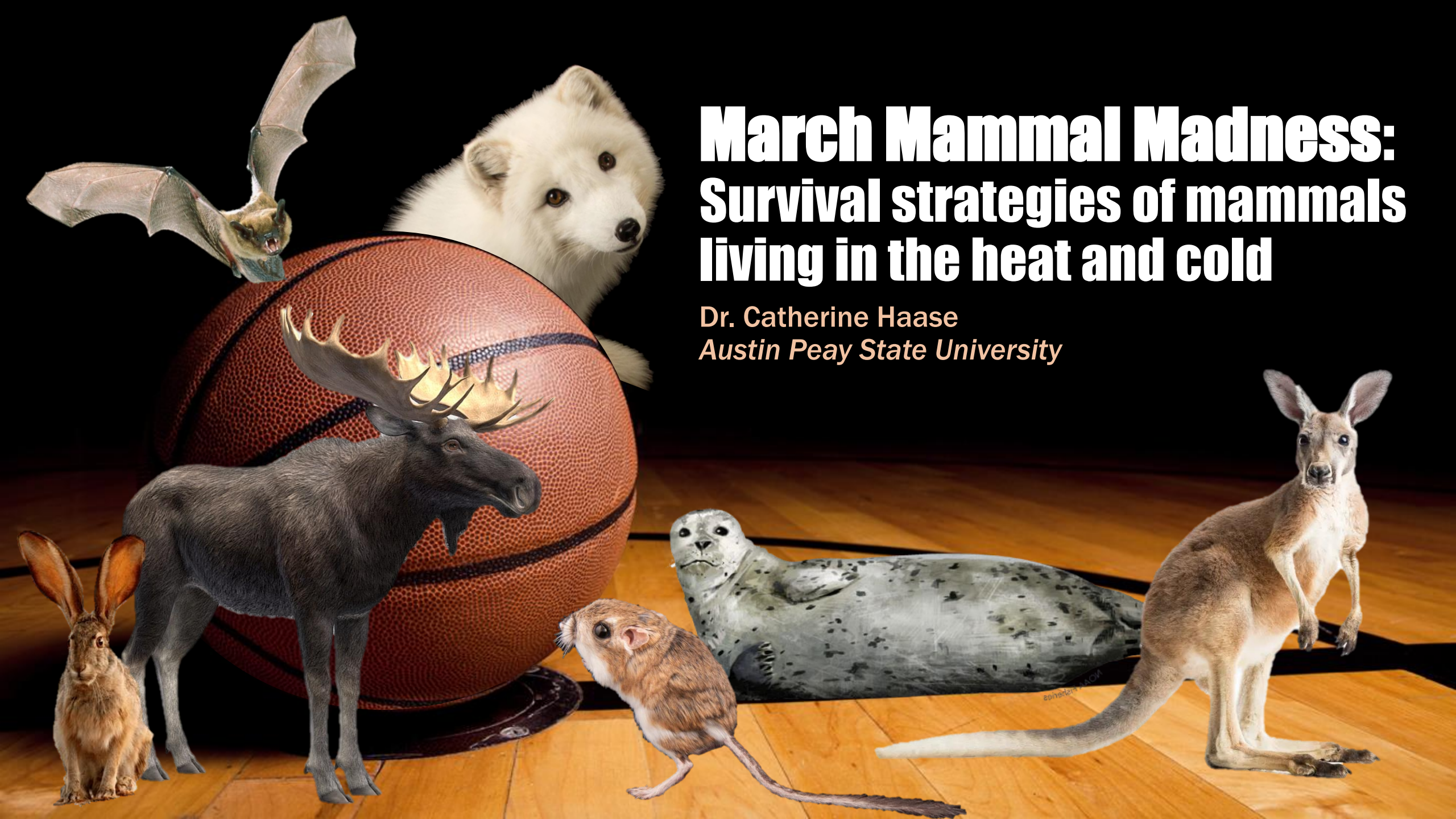


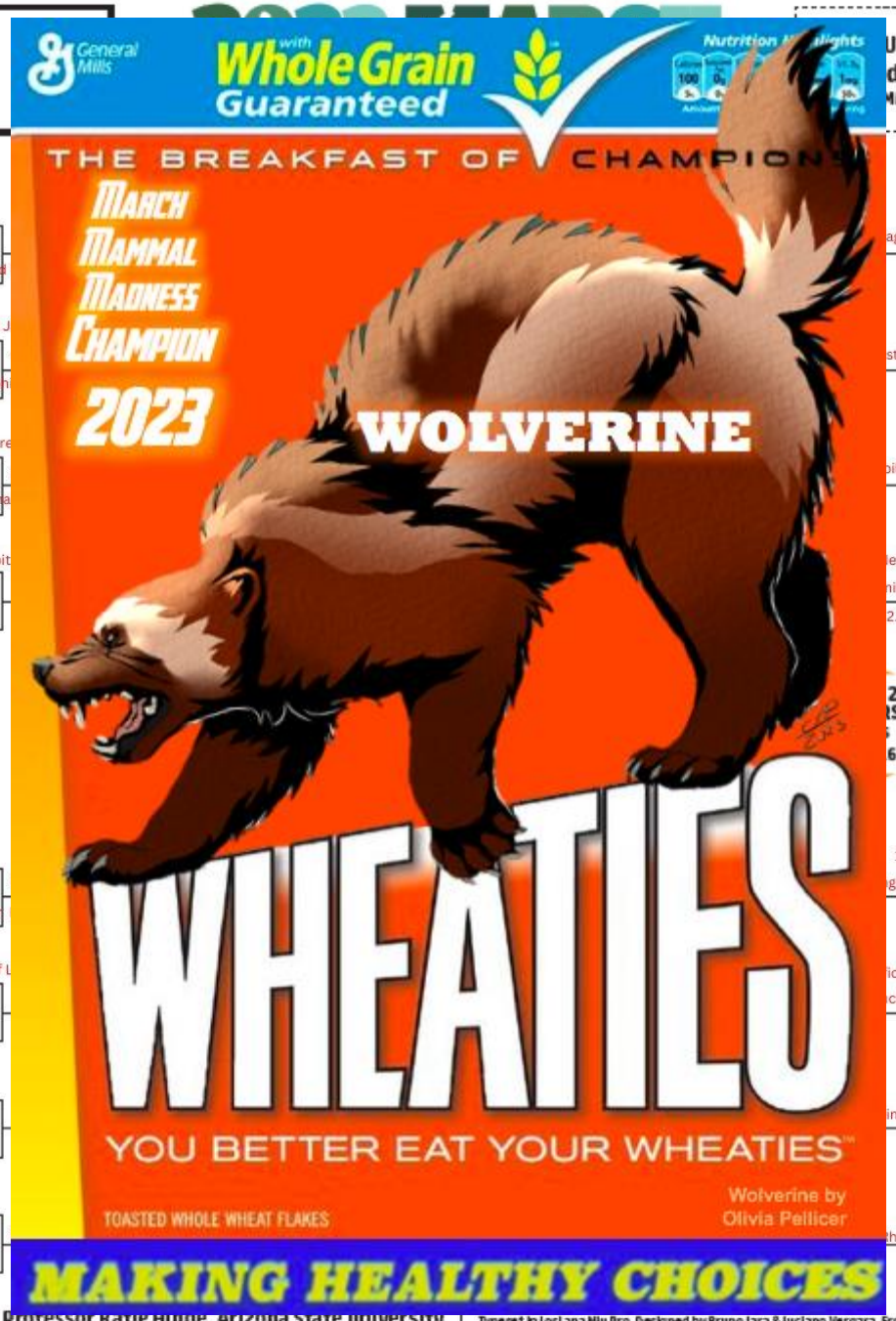
March Mammal Madness: Survival strategies of mammals living in the heat and cold

Dr. Catherine Haase
Austin Peay State University


2023 MARCH
MAMMAL
MADNESS
"If you're learning, you're winning!"

Results

Your Name Goes Here



TURNAMENT INFO:
des.asu.edu/MarchMammalMadness
MM includes many non-mammal species

MIGHTY STRIPES

Okapi 1 / Four-Striped Grass Mouse 16 → 1. Okapi
Striped Polecat 8 / Giant-Striped Mongoose 9 → 9. Giant-Striped
Side-Striped Jackal 5 / Striped Possum 12 → 5. Side-Striped J
Striped Dolphin 4 / Chequered elephant Shrew 13 → 4. Striped Dolph
Wildcat 6 / Highland Streaked Tenrec 11 → 11. Highland Stre
Striped Hyena 3 / Fire-Footed Rope Squirrel 14 → 3. Striped Hyena
Striped Rabbit 7 / Numbat 10 → 7. Striped Rabbit
Kudu 2 / Badger Bat 15 → 2. Kudu

