

HIBERNATION METABOLISM

in

American Black Bears



ANIMAL PHYSIOLOGY & BEAR HIBERNATION

- Physiology – study of the functions of living organisms and their parts (organs, tissues, or cells)
- Hibernation – reduced metabolism in seasons of reduced food and cold temperatures



ANIMAL PHYSIOLOGY & BEAR HIBERNATION

QUESTIONS:

- During hibernation, how does a bear get energy without eating?
- What keeps a bear's muscles strong without exercise for up to 7 months?
- How do female bears successfully produce cubs while hibernating?



ANIMAL PHYSIOLOGY



- Seeks answers to two central questions about how animals work:
 1. How do the parts in the body system work together?
 2. How did this system come to be?
- How does a bear's 'physiology' allow it to hibernate?

ECOLOGY

- Ecology – relationships of organisms with each other and their non-living environment
- Atoms in animals are in dynamic exchange with atoms in their environment



METABOLISM



- Metabolism – life processes within animal bodies, including physiological responses to internal and external environments
 - Anabolism – molecule building, energy needed
 - Catabolism – molecule breakdown, energy released

HOMEOSTASIS

- Homeostasis – a state of balance in the body
- Living things need systems that control body processes (metabolism) so they can respond to environmental change and maintain an internal balance (regulation or homeostasis)
- What's going on in bears?



5 STAGES OF BLACK BEAR ACTIVITY



Annual Cycle:

1. Normal Activity
2. Hyperphagia
3. Fall Transition
4. Hibernation
5. Walking Hibernation

STAGE 1 – NORMAL ACTIVITY

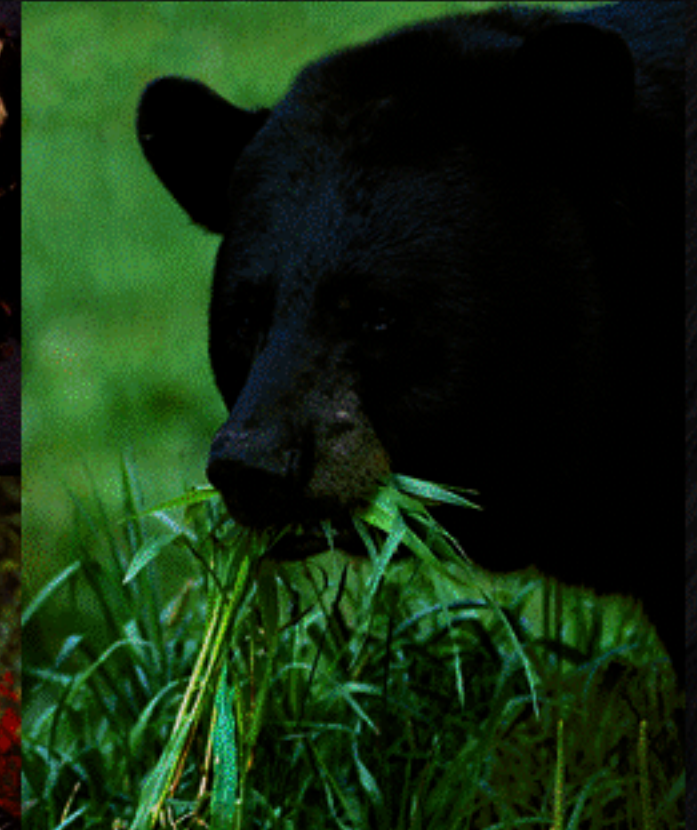
- Spring green-up to mid-summer or fall, depending on location
- In good food years, bears eat 5000-8000 kilocalories per day
- Food shortage in summer can cause starvation rather than hibernation
- Adult active heart rates: 80-100 beats per minute



STAGE 1 – NORMAL ACTIVITY

A Sampling of Bear Foods

- Easily digestible early spring greens (wild calla, grasses, various flowers)
- Insect larvae, occasionally small animals
- Blackberries, blueberries, swamp dewberries, cherries, dogwood berries
- Beechnuts, acorns, hazel nuts, hickory nuts



STAGE 2 – HYPERPHAGIA



- Hyperphagia – excessive eating to produce fat
- Mid-summer to fall
- May consume 15-20,000 kilocalories per day
- Stored fat provides energy for survival without eating during hibernation

