Solar Education for NY
SchoolPower
...Naturally

Heating and Cooling a Really Large Lizard

SPN LESSON #16

TEACHER INFORMATION

LEARNING OUTCOME

After experimenting with a light source and a thermometer mounted on a card, students are able to relate card position to temperature changes and use that information to infer similar results for the positioning of photovoltaic panels on roofs.

LESSON OVERVIEW

This lesson investigates the effect of temperature on cold-blooded animals, using dinosaurs as the model organism. Students use a 5 x 8 inch index card to represent a dinosaur. By inserting a thermometer in the card, students are able to measure temperature changes associated with positioning the card at different angles to a light source. The importance of maintaining an appropriate body temperature in order to regulate the organism's metabolic rate is included. After completing the "dino card" portion of the activity, students apply what they have learned to the functioning of the school's photovoltaic panel.

GRADE-LEVEL APPROPRIATENESS

This Level II Living Environment lesson is appropriate for students in grades 5–6.

MATERIALS

For each team of two students, you will need:

- one 5 x 8 inch index card (either white or colored)
- thermometer
- timer (preferably a stopwatch)
- tape
- light source (the Sun or a lamp), stand for lamp optional
- white cloth, white butcher-block paper, or four 8½ x 11 inch sheets of white paper taped together
- metric ruler or tape measure
- dark-colored crayons, markers, or colored pencils

SAFETY

- If students are using a lamp as a light source, remind them that the lamp can get very hot.

TEACHING THE LESSON

- Post a series of pictures of both warm- and cold-blooded animals on the bulletin board or wall. Use a variety of fish, amphibians, birds, mammals, and reptiles. If you have enough pictures, divide students into groups of two or three and give each group five or six pictures. Ask students to think of as many different ways as they can to group the animals into categories. They will most likely organize them by size, color, number of legs, diet, or habitat. Ask student groups to share their ideas and record these on the chalkboard or a transparency. You will probably need to introduce the idea that some of the animals are warm-blooded and others are cold-blooded.
- Ask students if, at this time, they are able to explain the difference between warm-blooded and cold-blooded animals. Record their ideas on chart paper, the chalkboard, or a transparency.
- Next, ask students to check textbooks, dictionaries, encyclopedias, and the Internet to determine how close the ideas they came up with are to the "scientific" definitions of *warm-blooded* and *cold-blooded*. (See the Background Information section of this activity.)
- Provide students with copies of the activity and materials needed for the investigation. Consider taking the class outside and using the Sun as a light source when doing this activity during the fall or spring. If you are using lamps in the classroom as a source of light, try the activity ahead of time. Determine an appropriate distance from the light source for the students to place their cards. Be sure that they will observe some temperature change. Having students place their setups on white surfaces cuts down on the time it takes for the system to return to room temperature. Have students take turns keeping track of time. While one person in the group is keeping track of time or watching to see when the system returns to room temperature, the others in the group might be provided short reading or writing activities to complete. In between the part of the lesson involving direct light and the part involving indirect light, the light source is turned off and the system returns to room temperature.
- Before accessing data from the solar panel, ask students what they expect to find. Also ask them what they know about the panel and how it works. Mention to them that it is a stationary structure. *Don't* tell them that some panels are designed to "follow" the Sun for maximum efficiency. Hopefully, this is an idea they will come up with on the basis of their experience with other parts of the activity. You might mention that there are plants whose leaves change position in order to follow the Sun and carry out maximum photosynthesis. Wild lettuce is one example.
- For Activity Analysis, item 3c, you could make a noontime comparison if you do not want to work with averages.
- The students have been provided limited information regarding directions for gathering data. Because information is limited, students must pay close attention to technique in order to succeed in this activity. You need to monitor results for each group, alert those whose technique is improper or sloppy, and have those groups redo the lab work one or more times. If you are more interested in having students experience success the first time around, there is advance preparation you can do to help ensure this. For each setup,

you might provide a stand to hold the light source. You can then secure the light source in a fixed position that you found to work well when you personally gathered data. You can mark the butcher-block paper showing where the stand is to be positioned, and where the bulb of the thermometer should be positioned no matter what direction the card faces.