ITTY BITTY COMEBACK CITY

WILD CARD WINNER — 1 POINT
ROUND 1 WINNERS — 1 POINT

Shrew Mole — Bumblebee Bat — Bumblebee Bat

Sea Otter 1 / Wild Card Winner 16 → 1. Sea Otter
Southern Ningaui 8 / Grasshopper Mouse 9 → 9. Grasshopper
Sibree Dwarf Lemur 5 / Silver Pika 12 → 5. Sibree Dwarf L
Mara 4 / Siberian Chipmunk 13 → 4. Mara
Itjaritjari 6 / Silky Anteater 11 → 6. Itjaritjari
Dik-dik 3 / Colo Colo Opossum 14 → 3. Dik Dik
Bulldog Bat 7 / Thor's Hero Shrew 10 → 7. Bulldog Bat
Rock Hyrax 2 / Pygmy Jerboa 15 → 2. Rock Hyrax

ANIMAL ENGINEERS

1. Golden Eagle — 1 Golden Eagle / 16 Spongilla Fly
9. Puffer Fish — 8 Veined Octopus / 9 Puffer Fish
5. Palaeocastor — 5 Palaeocastor / 12 Trapdoor Spider
4. Lungfish — 4 Lungfish / 13 Tent-Making Bat
6. Goanna — 6 Goanna / 11 Rufous Hornero
3. Homo Habilis — 3 Homo habilis / 14 Bee
New Caledonian Crow — 7 Montezuma Oropendola / 10 New Caledonian Crow
2. Cathedral Termite — 2 Cathedral Termite / 15 Dung Beetle

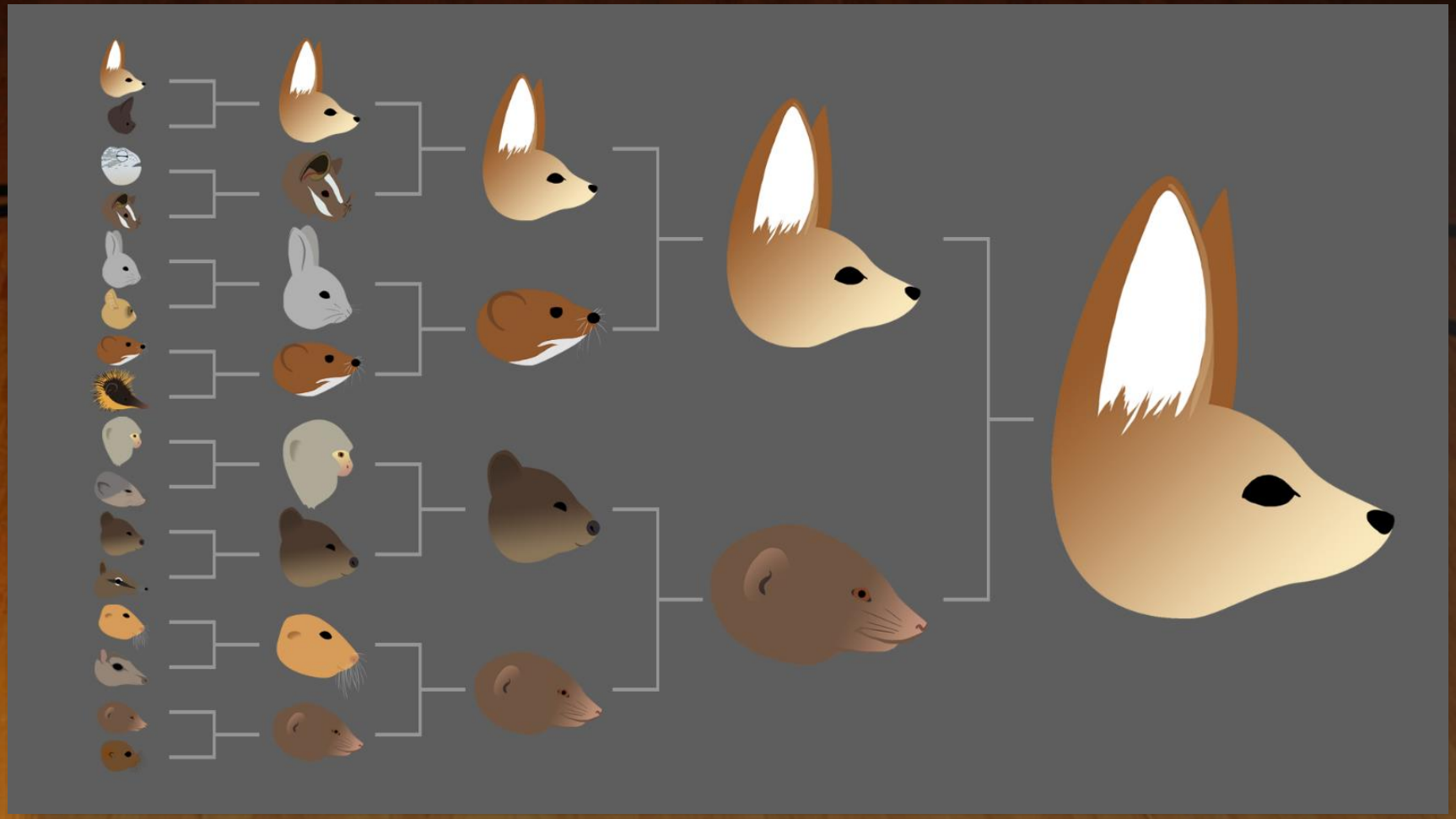
ROUND 1 WINNERS — 1 POINT

DAD BODS

1. Emperor Penguin — 1 Emperor Penguin / 16 Lined Seahorse
8. Owl Monkey — 8 Owl Monkey / 9 Caspian Tern
Pacific Spiny Lumpsucker — 5 Pacific Spiny Lumpsucker / 12 Peacock Wrasse
4. Siamang — 4 Siamang / 13 Darwin's Frog
6. Bat-Eared Fox — 6 Bat-Eared Fox / 11 Spotted Sandpiper
3. Wolverine — 3 Wolverine / 14 Giant Water Bug
10. Dyak Fruit Bat — 7 Greater Flamingo / 10 Dyak Fruit Bat
2. Greater Rhea — 2 Greater Rhea / 15 Three-Spined Stickleback

Professor Katie Hinde, Arizona State University | Typeset in LosLana Niu Pro. Designed by Bruno Jara & Luciano Vergara. From Latinotype Foundry.

MMM Survival Brackets




Phocidae
true seals
Procyonidae
racoons, coatis
Mephitidae
skunks
Prionodontidae
Asiatic linsangs
Viverridae
genets, oyans, civets
Ursidae
bears, giant pandas
Ailuridae
red panda
PINNIPEDIA
Nandiniidae
African Palm Civet
FELIFORMIA
Canidae
canines - dogs, foxes, coyotes, wolves, jackals
Pholidota
pangolins
Soricidae
shrews
CANIFORMIA
CARNIVORA
specialized shearing teeth

