Squirrels recycle to survive winter

An Arctic animal reuses muscle nutrients while hibernating

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In a hibernating Arctic ground squirrel (one held by a researcher), nitrogen from broken-down muscle gets incorporated into other tissues in the body.

Arctic ground squirrels can survive harsh winters with below-freezing temperatures by holing up for some eight months without eating. These hibernators "live at the most extreme edge of existence, just barely hovering over death, and we don't fully understand how this works," says Sarah Rice, a biochemist at the University of Alaska Fairbanks.

By snooping on what goes on inside these squirrels, researchers now have a better idea. Nutrients recycled from muscle breakdown help the animals get by during hibernation, Rice, and colleagues report December 7 in *Nature Metabolism*.

From autumn to spring, Arctic ground squirrels (*Urocitellus parryii*) hibernate in bouts of deep torpor. In a state akin to suspended animation, the squirrels breathe just once a minute, and their hearts beat five times per minute. Every two or three weeks, the squirrels revive somewhat for between about 12 and 24 hours: Their body temperatures rise, and the animals shiver and sleep, but don't eat, drink, or defecate.

To monitor body chemistry, "I worked in dark, cold chambers — utterly quiet — surrounded by hibernating squirrels," Rice says. Periodically, she carefully withdrew blood from tubes inserted in their blood vessels.

During the squirrels' torpor, Rice and colleagues observed a chemical signal indicating that skeletal muscle was slowly breaking down. That process would release compounds containing nitrogen, an element important for making the proteins found in muscle. But hibernators, including these squirrels, are known to hang on to muscle mass as they hibernate. So, the scientists wondered whether the squirrels build up new stores of protein during hibernation, and if so, how.

Tracking the flow of nitrogen in the animals' bodies provided clues. The researchers gave the critters a cocktail of chemicals labeled with isotopes, forms of elements having different masses. During those brief periods between bouts of torpor, nitrogen went into amino acids, the building blocks of proteins, that formed in the animals' muscles and in the lungs, kidneys and other areas of the body, the researchers discovered.

By recycling nutrients from their muscles, the squirrels sustain themselves and avoid a toxic consequence of muscle breakdown, says team member

Kelly Drew, a neurochemist also at the University of Alaska Fairbanks. During hibernation, nitrogen would otherwise end up forming ammonia, which could build up to potentially deadly levels. Instead, the squirrels can incorporate that nitrogen into new molecules, she says.

Other studies have pointed to a role for the microbiome — the microbes living on and inside animals — in recycling nitrogen while animals hibernate, says James Staples, an environmental physiologist at Western University in London, Canada. Typically, the breakdown of proteins eventually creates urea, a nitrogen-containing chemical that gets excreted. Microbes can scavenge that urea and release its nitrogen, which can be reabsorbed back into the blood. But in the squirrels, the muscle is "being broken down and then recycled directly back into these amino acids ... the gut microbiome may not be as important as we thought."

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Insights from hibernators could someday help humans, says Sandy Martin, a biochemist at the University of Colorado School of Medicine in Aurora. "Hibernators are so extraordinary" in their abilities to withstand conditions that humans are extremely sensitive, she says. For instance, animals like these squirrels are far more resistant to the harm that can result when organs don't receive necessary blood flow and oxygen. And harnessing hibernation-like approaches could prove advantageous in cases where a slower metabolism would be useful, from routine surgery to long voyages in space, she says.

Summarize > **Based on the previous article, complete the summary below. Use information taken directly from the text. Use NO MORE THAN TWO WORDS IN EACH BLANK.**

In nature one of most extreme hibernators are the arctic ground squirrels, which surviving 1. _____ temperatures can almost remain 'dead.' Researchers have been intrigued about this phenomenon and have found the answer: *recycling nutrients from muscle breakdown*. During their state of hibernation, the arctic ground squirrels barely 2. _____ and reach a low heart rate of five beats per minute. In fact, these animals 3. _____ for some hours every two or three weeks. Sarah Rice and her colleagues have monitored these squirrels, taken blood samples, and observed that their 4. _____ breaks down slowly releasing nitrogen, which is 5. _____ for protein-making. According to these researchers, the squirrels survive incorporating this element into 6. _____ formed inside squirrels' muscles and lungs. Other researchers have claimed that 7. _____ inside the squirrels may also help them to live during their hibernation. Finally, there is a lot to learn from hibernators and their unique ways to survive since they can be more 8. _____ when their organs lack blood flow and oxygen. In fact, this would be advantageous in surgical procedures or 9. _____ travel.

Finding Facts and Details > **Based on the previous article, decide if the following statements are TRUE or FALSE.**

	TRUE	FALSE
10. Arctic ground squirrels hibernate in winter for nearly three months.		
11. Dr. Rice obtains tissue samples from squirrels to analyze their body chemistry.		
12. Sandy Martin studies microbes to understand squirrels' hibernation processes.		
13. Arctic ground squirrels may survive without eating for more than six months.		
14. Squirrels' organs such as lungs or kidneys may be affected while hibernating.		
15. The influence of microbiomes seems to have little relevance with the object of the study of the arctic ground squirrels' hibernation.		

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