- When bringing the lesson to a close, keep in mind that you will have two analogies to discuss when you debrief with the students. The card with the drawing is an analogy for the lizard, and the positioning of the lizard is an analogy for the positioning of the solar panels on your roof.

ACCEPTABLE RESPONSES FOR DEVELOP YOUR UNDERSTANDING SECTION

Sample Data

5. Read and record the temperature in degrees Celsius. ______*18^0C*______ *Temperature (^0C)*

Also record the time. ______*10:45 AM*______ *Time*

7. After 3 minutes with the light source on, read and record the temperature in degrees Celsius. Also record the time.

__________*19^0C*__________ *Temperature (^0C)* __________*10:48 AM*__________ *Time*

8. With the light source on, wait 3 minutes more and record the temperature and time again. Turn the light source off.

__________*21^0C*__________ *Temperature (^0C)* __________*10:51 AM*__________ *Time*

9. (a) While waiting for the system to return to room temperature, describe what happens to the temperature when the dino card is placed directly in the light. Use data from this activity to support your answer.

The temperature of the card increases. Over the 6 minutes the card was in the direct light, the temperature changed from 18^0C to 21^0C.

(b) Also, explain what would happen to the body temperature of a dinosaur or other cold-blooded animal if it were positioned in the sunlight in the same way that the card was positioned in the light during this activity.

The body temperature of the dinosaur would go up.

11. After 3 minutes with the light on, read and record the temperature in degrees Celsius. Also record the time.

__________*20^0C*__________ *Temperature (^0C)* __________*11:00 AM*__________ *Time*

12. Turn the light source off and wait 3 minutes and record the temperature and time again.

_*19^{0}C*_ *Temperature (^{0}C)* _*11:03 AM*_ *Time*

13. (a) Describe what happens to the temperature when the dino card is placed at an angle to the light source. Use data from this activity to support your answer.

    The temperature increases less when the card's position relative to the light source is changed. The temperature increased from room temperature to 20^{0}C when lizard had less surface exposed to the light.

    (b) Explain why the same thing might happen to the body temperature of a dinosaur or other cold-blooded animal.

The same thing would happen because some of the light shining on the dinosaur would be absorbed and cause the temperature to go up—just as it did with the card. But with less surface exposed to light, the temperature went up less.

Activity Analysis

1. In addition to changing the direction they face in regard to the position of the Sun, list two other ways cold-blooded animals are able to maintain an appropriate body temperature.

   Possible answers include but are not limited to:
   (a) They can move into the shade.
   (b) They can burrow into the ground where it is cooler.

2. Think of dinosaurs as large, living solar collectors. They had to collect heat and then regulate the amount of heat they had collected so that they could maintain an appropriate rate of metabolism. Describe what would happen to the rate of metabolism of a dinosaur if it always had to face in the same direction.

   If a dinosaur could not have changed the direction it faced, it would most likely have become too hot and would possibly have died due to the heat's destroying its enzymes and other proteins. This would have happened because its metabolism would have sped up due to the increased temperature. If it had survived the heat, the dinosaur would most likely have become too cold during the evening and night. It would have been a prime target for predators since it could not have responded quickly, due to a slower metabolism.

3. The solar panel on the roof of the school is in many ways like a very large lizard stuck facing in one direction. Its temperature and ability to generate electricity depend on the presence of light.

   (a) Check the temperature data output and find the average temperature of the panel on a sunny day. Record the temperature and the average amount of electricity being generated during that time.

   Sunny Day: Temperature (^{0}C)_______?_______ Electricity________?________

   (b) Check the data output for a cloudy day and record both the average temperature and amount of electricity generated.

Cloudy Day: Temperature (^{0}C)________?________ Electricity__________?________

(c) Compare the temperature reading of the panel on a sunny day to the reading on a cloudy day.