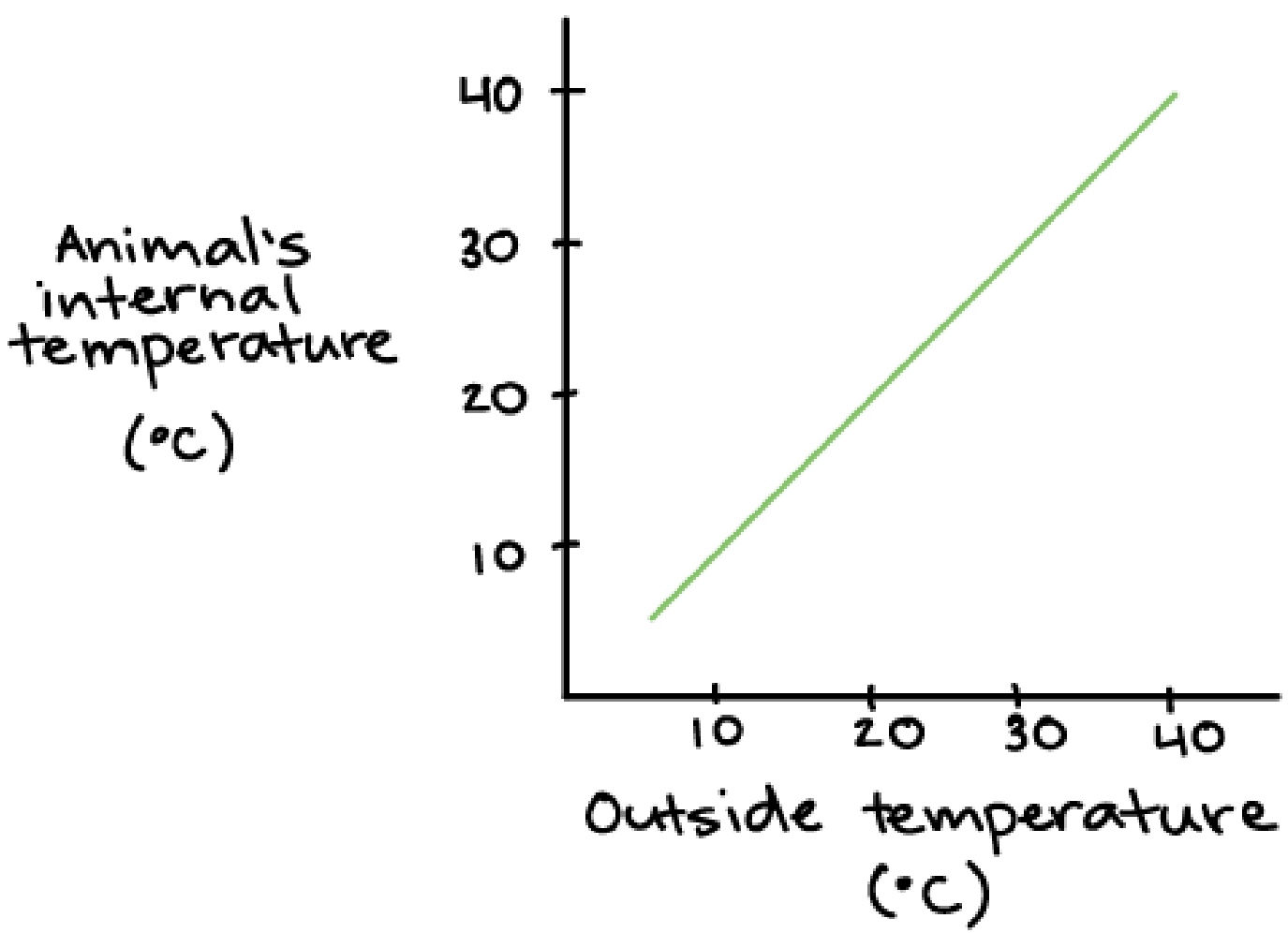
Mammals are morphologically diverse

How do they compare?

- Amphibians: 7,000 species
- Reptiles: 8,950 species
- Birds: 10,000 species
- Fish: 25,000 species
- >350,000 described plants
- >1,000,000 described insects

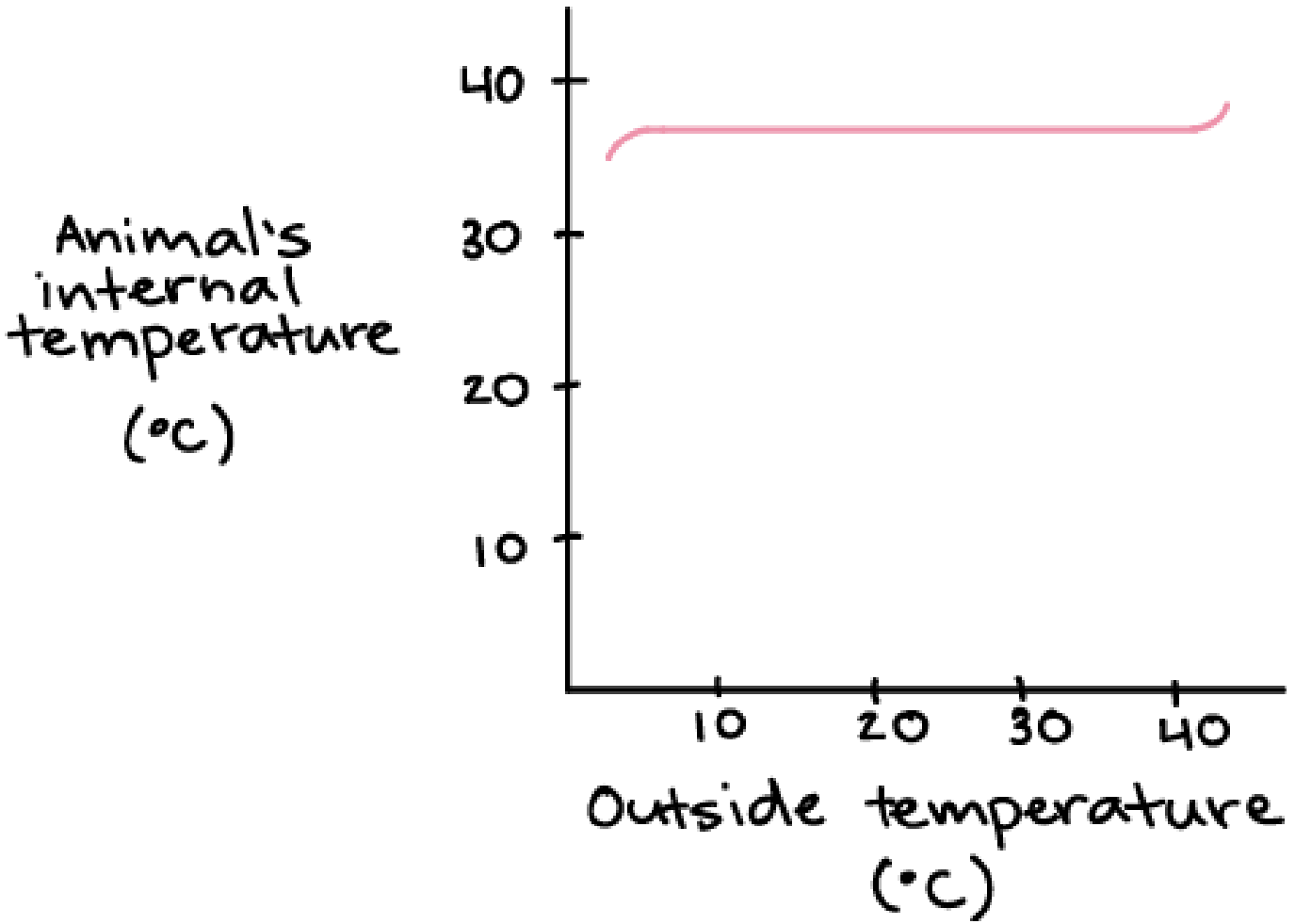
Why are they not as diverse?

- High energetic costs due to endothermy
- **Endothermy**: generates internal heat through metabolism to [usually] maintain an consistent internal body temperature
- "***warm-blooded***"



ECTOTHERMS

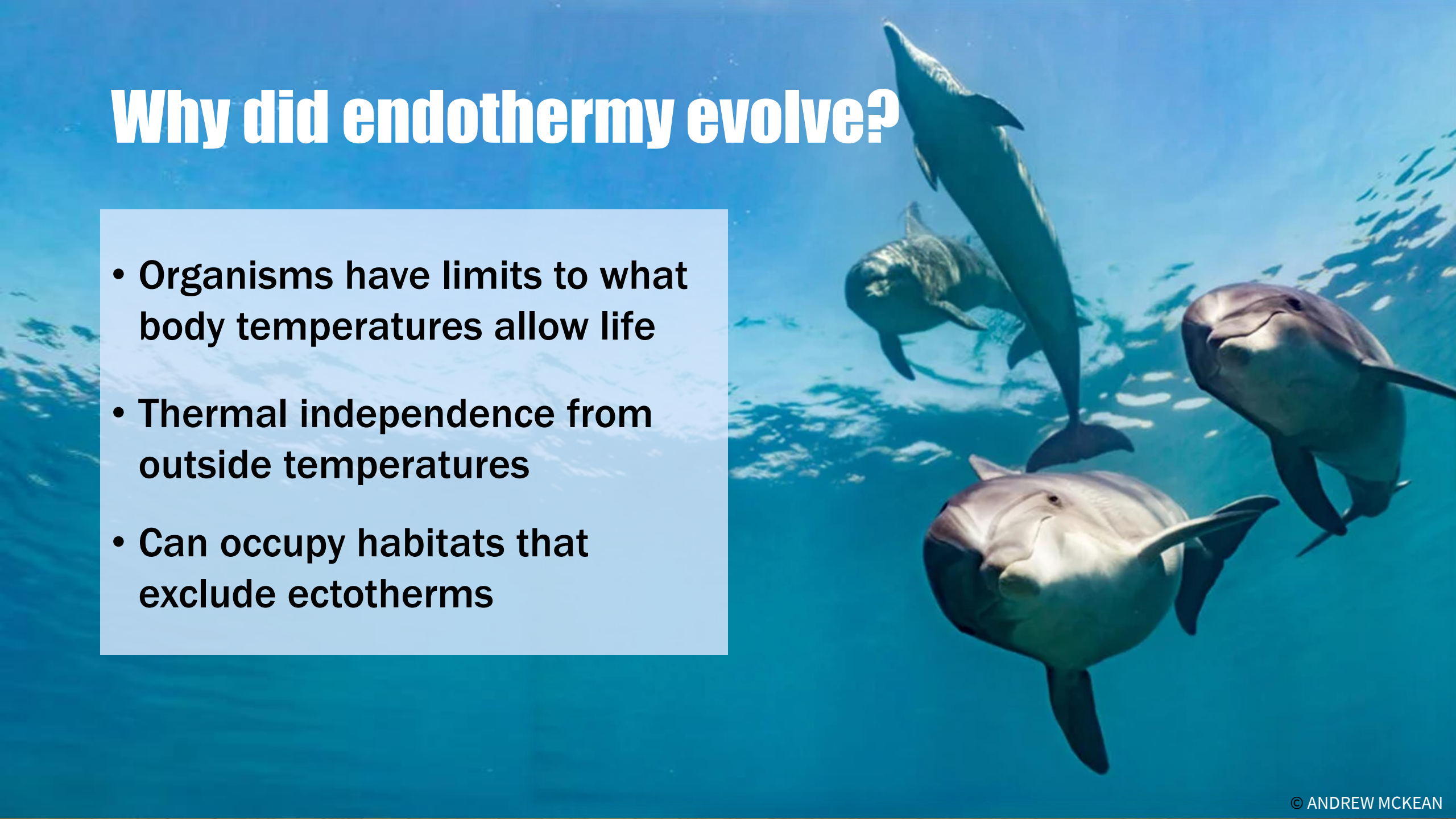
like the snake have a body temperature that changes with the temperature of the environment