STAGE 3 – FALL TRANSITION

- **Body processes are preparing for hibernation – eating less**
- **Lack of energy (lethargy) – may rest up to 22 hours a day**
- **Adult active heart rates may fall from 80-100 to 47-60 beats per minute**
- **Sleeping heart rates fall from 66-80 to 22 beats per minute**



STAGE 4 – HIBERNATION

- Reduced metabolism in seasons of reduced food and cold temperatures
- Onset of hibernation varies with region, genes, food supply, and stage of life
- Fat bears, especially pregnant females, den first
- Hibernation is typically 3-4 months in eastern deciduous forests and 5-8 months farther north



STAGE 4 – HIBERNATION

- In southern areas where food is available in winter, many bears remain active
- In eastern deciduous forests, some bears remain active in winters when acorns or beechnuts are abundant
- In northern regions where food is not normally available in winter, bears hibernate



THE HIBERNACULUM



Cedar trees stripped of bark to use as bedding

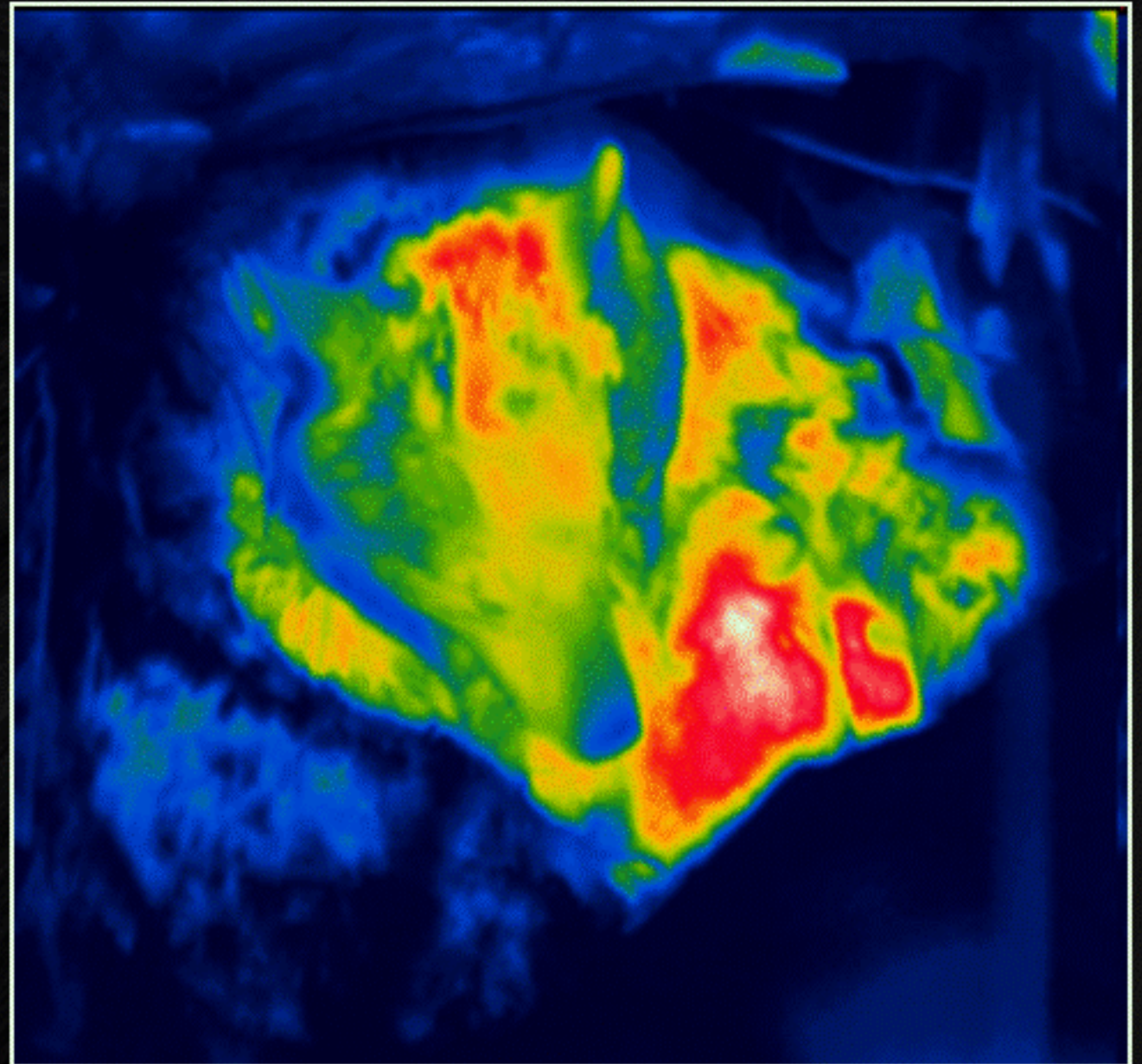
- Hibernaculum – the place an animal hibernates (for example, a bear's den)
- Bears may dig a den, use rock crevices, hollow trees, culverts, brush piles, or an open 'nest'
- Bears usually rake a bed of soft materials to lie on
- Orphaned cubs create dens and rake bedding without being taught