The temperature reading is higher on a sunny day than on a cloudy day.

(d) The amount of light shining on a dinosaur affected its rate of metabolism. Describe the relationship between the amount of light shining on the solar panel and the amount of electricity generated.

The greater the amount of light, the greater the amount of electricity generated.

4. Using what you have learned from the dinosaur activity, suggest how the design of the solar panel on the roof of the school could be improved so that it could generate the most possible electricity throughout the entire day.

   The solar panel would work better if it were able to change the direction it faces so that it could receive the greatest amount of sunlight.

ADDITIONAL SUPPORT FOR TEACHERS

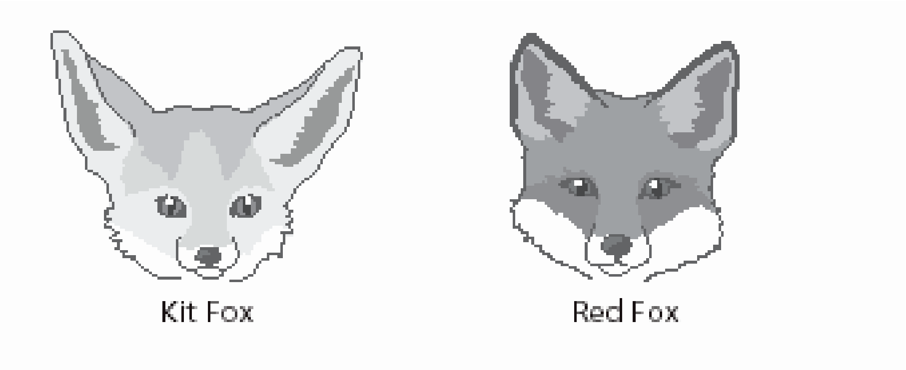
SOURCE FOR THIS ADAPTED ACTIVITY

The basic idea for the dinosaur card part of this activity is modified from “Warm Up,” found in Janice VanCleaves’ *Guide to the Best Science Fair Projects*, John Wiley & Sons, Inc., New York, 1997.

BACKGROUND INFORMATION

- An important difference among the vertebrates is the ability to regulate body temperature. All animals produce heat as a result of digesting the food they eat. Fish, amphibians, and reptiles lose this heat almost as fast as they produce it. Because their temperature is primarily regulated by their external environment, they are classified as ectotherms (*ecto* means “outside,” *therm* means “heat”) and are often referred to as being cold-blooded. Birds and mammals are able to maintain a constant body temperature by converting food energy to heat and controlling heat loss. They are therefore classified as endotherms (*endo* means “inside”) and often referred to as being warm-blooded. A nice feature of being warm-blooded is that the animal can forage for food in the shade at peak efficiency. A cold-blooded animal must move back and forth between the shade and sunlight. As it forages in the shade, its body temperature will go down and its metabolism will also slow. To remain alert and efficient, the cold-blooded animal must periodically bask in the Sun to warm up and then return to the shade and continue its quest for food.

- Many dinosaurs possessed spines and bony plates on their backs. Many scientists think that these features helped the animals maintain a more constant body temperature. One example that children are typically aware of is the *Stegosaurus*. Another example, and one that is still controversial, is the *Dimetrodon*. Some scientists think that its grand spiny back-sail was an adaptation for mating and intimidation, while others are confident that it was for thermal regulation. Some think that in the morning, when *Dimetrodon* was cold from the night air, it would turn its sail toward the Sun and warm itself. Blood flowing through the skin stretched between the spines would go throughout the animal, warming it. As the day became warmer and *Dimetrodon* was in danger of overheating, the sail could be turned into the breeze for a cooling effect. It is thought that some species of dinosaurs were warm-blooded. Adaptations such as spines and sails in these species probably served a purpose other than thermoregulation—but perhaps not! The kit fox, which lives in desert areas, has very large ears that are an adaptation for heat removal. A closely related species, the red fox, inhabits cooler regions and has smaller ears.