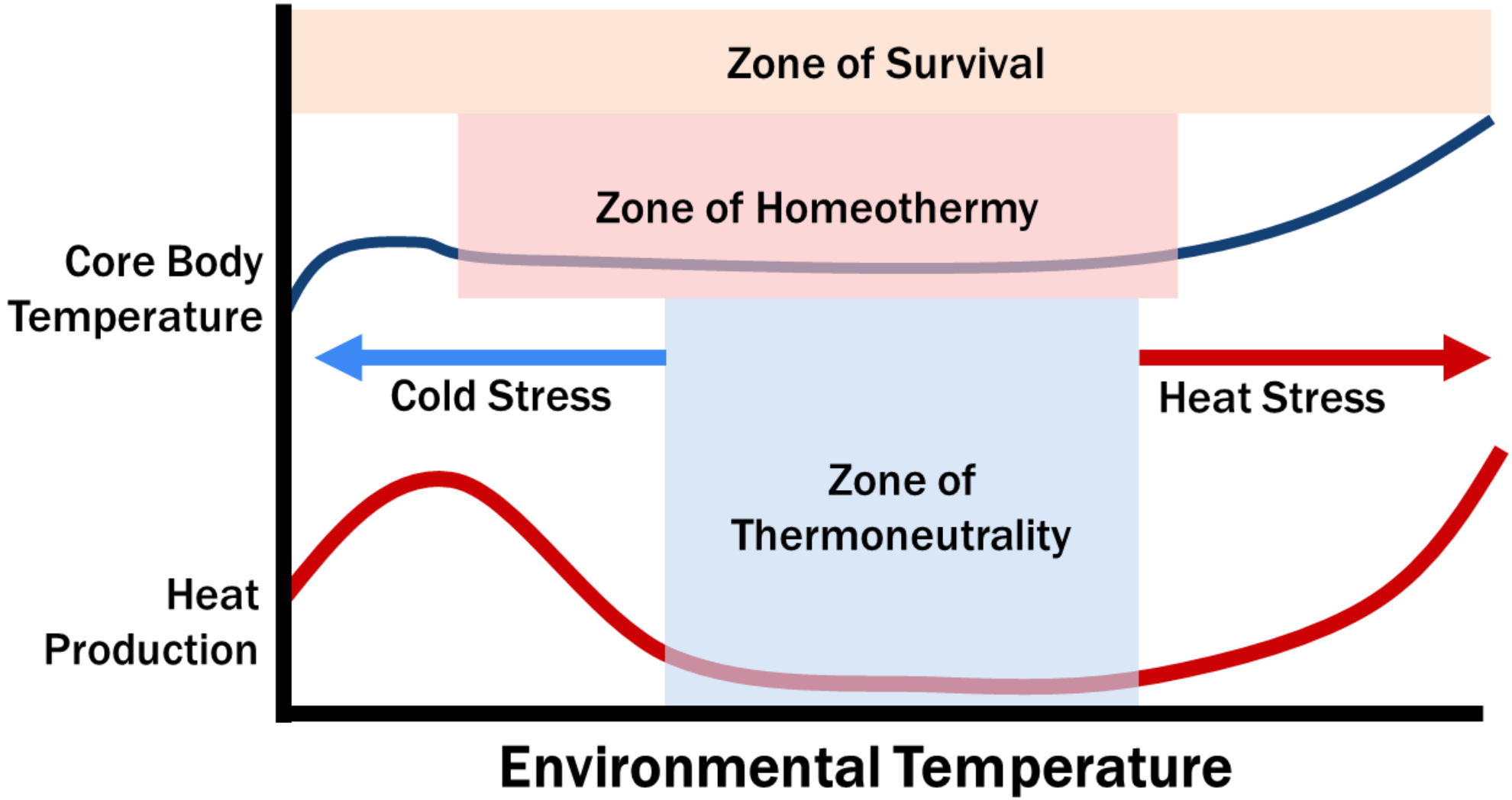


ENDOTHERMS
like the mouse generate metabolic heat to maintain internal temperature

Why did endothermy evolve?

- Organisms have limits to what body temperatures allow life
- Thermal independence from outside temperatures
- Can occupy habitats that exclude ectotherms




Zone of Survival
Zone of Homeothermy
Core Body Temperature
Cold Stress
Heat Stress
Zone of Thermoneutrality
Heat Production
Environmental Temperature

Environment

Animal

When temperatures exceed limits:

<u>Thermoregulation:</u>

Morphology

Physiology

Behavior

$$\text{Heat loss/gain} = \frac{\text{Surface Area} \times \Delta\ \text{Temperature}}{\text{Thermal Resistance}}$$

Body area over which heat is lost/absorbed

$$\text{Heat loss/gain} = \frac{\textbf{Surface Area} \times \Delta\ \text{Temperature}}{\text{Thermal Resistance}}$$

Surface Area: Bergmann's Rule

Species groups show increased body size farther from the Equator

Large bodied animals are better at conserving heat due to lower surface-to-volume ratio

Arctic hares (*Lepus arcticus*) live in arctic environments

Snowshoe hares (*L. americanus*) live in cold environments

Black-tailed jackrabbits (*L. californicus*) live in warm environments

Antelope jackrabbits (*L. alleni*) live in desert environments

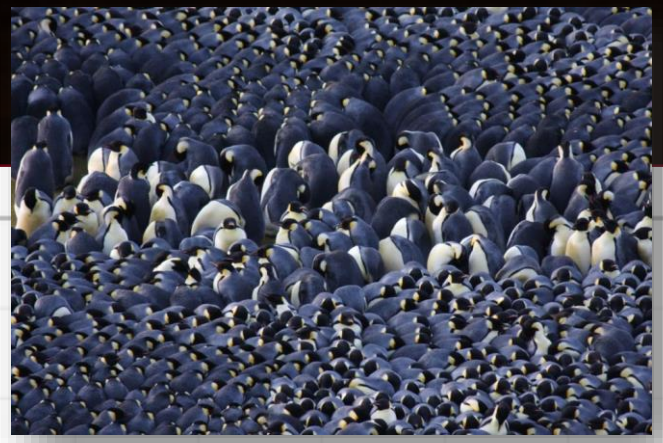
Surface Area: Allen's Rule

Animals that are adapted to colder climates tend to have smaller limbs and body appendages in comparison to animals that are adapted to more warm climates

Body area over which heat is lost/absorbed

Difference between body and environmental temperature

$$\text{Heat loss/gain} = \frac{\text{Surface Area} \times \Delta\ \textbf{Temperature}}{\text{Thermal Resistance}}$$