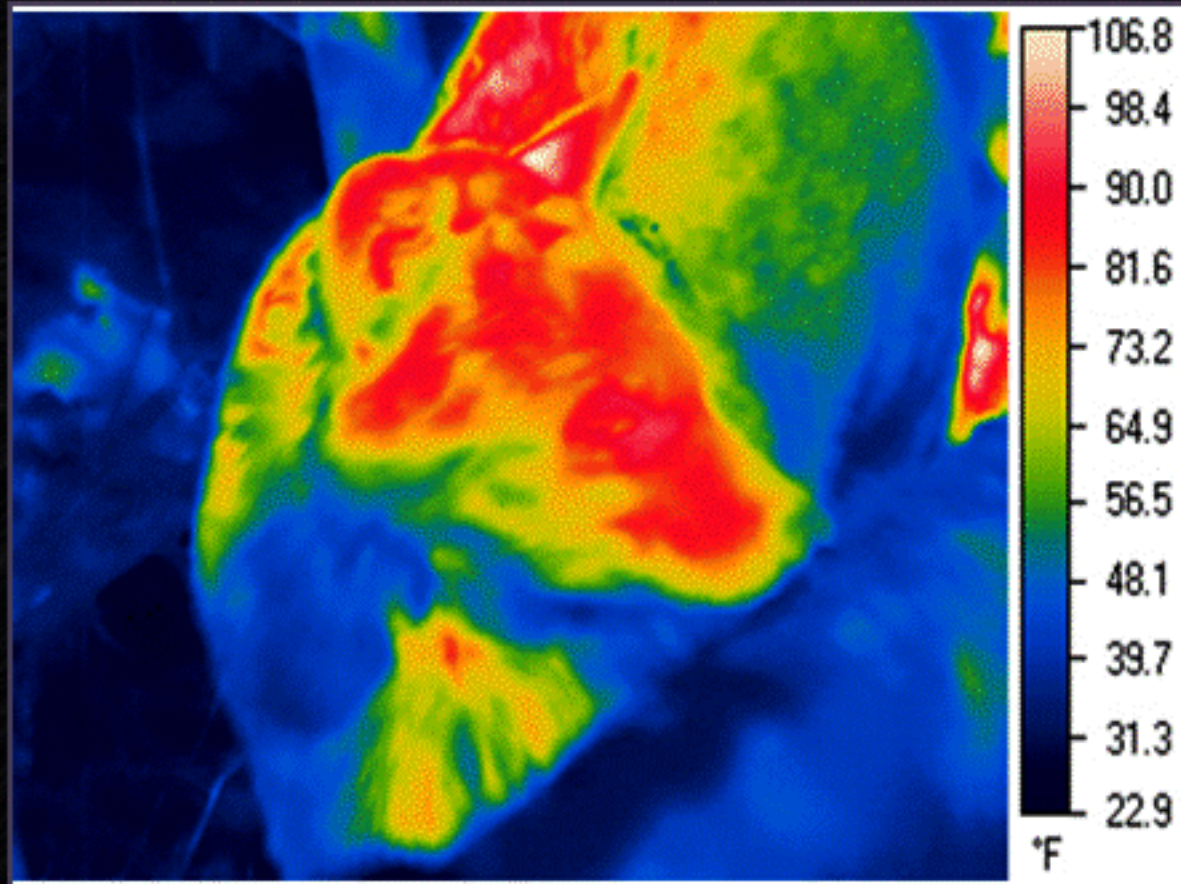
HEAT LOSS IN THE HIBERNACULUM

- A thermal image of a mother and cubs in a den
- Heat loss is greatest through the eyes, nose, and forehead
- Bears typically tuck these areas under their chest while hibernating

