Lizard Leap-a-meter
Ectotherms in an urban environment

Objectives:
Students will be able to:
▪explain ectotherms and compare them to endotherms, including comparing adaptations of organisms to heat.
▪experience and measure environmental temperature variations among microclimates .
▪simulate the behavioral responses of an ectothermic animal to maintain a stable temperature.
▪understand that the Urban Heat Island affects living organisms differently depending on their adaptations and microclimates.

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Time:
30 min.

Grade Level:
6-9

Standards
AZ Science Strands
Inquiry, Personal and Social Perspectives, Life Science, Earth Science

NGSS - Core Ideas
Solutions; Energy; Information Processing; Interdependent Relationships; Human Impacts

Practices -Solutions, more

Crosscutting Concepts
Structure/function, more

Specific AZ, Common Core, and NGSS standards on page 4.

Background:
Many species of lizard live in the Sonoran desert. The arid climate and extreme temperatures are challenging for lizards. Unlike birds and mammals, including humans, reptiles can not maintain a constant internal body temperature. The body temperature of reptiles fluctuates with the temperature of the surrounding environment. This is why they are called **ectotherms**. (Birds and mammals are called **endotherms**). Most lizards also have thin skin and little insulation. However, over many generations, natural selection has allowed lizards to adapt to the desert environment through **thermoregulation.** Body structures (like a long tail), body processes (like hormone production) and behaviors (like burrowing) can all help animals thermoregulate.

Behavioral adaptations for thermoregulation are the easiest to observe. For example, some lizards change their activity patterns with the seasons or during the day. Lizards that are active in the day bask in the sun. They move back and forth between the sun and shade, or change the angle of their body to the sun in order to maintain a stable body temperature. Some lizards can change color to attract or reflect sunlight (dark skin absorbs radiation faster). Nocturnal reptiles, such as the banded gecko, passively exchange heat with the air and soil. In winter, when temperatures are cool, many lizards hibernate. During times of environmental stress, desert reptiles spend long periods of inactivity in burrows. Some desert reptiles can tolerate high body temperatures; the normal temperature of the desert iguana, for example, is 114° F (44° C).

Despite these many desert adaptations, the urban environment may present special challenges for ectotherms. Urban temperatures have increased recently, making the city a hotter place to live than the desert. The average nighttime low temperature in Phoenix has increased by 8°F over the last 30 years and, during the months of May through September, the average number of hours per day with temperatures over 100°F has doubled since 1948.

Can lizard adaptations help them maintain a stable body temperature in this extreme urban environment? How do lizards in the city cope with high temperatures caused by the urban heat island?

Reference: Adaptations of Desert Amphibians and Reptiles, Tom Van Devender, Desert Museum Senior Research Scientist from sonorensis, Volume 17, Number 1 (Spring 1997)

Vocabulary:
ectotherm - outside heat, an animal who's body temperature fluctuates with the environmental temperature

endotherm - inside heat, an animal that generates its own internal heat

thermoregulation - the ability of an organism to modify and stabilize its body temperature

Advanced Preparation:
Establish an area for the activity that will be warm and sunny, with some areas of partial and full shade as well. Draw a circle two meters in diameter in the center of the area.

Using the tape measure, set up one flag for every four students eight meters away from the circle to mark the finish points. The paths from the circle to the flags should vary in the amount of sun and shade they pass through (e.g. make one very sunny and one very shady etc.)

Tie a one meter length of string to each thermometer. Practice measuring air and ground temperatures with the thermometers. (Hold it from the top so the heat from your hand does not affect the measurement).

Optional: Have students draw a lizard of their choice on 8 1/2 x11 paper or cardstock. They may use identification guides to Sonoran desert species as references. Using authentic lizard species provides a basis for realistic temperature ranges on the second round of the game. Alternatively, students may cut out the generic lizard silhouette on the Student Worksheet: Lizard cut-out. Use the lizard cut out as a platform and tape the thermometer to the top. Each team may use only one lizard for each round (they may take turns).