Temperature Difference

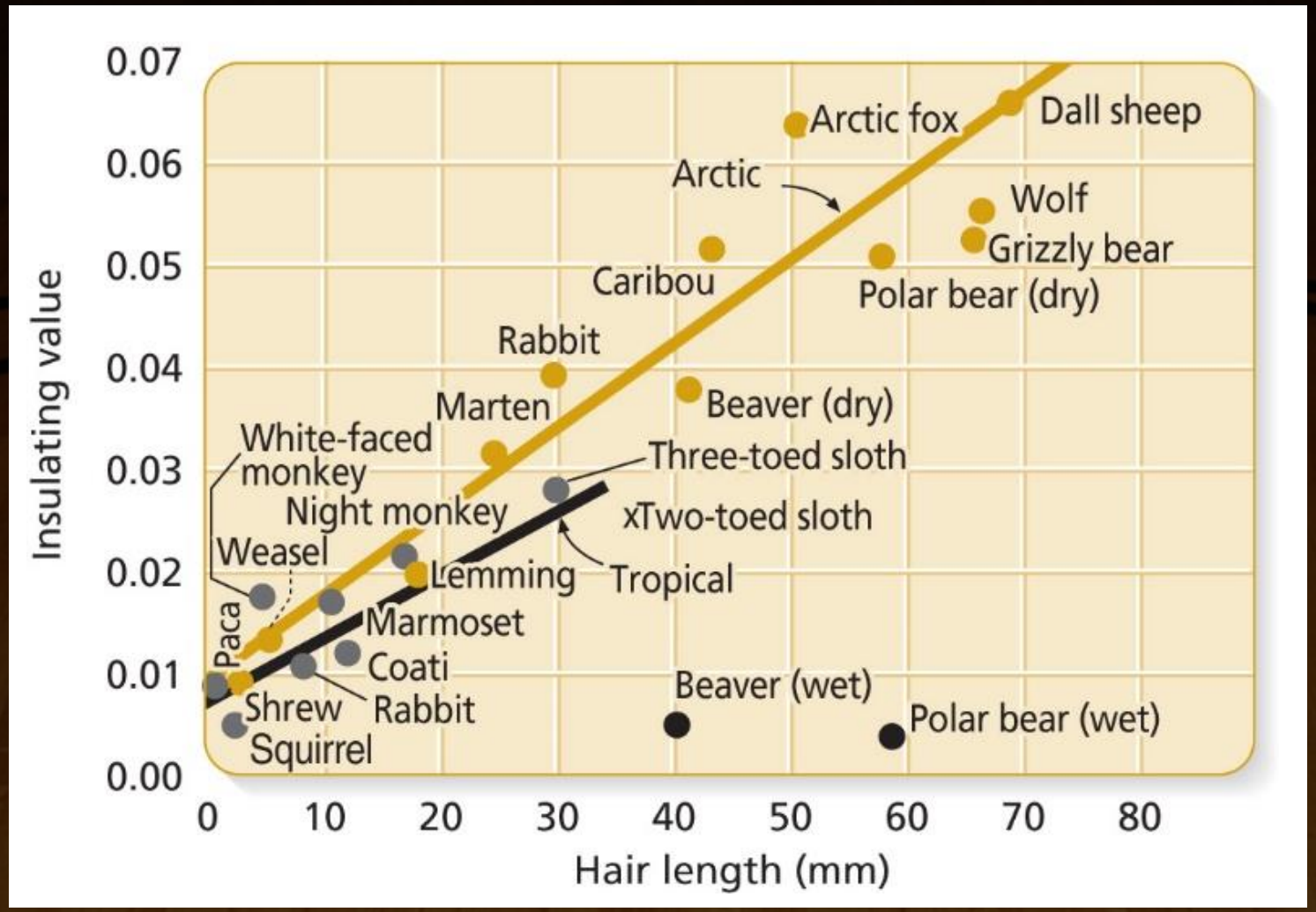
Various adaptations, such as huddling, can alter the surface temperature and change the temperature difference for the animal

Body area over which heat is lost/absorbed

Difference between body and environmental temperature

$$\text{Heat loss/gain} = \frac{\text{Surface Area} \times \Delta\ \text{Temperature}}{\textbf{Thermal Resistance}}$$

The ability of fat, blubber, skin, hair, fur to slow heat loss



Thermal Resistance

Longer hair length increases insulative value (decreases heat loss) through catching air in between hairs


21.9
17.4
14.2
12.7
11.5
10.3
9.2
8.0
6.8
5.5
4.2
2.9
1.4
-0.1
-1.7
-3.3
-5.1
-7.2
-9.3
-11.5
-14.0
-16.6
-19.7
-24.1

All About Adaptations

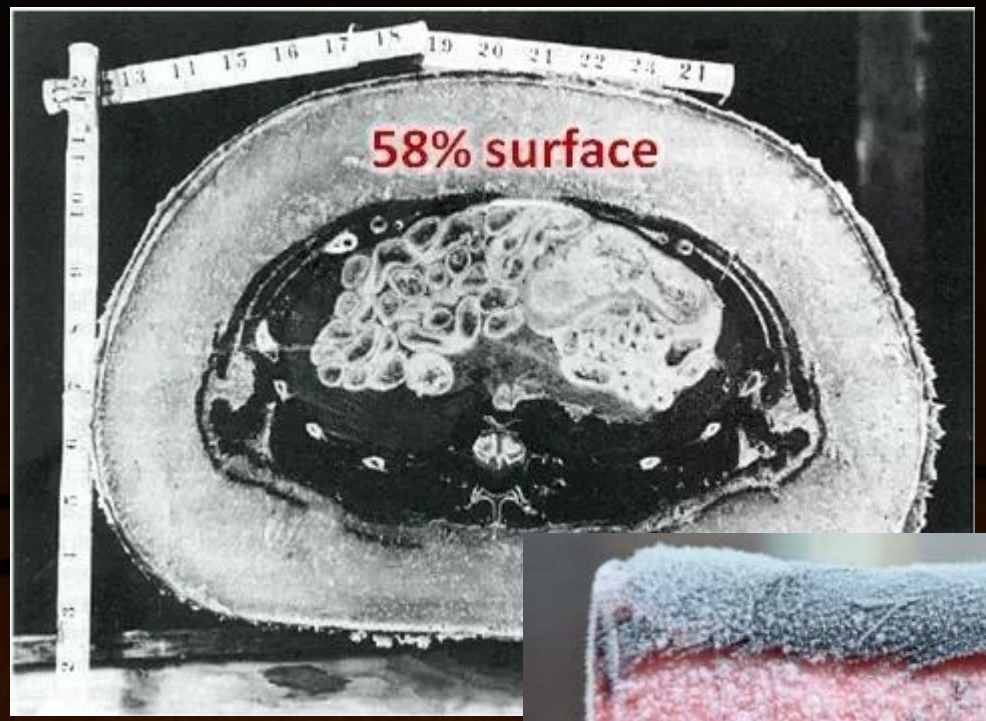
Adaptations are morphological, behavioral, or physiological traits that allow an organism to survive in a particular environment

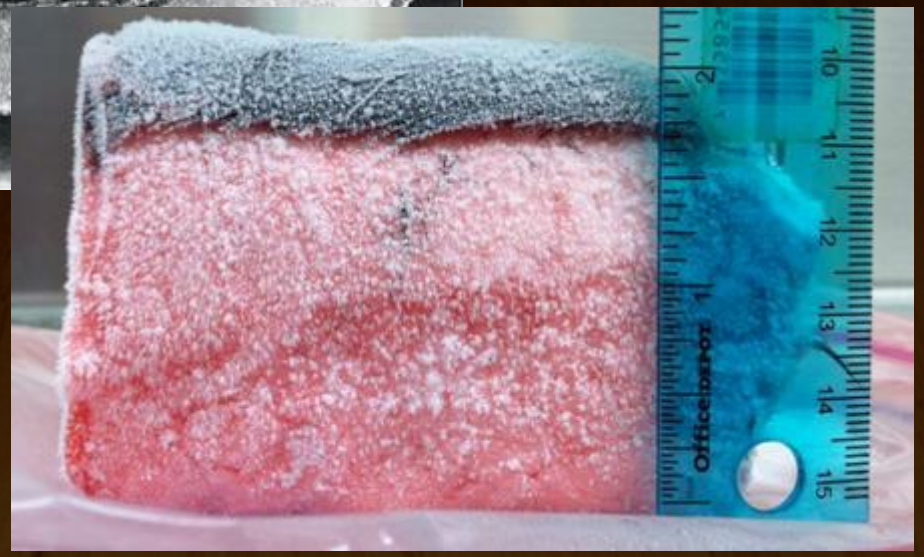
Cold Weather Adaptations

MORPHOLOGY: Insulation Mechanisms

Fur and hair trap a layer of air close to the body, which creates a barrier against heat loss

$$\frac{\text{Surface Area} \times \Delta\ \text{Temperature}}{\textbf{Thermal Resistance}}$$





MORPHOLOGY: Insulation Mechanisms

Blubber is a thick layer of fat that provides insulation as heat loss slows down through the fat molecules