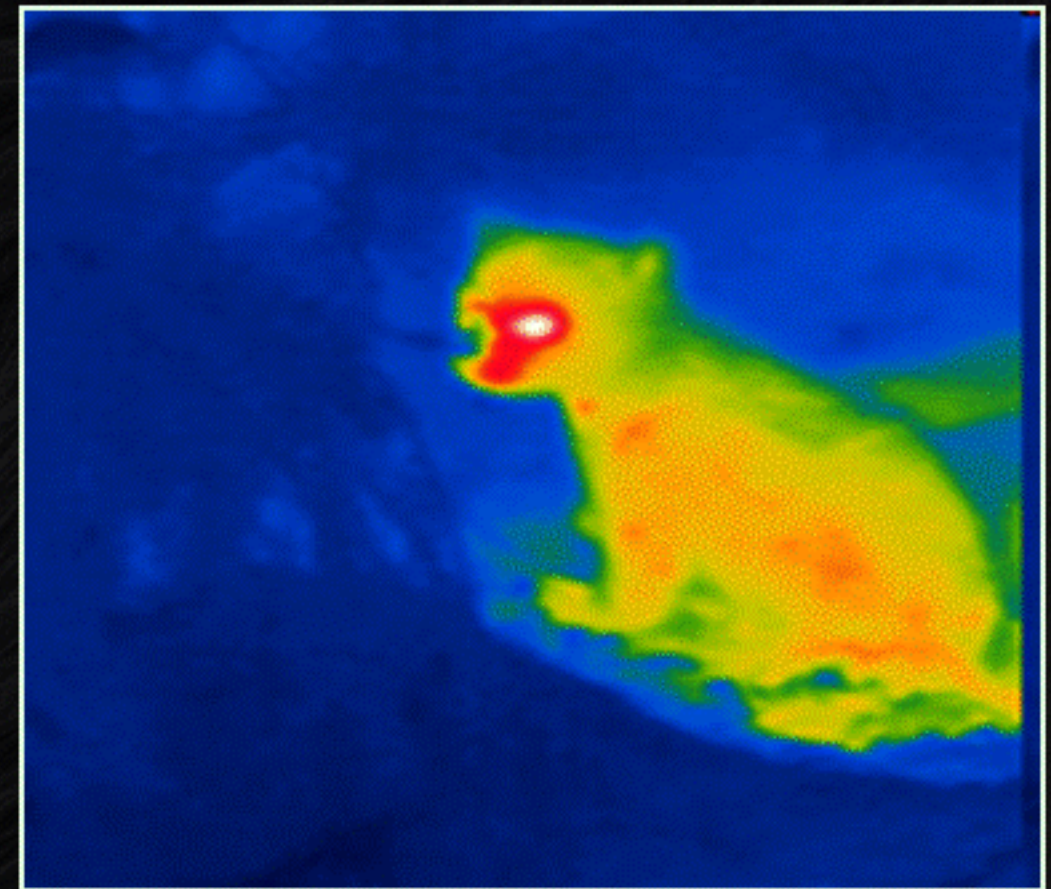


Thermal image of mother and cub – BBC, February 2003

HEAT LOSS IN THE HIBERNACULUM



Thermal image of mother after she was warmed by the sun – BBC, February 2003



Thermal image of cub – BBC, February 2003

HIBERNATION METABOLISM

- Heart rate and metabolism decrease
- Skinny bears hibernate more deeply than fat bears
- Heart rate may become irregular, slowing briefly to 6-10 beats per minute followed by more rapid beats



HIBERNATION METABOLISM

- Breathing slows to 2-4 breaths per minute for fat bears
- Skinny bears may breathe only once in 45 seconds
- May use only 4000 kilocalories per day
- May not eat, drink, urinate, or defecate during hibernation



