Observations

Opinion, arguments & analyses from the editors of Scientific American

Hibernating black bears suggest new paths for tissue preservation [Video]

By Katherine Harmon | Feb 17, 2011 04:30 PM | 0

Some mammals have an attractive solution for coping with long winters—sleep through them. Black bears (*Ursus americanus*) for example can hibernate for five to seven months of the year, going without food and water or the light of day.

Fat loss and perhaps a little grogginess aside, when they emerge from their dens in the springtime, the bears seem no worse for the wear. The secrets to their successful hibernation, in which bone and muscle mass remain intact despite long periods of nonuse, have eluded scientists, who had trouble consistently monitoring the large animals in naturalistic conditions.

A new study offers insights into this metabolic limbo that might eventually prove medically useful in preserving human tissue after trauma or during long periods of inactivity (by decreasing energy and oxygen demands) if scientists can find the genetic pathways responsible for these shifts. "We simply need to learn how to turn things on and off to induce state that take advantage of the different levels of hibernation," Øivind Tøien, of the Institute of Arctic Biology at the University of Alaska Fairbanks and co-author of the new study, said in a prepared statement.

Follow Scientific American

Scientific American Newsletter
Get weekly coverage delivered to your inbox.
Enter your email address Sign Up Now

Scientific American Blogs

Scientific American Observations
Opinions, Arguments & Analyses from the Editors of *Scientific American*

Bering in Mind
A Research Psychologist's Curious Look at Human Behavior

Cross-check
Critical views of science in the news

Extinction Countdown
News and Research about Endangered Species from Around the World

Solar at Home
The Trials, Tribulations, and Rewards of Going Solar

Expeditions

Unlike smaller hibernators, such as ground squirrels, which can allow their body temperatures to approach freezing, the 34- to 104-kilogram black bears maintain a relatively high body temperature of 30 to 36 degrees Celsius during torpor. Most other hibernating animals have been observed to consistently halve their metabolic rates for each 10 degree C body temperature reduction. But the black bears lowered their metabolisms by 75 percent—without decreasing their body temperature more than an average of five to six degrees.

What was even more unusual, the researchers found, the bears' body temperatures changed cyclically over multiple days. (Smaller hibernating mammals go through periods of spontaneous arousal during which they raise their body temperature.)

"We knew that bears decreased their body temperatures to some degree during hibernation," Tøien said. But he and his colleagues found that "these black bears regulate their core temperature in variable cycles over a period of many days, which is not seen in smaller hibernators and which we are not aware has been seen in mammals at all before." The temperature cycles ranged from 1.6 to 7.3 days.

The results of the work were presented February 17 in Washington, D.C., at the annual meeting of the American Association for the Advancement of Science and will be published February 18 in *Science*.

For the study, five black bears were collected from central Alaska and transported to mock hibernation dens scattered throughout a wooded area near Fairbanks. Throughout the fall, winter and spring, an implanted radio transmitter kept track of heart rate, body temperature and muscle movement, and an air sensor recorded oxygen and carbon dioxide levels to assess breathing and thus metabolic rates. Infrared cameras documented the bears' movements.

"They function pretty much like a closed system—all they need is air," Brian Barnes, also of the Institute of Arctic Biology and study co-author, said at a press conference. The bears changed positions or got up one to four times every two days, and could be observed shivering to bring their body temperature up when it dipped close to 30 degrees C.

As part of the overall metabolic decrease, the bears' heart rate slowed substantially from a summer level of 55 beats per minute. During hibernation, heart rate would drop to nine beats per minute between breaths—which often occurred only once or twice per minute—and then speed up with each inhale. "The bears show an extreme form" of this phenomenon, known as sinus arrhythmia, in which heart rate varies with breathing, Tøien said.

Female bears will even gestate, give birth and lactate during hibernation, and the one pregnant bear in the study had a low metabolism consistent with the other bears

but kept a higher body temperature until the birth of her cub. The researchers suggested that keeping a warmer and more stable body temperature might be important for embryonic development.

When the bears left their experimental dens in the spring, their average resting heart rates had risen from 26 percent to about 43 percent of summer rates and their core temperatures were soon back up close to summer levels. But their metabolisms were sluggish for a few weeks, which was "very surprising," Tøien noted at the press conference.

Funding for the study came in part from the U.S. Military, which, Barnes noted at the press conference, is interested in work that might improve rehabilitation for injured veterans, who often have to battle muscle atrophy after lengthy, bed-bound recovery from other injuries.

The bears, he explained, "are quite immobile" during hibernation, "yet somehow they've tricked their tissue—their bones and muscles—to think they're doing work." Other labs are currently looking for molecular pathways that might be behind this sleight of slumber.

As Gerhard Heldmaier, of the department of animal physiology at Philipps-University Marburg in Germany explained in an essay published in the same issue of *Science*, a torpor-state metabolism is generally characterized by a decrease in adenosine 5'-triphosphate (or ATP), which is involved in energy transfer within cells. But the precise pathways involved in this shift remain unknown.

"If we could discover the genetic and molecular basis for this protection, and for the mechanisms that underlie the reduction in metabolic demand," Barnes said in a prepared statement, "there is the possibility that we could derive new therapies and medicines to use on humans to prevent osteoporosis, disuse atrophy of muscle, or even place injured people in a type of suspended or reduced animation until they can be delivered to advanced medical care—extending the golden hour to a golden day or a golden week."

And, as Tøien noted at the AAAS meeting, the tricks of hibernation could even be exported into outer space, to help humans cope with the ill effects of zero gravity.

Image of young male black bear emerging from hibernation during study, image of young hibernating male black bear during study, and infrared video of snoring black bear during hibernation all courtesy of Øivind Tøien/Institute of Arctic Biology/University of Alaska Fairbanks