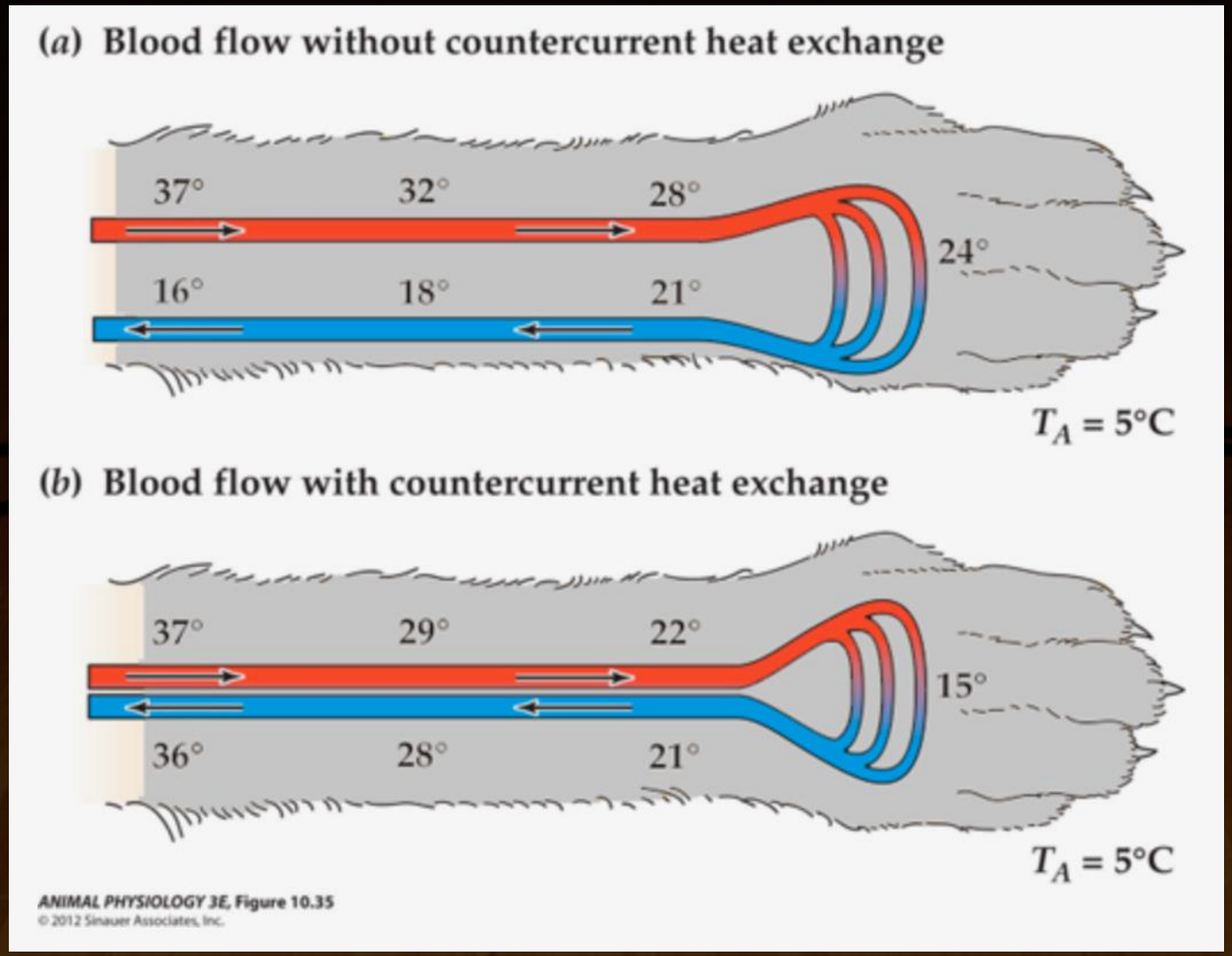
Important for marine mammals as water conducts heat faster than air

$$\frac{\text{Surface Area} \times \Delta\ \text{Temperature}}{\textbf{Thermal Resistance}}$$

MORPHOLOGY: Limb and Appendages

Compact body shapes prevent heat loss from appendages and decrease surface area, slowing down heat loss

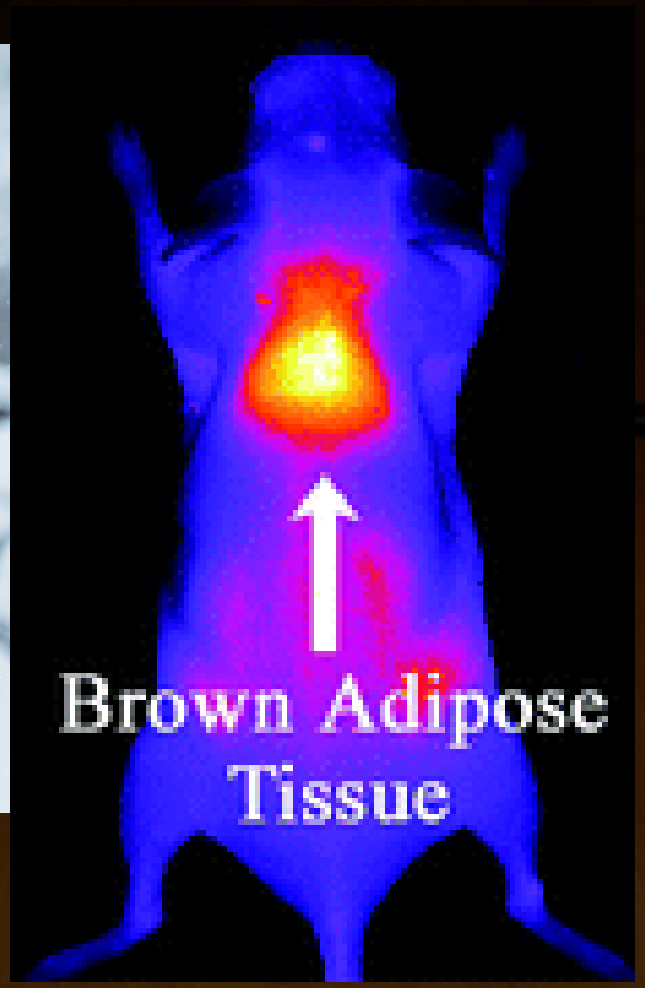
$$\frac{\text{Surface Area} \times \Delta \text{ Temperature}}{\text{Thermal Resistance}}$$



PHYSIOLOGY: Limb and Appendages

Counter-current heat exchange places arteries and veins close to each other so warm blood coming from the heart will warm cold blood coming from extremities

$$\frac{\text{Surface Area} \times \Delta\ \textbf{Temperature}}{\text{Thermal Resistance}}$$



PHYSIOLOGY: Metabolic Adjustments

Shivering thermogenesis uses muscle contractions to increase body temperatures

Brown adipose tissue (brown fat) can be broken down to release heat

$$\frac{\text{Surface Area} \times \Delta\ \textbf{Temperature}}{\text{Thermal Resistance}}$$

$$\frac{\text{Surface Area} \times \Delta\ \textbf{Temperature}}{\text{Thermal Resistance}}$$

PHYSIOLOGY: Metabolic Adjustments

Torpor is a brief period of dormancy in which individuals reduce activity and body temperature

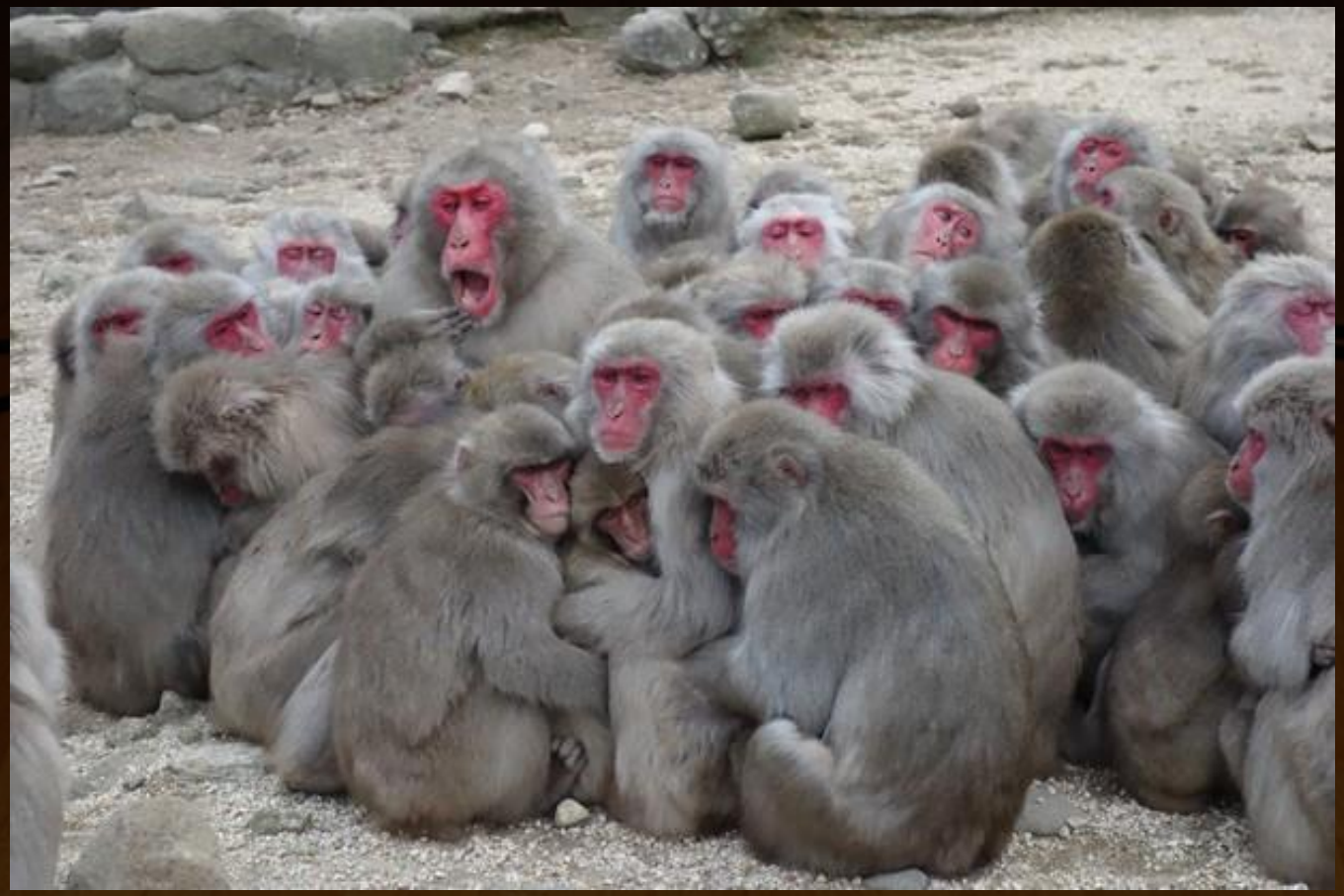
Hibernation is multiple long torpor bouts

$$\frac{\text{Surface Area} \times \Delta\ \textbf{Temperature}}{\text{Thermal Resistance}}$$