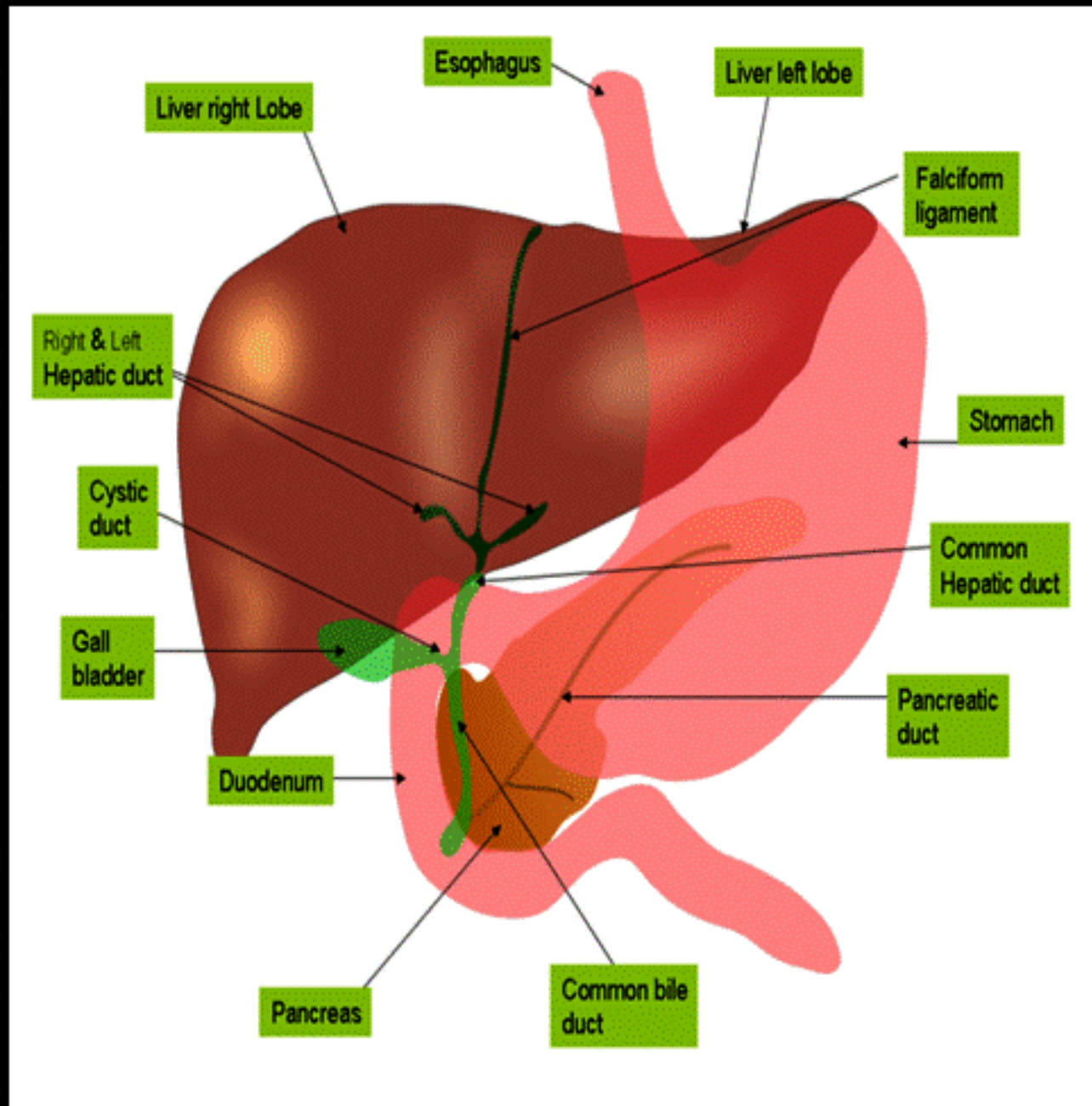
HIBERNATION METABOLISM

A Closer Look

- The hibernation metabolism of bears is unique and is still puzzling to researchers
- Cholesterol levels are twice as high as in summer, yet bears do not develop hardening of the arteries or cholesterol gallstones



BILE



- A chemical mixture produced by the liver, stored in the gall bladder, and excreted into the small intestine through the bile duct
- Function: important for digestion, absorption of vitamins and fats, and elimination of wastes