REFERENCES FOR BACKGROUND INFORMATION

Bakker, Robert T., Ph.D. *The Dinosaur Heresies.* William Morrow and Company, New York, 1986.

Norman, David. *Dinosaur.* Prentice Hall, New York, 1991.

Strauss, Eric and Marylin Lisowski. *Biology: The Web of Life.* Addison-Wesley Longman, Inc., Menlo Park, CA, 1998.

EXTENDED ACTIVITIES

Experimental Design

Ask students, “Could lying against the warm soil help dinosaurs stay warm at night?” Invite them to design an experiment to determine whether soil cools at a slower rate than the air above it. One possible version follows:

1. Fill two 12-ounce Styrofoam cups halfway with soil.
2. Carefully insert the bulb of a thermometer about 1/4 to 1/2 inch beneath the surface of the soil in one cup.
3. Place a second thermometer on the surface of the soil in the other cup.
4. Place the cups side by side in the Sun or in direct light from a lamp. After 5 minutes, record the temperature on both thermometers.

5. Place both cups in a refrigerator or freezer. After 5 minutes, remove the cups and read the temperatures on both thermometers.

Using Numbers

Use numbers to compare the amount of temperature increase recorded by the thermometer in direct light compared to indirect light. Compare both numbers by ratios and by percentage change. Students who show special interest in this activity might want to modify distances and/or times and predict and compare the results, using numbers.

Internet Research

Ask students to research how reptiles and amphibians alive today deal with daily changes in temperature. What body adaptations (such as bony plates on their back or antifreeze in their blood) do they possess? Also have students look for behavioral adaptations such as foraging for food at night in hot climates or coloration changes.

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(STUDENT HANDOUT SECTION FOLLOWS)

Name____

Date ____

Heating and Cooling a Really Large Lizard

Introduction

The Sun can be a lizard's best friend or its worst enemy! When the Sun's rays are warm, a 10-pound lizard's blood is just as warm as the blood of a 10-pound pig. This is surprising because a lizard is classified as a cold-blooded animal while a pig is classified as warm-blooded.

If the Sun's rays are blocked by clouds or trees, the rate of the lizard's metabolism decreases. Metabolism is the sum of all the activities that provide the energy and nutrients necessary to stay alive. In the shade, the lizard's rate of metabolism is too slow to keep its body temperature as high as the pig's body temperature. As the lizard's body temperature decreases, its mental and physical activities also slow down.

If the Sun's rays are too hot, the lizard is in trouble. Since it can neither sweat nor pant, its body temperature goes up. The elevated temperature can damage the lizard's nervous system and destroy enzymes and other proteins.

If the lizard's body temperature is too high or too low, it is in trouble. In both instances, it is not able to quickly interpret stimuli and respond to changes in its external and internal environment.

Imagine what maintaining a proper body temperature (heating and cooling) in a very large lizard such as a 5-ton dinosaur would involve. Complete the following investigation.

DEVELOP YOUR UNDERSTANDING

Materials

For your team of two students, you will need:

- one 5 x 8 inch index card (either white or colored)
- thermometer
- timer (preferably a stopwatch)
- tape
- light source (the Sun or a lamp)
- white cloth, white butcher-block paper, or four 8 ½ x 11 inch sheets of white paper taped together
- metric ruler or tape measure
- dark-colored crayons, markers, or colored pencils

Procedures

1. Fold a 5 x 8 inch index card in half the long way.

2. Draw a large dinosaur in the center of the outside of one side of the folded card (see Figure 1). Color the dinosaur.

Figure 1: Dino Card

3. Mount a thermometer on the inside of the part of the card that includes the dinosaur. Position the bulb so it points in the same direction as the tail end (posterior) of the dinosaur. The mounting of the thermometer is done by taking two strips of tape and using it to attach the thermometer to the inside of the folded card. The strips should be about 8 centimeters in from each edge and their centers should be about 3.5 centimeters up from the bottom edge. The centers of the strips should be 4 centimeters apart if your measurements are correct (see Figure 2: Dino Card with Thermometer).

