frerichs. □

Biology

Biological clocks fly into view

Clocks are ubiquitous in today's society. In addition to their traditional homes on mantles, nightstands, and wrists, timepieces now appear on VCRs, computer screens, TVs, microwave ovens, and much more. Nature's fondness for clocks may be even more impressive, however. Scientists report in the Nov. 28 SCIENCE that the fruit fly harbors biological clocks in its head, thorax, abdomen, leg bristles, wings, antennae, and proboscis. "We were really shocked there were these light-resettable clocks throughout the animal," says Steve A. Kay of the Scripps Research Institute in La Jolla, Calif.

Biological clocks are the internal timekeepers that generate circadian rhythms, the day-long cycles of activities. One clock has been well documented in the brains of many animals. Its rhythm governs several easily observable behaviors such as sleeping, and it has been considered the body's master clock. Yet investigators have found that other tissues seem to maintain their own biological clocks. For example, Jadwiga M. Giebultowicz of Oregon State University in Corvallis and her colleagues have found biological clocks in the testes of moths and in the fruit fly's Malpighian tubules, excretory organs similar to kidneys.

By linking the activity of *per*, a gene that acts as a gear in the fly's biological clock, to genes encoding fluorescent markers, Kay and his colleagues obtained striking visual evidence of daily cyclical activity in almost every fruit fly tissue studied. They could reset each clock by exposing isolated tissues to a new light-dark cycle. Rather than being controlled by the clock in the fly's brain, the other clocks may be governed independently by the day-night cycle, suggests Kay. "The master clock for the fruit fly is sunlight," he proposes.

The new work is "mind-boggling. It suggests that there are circadian oscillators all over," says Michael Menaker of the University of Virginia in Charlottesville, who discovered that the mammalian retina has its own biological clock (SN: 4/20/96, p. 245). Unfortunately, adds Menaker, scientists still have few clues to why most of these clocks exist and whether they indeed act independently or form a hierarchy.

Kay and his colleagues now plan to repeat their fruit fly work in mammals by creating transgenic mice in which clock genes are linked to genes encoding fluorescent markers. They will also explore how the individual fly clocks perceive light. "It looks like the circadian photoreceptor is not going to be a known visual pigment," says Kay. —*J.T.*

Resolving the magnetoreception puzzle

Birds and bees do it. So do turtles and fish. All these creatures seem to discern Earth's magnetic field and use that information to chart migratory paths or perform other navigational tasks. Yet the sensory apparatus that makes such feats possible has remained a mystery.

Some investigators have proposed that iron-rich particles called magnetite, which have been found in the brains of several animals, make possible the detection of weak magnetic fields. A few years ago, a research group led by Michael M. Walker of the University of Auckland in New Zealand reported that rainbow trout have particles that appear to be magnetite and a nerve that responds to shifting magnetic fields (SN: 7/8/95, p. 31). In the Nov. 27 NATURE, the same group now describes behavioral experiments demonstrating that the fish can indeed perceive magnetic fields. Moreover, sensory cells near the magnetitelike particles connect to the nerve that fires when the trout is exposed to a magnetic field.

"This is the first real, concrete evidence that magnetite might actually be the basis of a sensory response," says Charles Rafferty, a magnetoreception investigator at the Electric Power Research Institute in Palo Alto, Calif. —*J.T.*