URSODEOXYCHOLIC ACID

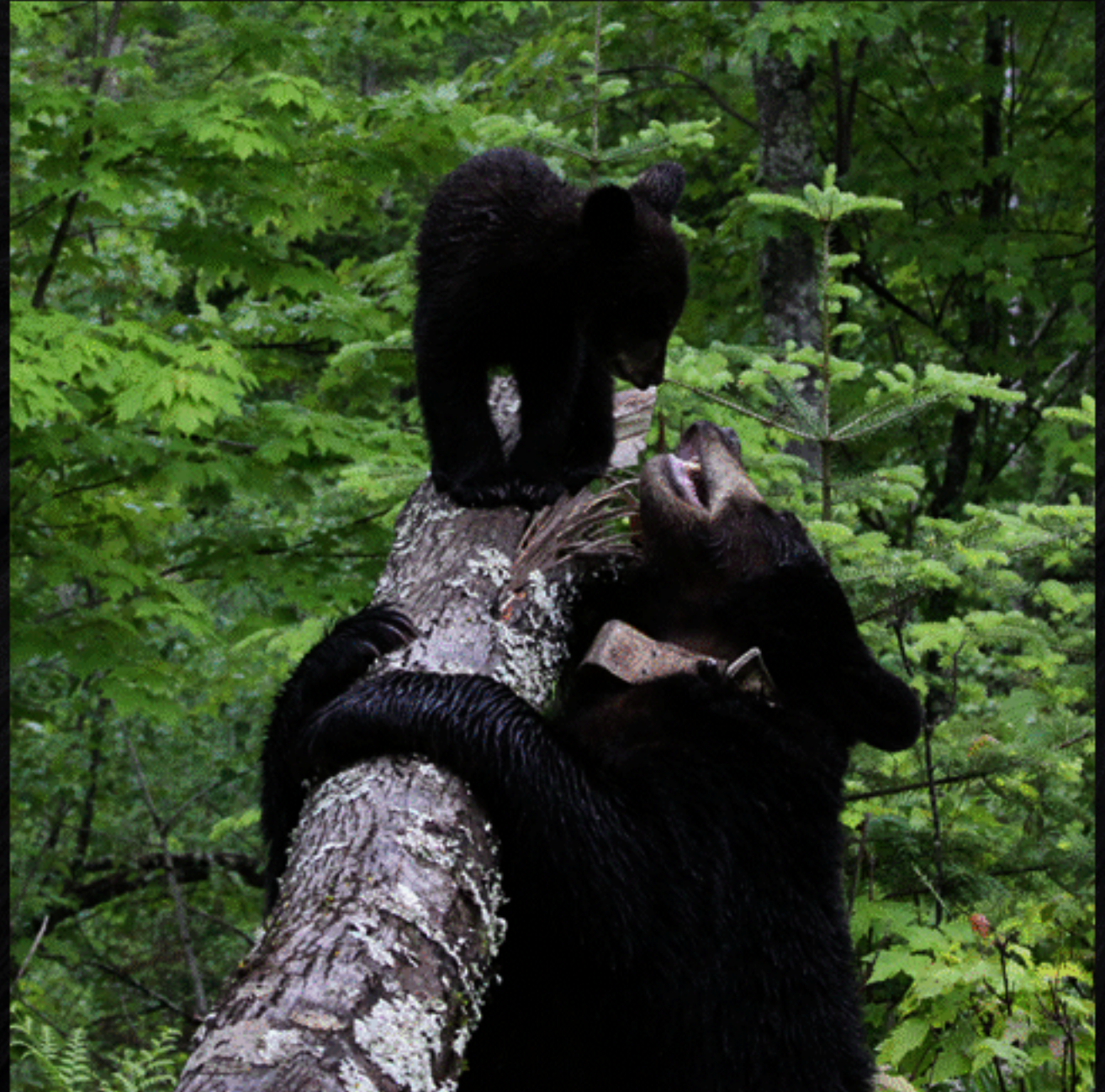
- Ursodeoxycholic Acid (UDCA) – unique bile salt found in bears (except giant pandas)
- Used to treat cirrhosis of the liver and dissolve gall stones in humans
- Used to reduce cell death (apoptosis) after strokes and in cases of colon cancer



UDCA TRADE

A Threat to Bears Worldwide

- Japanese synthesized UDCA in 1955
- Poachers still kill bears just for their gall bladders OR
- Capture bears, hold them in cages, and painfully extract bile from gall bladders daily
- Result: Asian bear populations in danger of extinction



HOW DO BEARS MAINTAIN MUSCLE MASS WITHOUT EXERCISE?