Materials:
For each team of two:

- 1 Celsius thermometer (with a metal back, if possible)
- 1 one-meter length of string

For the class:

- 4-8 flags on small sticks or dowels
- masking tape
- 1 timer or watch with a second hand
- 1 eight-meter tape measure or length of string
- clipboards

Recommended Procedure:

Engagement:

1) Go out to the activity area and observe the surroundings. Ask students to predict where would be the hottest and coolest temperatures. Why? Discuss their reasoning. Write their answers on the Student Worksheet: Measuring Temperatures.

2) Pair students in teams of two. Explain how to read the thermometer. Challenge the teams to find the highest and the lowest temperatures in the activity area and record them on their Student Worksheet: Measuring Temperatures.

3) Call the group back together and find the average temperature of the area (shortcut estimate: add the highest and lowest values and divide by 2). Have students fill out the calculation table on their worksheet. Discuss microclimates and identify several possible microclimates in the activity area. What makes these areas different?

4) Instruct the teams to place one piece of masking tape on the thermometer 3 degrees above the average temperature and another piece of tape 2° below the average.

5) Discuss humans and body temperature. What is our normal average temperature? (about 37° C). Under what conditions do the students feel hot, when do they feel cold? Does their internal body temperature actually change when they are sweating or shivering? Ask the students if anyone has ever had a fever. If our body temperatures fluctuates just a few degrees around 37° we get sick or die.

6) Ask students to compare this to amphibians and reptiles, like lizards. Have they seen these animals basking in the sun on a desert trail or a neighborhood wall? Has anyone ever seen a pet reptile? What have students observed about these animals with respect to temperature?

   Explain that, unlike humans, these animals get their heat from the environment around them.

   On hot days the lizard's body temperature goes up and on cold days it goes down. Introduce the terms endotherm and ectotherm.

7) Ask students to make predictions: Where would be the best places to find lizards in the activity area? Record ideas on the Student Worksheet: Measuring Temperatures.

Exploration:

8) Introduce the game in which each team will pretend that they are a lizard. These lizards can only "leap" one meter at a time before they must rest for 30 seconds. In order to survive, the lizards must use their own behavior to maintain their body temperature within the five degree range (between the pieces of tape on the thermometer). The lizards must decide which microclimates to visit in their habitat. Explain that lizards have adapted over generations to respond to temperature by instinct. The students will have to use careful observation and

reasoning like a scientist to choose their next move.

9) Demonstrate how to use the 1 meter string to "leap" to the next spot. One team member will hold the thermometer and the other will rotate the string to an appropriate resting spot, no more than 1 meter away. Remember lizards can climb off the ground onto other surfaces. The teams will repeat this process every 30 seconds when the instructor rings a bell or calls out, "Go!".

10) Explain the goal of the game is to move from the circle starting area to one of the finish flags, but the lizards do not have to follow a straight line. The challenge is not to finish first, but to keep the lizards active and "alive". Students can not use their bodies to shade the thermometer. Any lizard whose temperature goes outside the 5° range must drop out (but they may continue to practice for the next round).

11) Assign a finish flag to each team (more than one team may use each flag). Have students double check that their starting temperature in within range and begin the game.

Explanation:

12) After the first game, discuss which lizards reached the finish flags. What strategies did successful lizards use? What problems did lizards encounter that caused them to "die"? Have students complete question 1 on the Student Worksheet: Results and Synthesis.

13) Play several more games, allowing the teams to switch flags. Again ask teams to share their observations and experiences.

Expansion:

14) Different lizard species are adapted to different microclimates. Tell the teams that they can simulate different kinds of lizards by moving the tape up or down on their thermometers. Adjust the tape to a new 5° temperature range. Challenge the teams to play the game again with their new lizards so they can take advantage of microclimates that they may not have used before.

Evaluation:

After the game, have students meet in small groups to discuss and answer questions 2-5 on the Student Worksheet: Results and Synthesis

Extensions:

- Lizards often burrow for thermoregulation. Play another version of the game in which students are allowed to bury their thermometers in the soil or ground cover to maintain their lizard within the 5° range. Record the ground temperature at different depths. Based on your data, discuss when and how burrowing helps lizards to survive.
- Ask students to think about how the urban heat island affects a variety of organisms in desert cities. Generate of list of birds, mammals, reptiles, amphibians and arthropods that interest the students. Identify them as ectotherms and endotherms. The ASU Chain Reaction article "At Home in the Sonoran Desert "can provide a good introduction. http://chainreactionkids.org/files/issues/2/chreact2_p08_11.pdf
- Conduct literature research to compare the differences in temperature limitations between the groups. What are the temperature limitations of each species? Which microclimates are best for each? Can you identify predators and their prey on your list? Can both live in the same microclimates? What can people do in response to Urban Heat Island? How can we reduce the effects of UHI on these organisms?
- Based on the first step of collecting hottest and coolest temperatures, students can make a map of their study area identifying different microclimates in different colors etc. The map provides a visual tool to generate predictions about where lizards will survive. Students can then use the data from their simulated lizard "species" to represent with colors or symbols where each "species" was able to survive. Additional maps can be made at different times of day or different seasons to compare the effects of sun exposure and thermal properties of various surfaces in the area.
- Have students read the ASU Chain Reaction magazine article "Thermoregulation: Hot Enough for You?" http://chainreactionkids.org/files/issues/2/chreact2_p30_32.pdf. Have students discuss the article in small groups. Name one advantage of being "cold-blooded" (ectothermic) in a desert environment. Which parts of a lizard body are good conductors? Which are good insulators?
- Using vocabulary from the article, ask students to describe the process in which heat from the sun warms a lizard body and how the lizard would respond. (This provides an opportunity to demonstrate understanding of thermoregulation, radiation, energy, conduction, heat capacity, insulation, convection, etc.).

Standards:

Arizona Science Standards

S1-C1-GR5-PO1, PO2
S1-C1-GRHS-PO1
S1-C2-GR5-HS-PO1
S1-C2-GR5-8-PO4
S1-C2-GR5-HS-PO5
S1-C3-GR5-8-PO1, PO2
S1-C3-GR5-6-PO3
S1-C3-GRHS-PO6
S3-C1-GR5, 7-8-PO1
S3-C1-GRHS-PO1, PO2, PO3, PO4
S3-C2-GR6-8-PO1 S4-C3-GR6-PO2
S4-C3-GR7-PO2, PO3, PO5
S4-C3-GR8-PO1, PO2, PO3, PO5, PO6
S4-C3-GRHS-PO1, PO2, PO3, PO4
S6-C2-GR6-PO4
S6-C2-GRHS, PO14, PO15, PO16, PO17

NGSS Core Ideas

ETS1.B: Developing Possible Solutions
LS1.D: Information Processing
LS2.A: Interdependent relationships in ecosystems
ESS3.C: Human impacts on Earth systems
PS3.A: Definitions of energy
PS3.B: Conservation of energy and energy transfer

NGSS Practices

Asking questions
Developing and using models
Planning and carrying out investigations
Analyzing and interpreting data
Using mathematics and computational thinking
Constructing explanations
Designing solutions
Obtaining, evaluating, and communication information

NGSS Crosscutting Concepts

Patterns
Cause and effect
Scale, proportion and quantity
Systems and system models
Energy and matter; Flows, cycles, and conservation
Structure and function
Stability and Change

Common Core/ELA Literacy

SL1: Participate in collaborations and conversations

Common Core/Mathematics

Domains: Number and Quantity
Measurement and Data
Statistics and Probability
Math Practices:
4. Model with mathematics.

Student Worksheet (#1)
Lizard cut-out

Student Worksheet (#2)
Measuring Temperatures

Observe the environment. Where do you think you will find the hottest temperature? The coolest?

Why? Explain your reasoning

Team temperatures

Site (microclimate)	Temperature

Class average temperature

High	Low	Sum	/2	Average (mean)

Were your predictions correct? Explain.

Where would be the best sites for lizards?

Student Worksheet (#3)
Results and Synthesis

Reflect on your experience as a lizard playing the game and answer the questions.

1) At the initial average temperature range, which locations or microclimates were safe? Which were too cold? Which were too hot?

2) When the teams chose their own temperature ranges, which ranges were successful in the sun? In the shade? In partial shade?

3) Rather than by moving into shade and sun, what other ways could lizards thermoregulate? Explain some possible adaptations.

4) What do you do as a human that you could not do if you were an ectotherm, like a lizard?

5) What can people do to maintain appropriate microclimates for lizards in urban areas?