BEHAVIOR: Microhabitats & Migration Patterns

Some animals will use microhabitats that provide warm refuges from colder air or water temperatures

Some animals will migrate to warmer areas



BEHAVIOR: Cuddling & Huddling

Huddling reduces heat loss by decreasing exposed surface area and increases the surrounding air temperature through neighbor's body heat

$$\frac{\text{Surface Area} \times \Delta\ \text{Temperature}}{\text{Thermal Resistance}}$$

BEHAVIOR: Postural Changes

Postural changes can reduce exposed surface area often cover up areas with reduce insulation

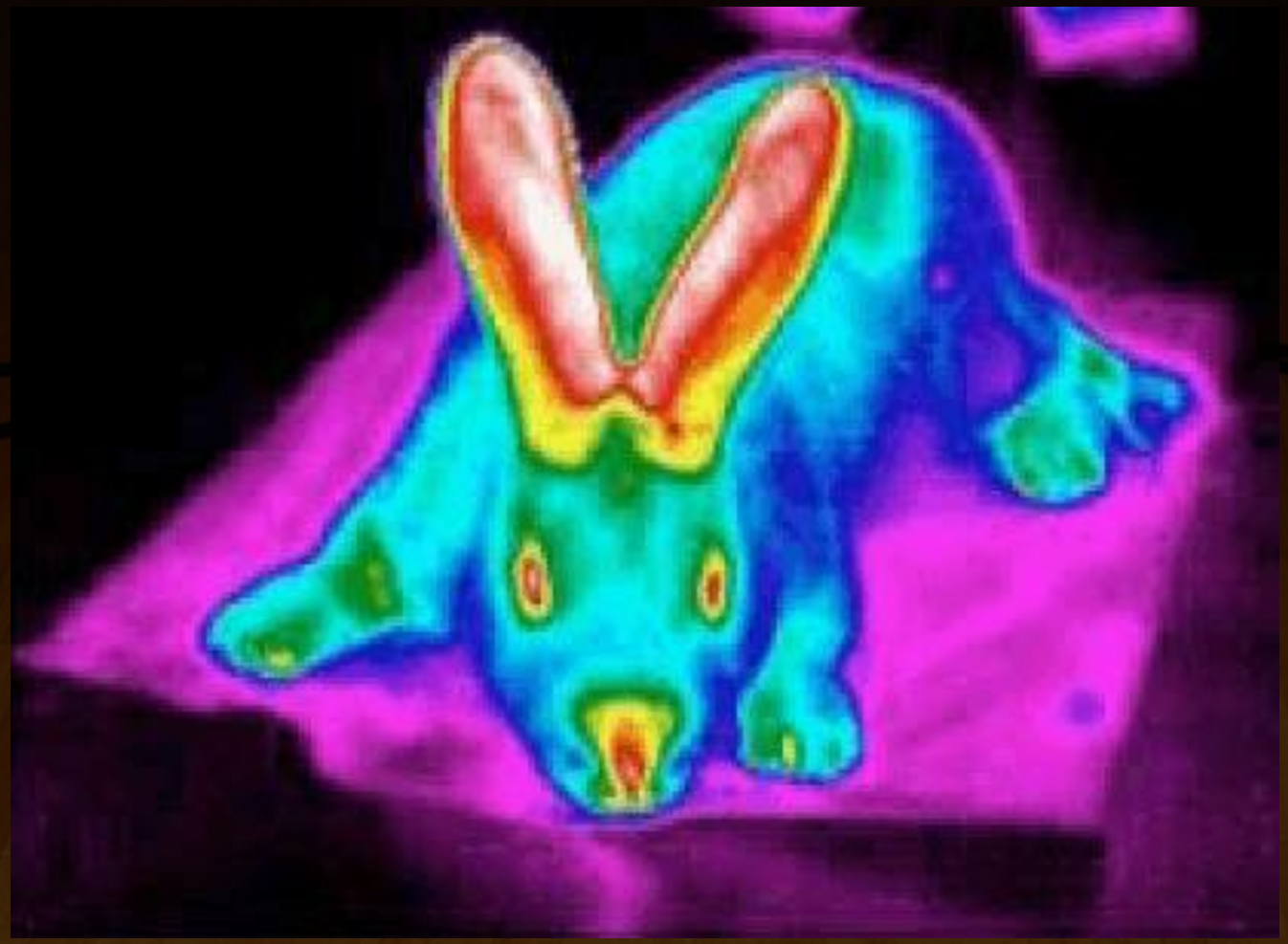
$$\frac{\text{Surface Area} \times \Delta \text{ Temperature}}{\text{Thermal Resistance}}$$

Warm Weather Adaptations

PHYSIOLOGY: Evaporative Cooling

Evaporative cooling is the most efficient way to lose heat, but many animals do not sweat as it results in water loss

$$\frac{\text{Surface Area} \times \Delta\ \textbf{Temperature}}{\text{Thermal Resistance}}$$



$$\frac{\text{Surface Area} \times \Delta\ \text{Temperature}}{\text{Thermal Resistance}}$$

PHYSIOLOGY:
Thermal Windows

Thermal windows are areas with little insulation, large surface area, and vascular structures to bring warm blood close to the skin's surface

BEHAVIOR: Nighttime Activity

Nocturnal activity allows animals to look for food when temperatures may not be as hot

$$\frac{\text{Surface Area} \times \Delta\ \textbf{Temperature}}{\text{Thermal Resistance}}$$

$$\frac{\text{Surface Area} \times \Delta\ \textbf{Temperature}}{\text{Thermal Resistance}}$$

BEHAVIOR: Microhabitats & Burrowing

Animals will alter their behavior to use burrows or shade during warm periods

BEHAVIOR: Posture Changes

Postural changes can increase surface area that is exposed to the air, which increases heat loss

$$\frac{\text{Surface Area} \times \Delta \text{ Temperature}}{\text{Thermal Resistance}}$$

MORPHOLOGY: Limb and Appendances

Often animals that live in warm environments will have thinner coats of hair which allows heat loss

$$\frac{\text{Surface Area} \times \Delta \text{ Temperature}}{\textbf{Thermal Resistance}}$$

Insights for Human Adaptations

By drawing parallels between mammalian adaptations and potential human applications, researchers can develop technologies, clothing, and lifestyle recommendations to enhance our ability to cope with heat stress and promote comfort in hot environments

Conservation Considerations

Many mammal species around the world have experienced population declines due to human activities, including habitat destruction, pollution, overexploitation, invasive species, and climate change

Climate change is causing declines in wildlife populations world-wide

- Shifting habitats
- Altered migration patterns
- Trophic level disruptions
- Phenology mismatches
- Increased disease impacts
- Ecosystem changes
- Local adaptation

Due to humans, extinction risk for 1,700 animal species to increase by 2070

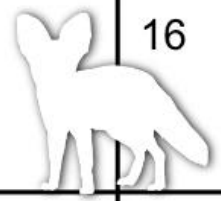
Amphibians, birds, and mammals at greater extinction risk by shrinking their natural habitats thanks to human land-use expansion

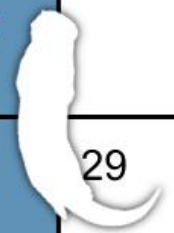
Call to Action: Understanding and Preserving Mammalian Biodiversity in a Changing Climate

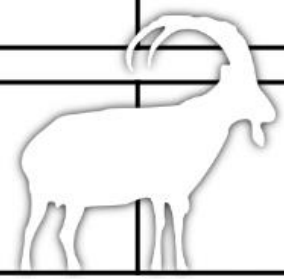

2024 MARCH
MAMMAL
MADNESS
"If you're learning, you're winning!"

2024 MARCH MAMMAL MADNESS

Sun	Mon	Tue	Wed	Thu	Fri	Sat
3 MARCH	4 RESEARCH COMBATANTS! PICK YOUR CHAMPION!	5	6	7	8	9
10 Rethink your whole bracket in agonies of second-guesses	11 WILD CARD	12	13 R1: Epic Animals	14 R1: Connoisseur Critters	15	16
17	18 R1: Rainbow Collection	19	20 R1: Take a Bow	21 R2: EA & CC	22	23
24	25 R2: RC & TaB	26	27 SWEET SIXTEEN	28 ELITE TRAIT	29	30
31 April	1 FINAL ROAR	2	3 CHAMPION-SHIP	4	5	







Animal silhouettes from PhyloPic.org, Public Domain.
Thank you Margot Michaud et al.

libguides.asu.edu/MarchMammalMadness

2024 MMM

The play-in battle for the 2024 tournament is **Sparklemuffin Peacock Spider** vs. **Rainbow Grasshopper**!