- **Answer: Recycling!**
- **Bears recycle bodily wastes during hibernation**
- **Toxins, like urea, are broken down, recycled, and reused**
- **Recycling urea helps maintain muscle mass**

RECYCLING UREA A Marvelous System

- Urea – toxic waste product of protein metabolism, usually excreted in urine
- Bears break down (hydrolyze) urea and release nitrogen (N)
- N combines with glycerol to make amino acids
- Amino acids enter protein synthesis pathways
- Protein rebuilds or maintains muscle and organ tissue



HIBERNATION METABOLISM & PREGNANT FEMALES

- If females do not have enough fat, blastocyst may be absorbed or fetus aborted
- Cubs born about 3 months after implantation
- Bears produce smallest baby to mother ratio of all mammals, except for marsupials
- Why are cubs born so small and immature?



HIBERNATION METABOLISM & PREGNANT FEMALES

Further Reducing Protein Loss

- Fatty acids (breakdown product of lipids) are too large to pass through the placental wall
- Fetus is fed by breakdown of mother's muscle proteins
- Once born, cubs are fed by breakdown of mother's fat stores to produce rich milk
- Utilization of fat to nourish cubs preserves mother's muscles



BEARS' UNIQUE METABOLISM

Surviving Winter – A Review



- Thick fur and rolls of fat keep bears warm
- Hibernation metabolism ensures that:
 - water is recycled
 - muscle loss is minimized
 - bone density remains strong
 - danger can be faced

BEARS' UNIQUE METABOLISM

Medical Implications for Humans

- Paralysis
- Bed sores
- Osteoporosis
- Heart disease
- Stroke (minimize apoptosis)
- What about long distance space travel?



STAGE 5 – WALKING HIBERNATION

- Occurs for 2-3 weeks after leaving den as metabolism adjusts to normal levels
- Eat and drink less than during normal activity
- Excrete less urine, nitrogen, calcium, phosphorus, and magnesium
- Metabolism increases and roaming begins by spring green-up



BACK TO STAGE 1 – NORMAL ACTIVITY

- Metabolism and appetite return to normal levels
- Cubs have become strong and experienced climbers
- Foods become available as green-up begins
- Bears begin roaming to access food sources
- The cycle of life for black bears begins again



SOURCES & FURTHER READING

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NORTH AMERICAN BEAR CENTER

Educational Outreach

During my four decades of scientific research, I came to realize how many misconceptions exist about black bears. Now, a team of educators is working with the North American Bear Center to replace those misconceptions with current scientific information. Together, we are developing curriculum that meets state and Common Core Standards and are working to provide that curriculum to schools, homes, summer camps, and anyone who wants to learn worldwide. This science-based curriculum differs greatly from the usual sensationalized hype we have all heard for so long. I feel deep respect and gratitude toward these educators who are helping both people and bears in this way.

Lynn Rogers, Ph.D.

*Chair, North American Bear Center
Biologist, Wildlife Research Institute
Ely, Minnesota*

Educational Outreach History

The Education Outreach Program was born in the den of a wild black bear near Ely, Minnesota. The bear, Lily, is part of the Wildlife Research Institute's long-term study of black bear behavior and ecology. When researchers placed a webcam in her den on January 8, 2010, she immediately became a worldwide internet sensation. On January 22, tens of thousands watched as she gave birth to a 12-ounce cub named Hope. Soon, hundreds of thousands, including hundreds of classrooms, were following her life and the lives of her offspring through den cams, video, and daily research updates on bear.org. That interest led talented educators to develop curriculum for distribution through the Educational Outreach Program. Replacing misconceptions with scientific facts helps people and bears to better co-exist.

NORTH AMERICAN BEAR CENTER

EDUCATIONAL OUTREACH

*Advancing the Long-term
Survival of Bear Populations
through Education*



This presentation has been brought to you by the

WILDLIFE RESEARCH INSTITUTE
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NORTH AMERICAN BEAR CENTER
Educational Outreach

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www.bear.org

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