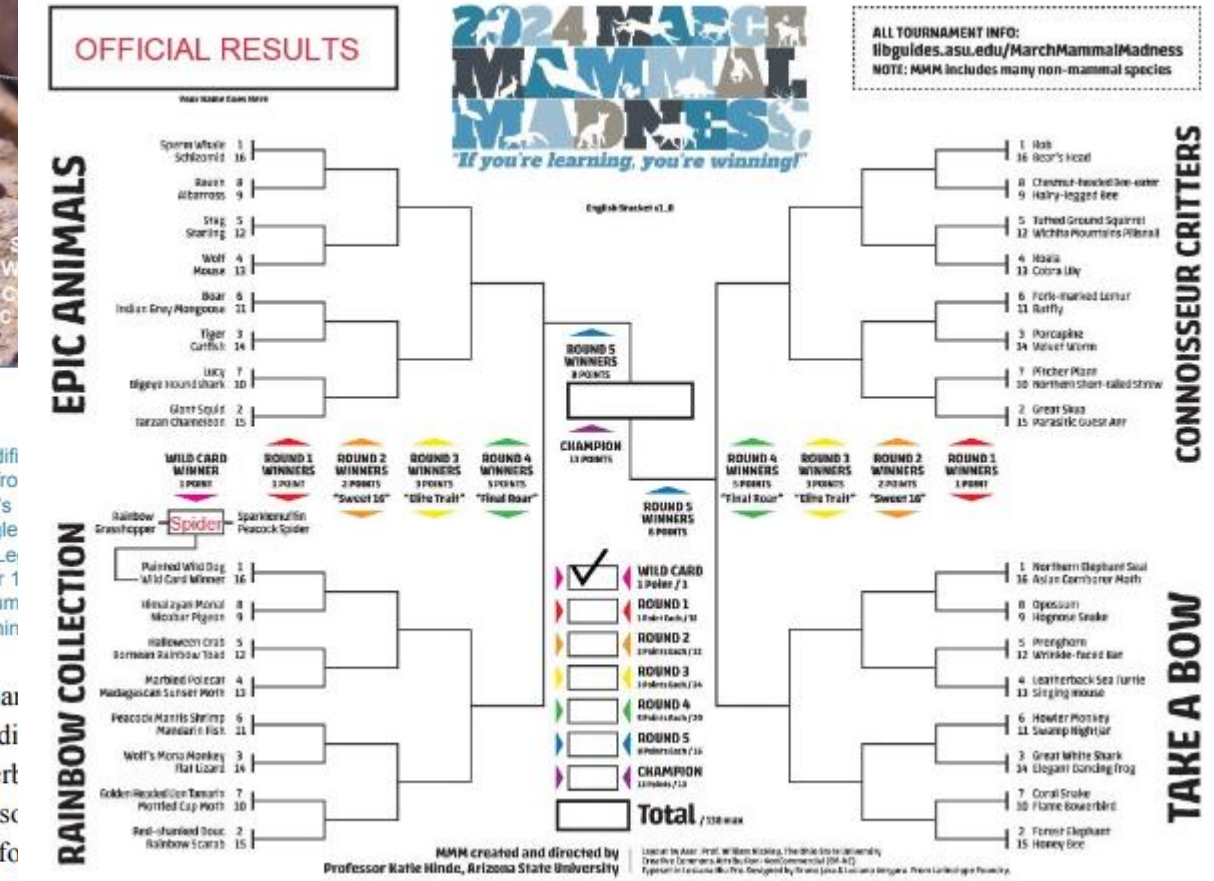
First described to science & quickly nicknamed Sparklemuffin, *Maratus jacatatus* is one of dozens of jumping peacock spider species from Australia. Sparklemuffin spiders are teeny tiny, the male's body length is ~4.6mm (0.2 inches). Male jumping peacock spiders have very colorful back-halfs (**opisthosoma**) & perform elaborate courtship dances. Sparklemuffin males have side flaps they lift to appear rounder. Sparklemuffin's scientific name "*jactatus*" is Latin for rocking and refers to his motion during his dance.

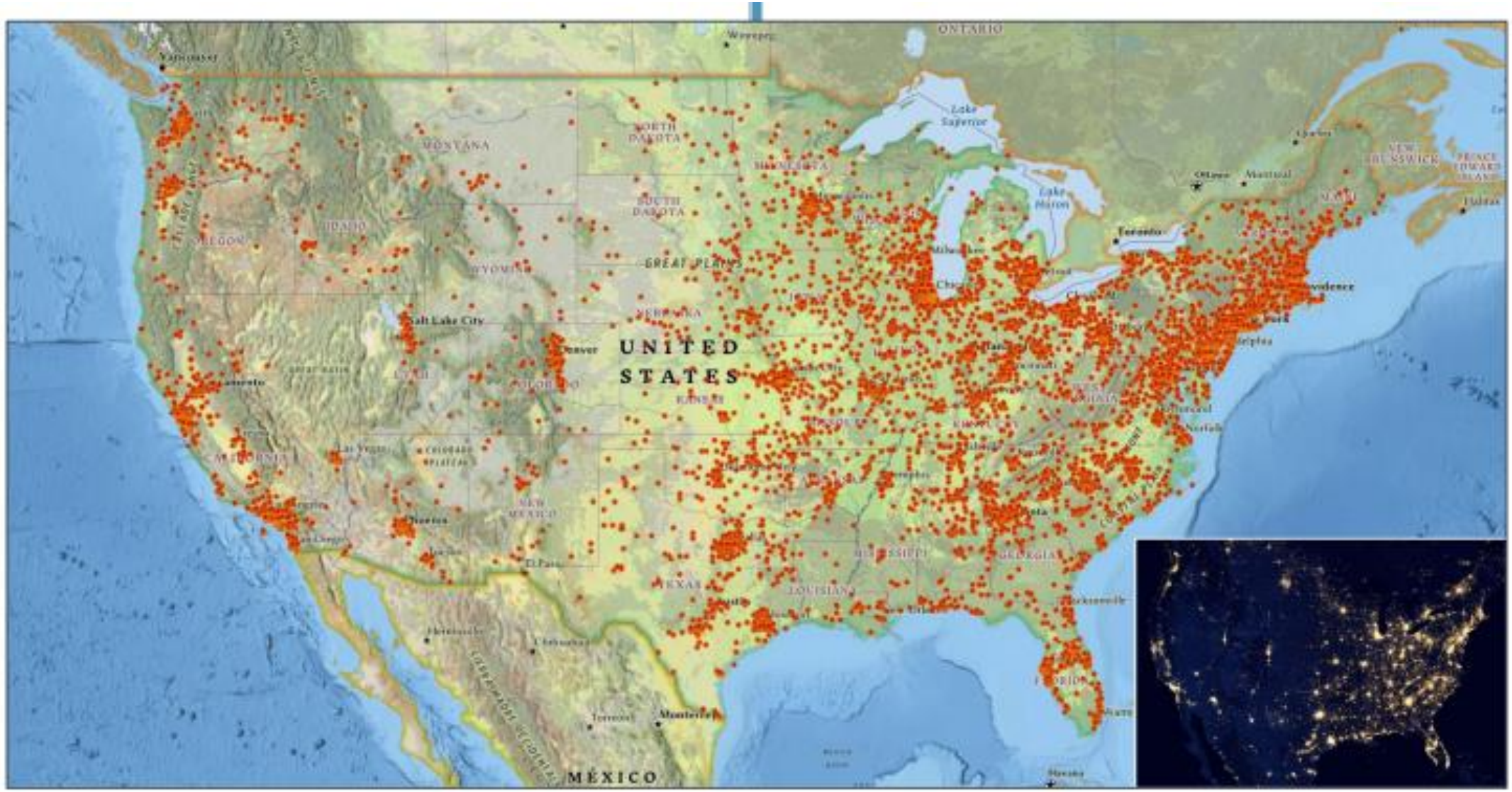
M. jacatus courtship dance Fig. 10 from Otto & Hill 2015

The largest rainbow grasshoppers get to be ~1.4 inches, 8x bigger than Sparklemuffin. Female Rainbow Grasshoppers weigh just under a gram, but females weigh 2.5x as much as males. Females have longer legs too.

Competition between cattle & mar herbivores like deer & rabbits are often di but grasshoppers are also an important herb grasslands, especially in the semi-arid sc where birds rely on grasshoppers in the fo BUT Rainbow Grasshopper colorat

Sparklemuffin jumps onto a rotting log just as the meat ant's pinchers plunge into the Rainbow Grasshopper egg. Sparklemuffin watches as the meat ant drags the Rainbow Grasshopper egg, rich in protein & fat, back to the





USA Geographic Distribution of Educators Requesting MMMaterials. Latitude and longitude locations, centered by postal zip code with inset image City Lights of the United States by NASA for population context. Educator survey conducted according to protocol STUDY00007542 approved by ASU IRB. Thank you to all survey participants! (Map Image by K. Hinde, special thanks to Marc Kissel for zip code conversions & Matt Toro for arcGIS guidance.)

Questions?

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