4. When the card is ready for the actual investigation of temperature regulation, check to see that the thermometer bulb and the dinosaur are on opposite sides of the folded card and that the card is placed on a white surface.

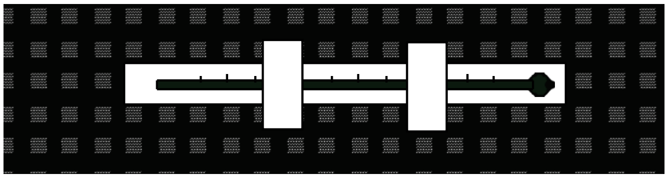

Figure 2: Dino Card with Thermometer

5. Read and record the temperature in degrees Celsius. ____________Temperature (^{0}C)

   Also record the time. ____________Time

6. Stand the dinosaur card so that it is in direct light. You can place it in the sunlight (indoors or
outside) or shine a light directly on it (see Figure 3: Dino Card in Direct Light). If you do this indoors using a light, the thermometer bulb should be between 20 and 30 centimeters from the light source.

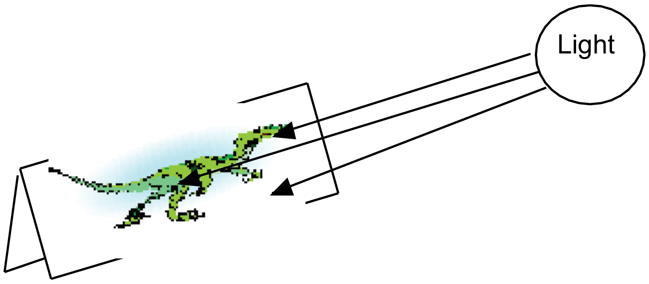

Figure 3: Dino Card in Direct Light

7. After 3 minutes with the light source on, read and record the temperature in degrees Celsius. Also record the time.

____________________Temperature (^{0}C) _________________Time

8. With the light source on, wait 3 minutes more and record the temperature and time again. Turn the light source off.

____________________Temperature (^{0}C) _________________Time

9. (a) While waiting for the system to return to room temperature, describe what happens to the temperature when the dino card is placed directly in the light. Use data from this activity to support your answer.

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(b) Also, explain what would happen to the body temperature of a dinosaur or other cold-blooded animal if it were positioned in the sunlight in the same way that the card was positioned in the light during this activity.

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10. How could a 5-ton dinosaur cool off? Try this!

Turn the card so that the head of the dinosaur (the anterior) points directly toward the Sun. The thermometer bulb should point away from the light. Measure to be sure that the bulb is the same distance from the light source here as it was in #6. When the temperature returns to room temperature, turn on the light.

11. After 3 minutes with the light on, read and record the temperature in degrees Celsius. Also record the time.

    ____________________Temperature (^{0}C)   _________________Time

12. Turn the light source off and wait 3 minutes and record the temperature and time again.

    ____________________Temperature (^{0}C)   _________________Time

13. (a) Describe what happens to the temperature when the dino card is placed at an angle to the light source. Use data from this activity to support your answer.

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    (b) Explain why the same thing might happen to the body temperature of a dinosaur or other cold-blooded animal.

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Activity Analysis

1. In addition to changing the direction they face in regard to the position of the Sun, list two other ways cold-blooded animals are able to maintain an appropriate body temperature.

   (a) ....

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   (b) ....

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2. Think of dinosaurs as large, living solar collectors. They had to collect heat and then regulate the amount of heat they had collected so that they could maintain an appropriate rate of metabolism. Describe what would happen to the rate of metabolism of a dinosaur if it always had to face in the same direction.

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3. The solar panel on the roof of the school is in many ways like a very large lizard stuck facing in one direction. Its temperature and ability to generate electricity depend on the presence of light.

   (a) Check the temperature data output and find the average temperature of the panel on a sunny day. Record the temperature and the average amount of electricity being generated during that time.

   Sunny Day: Temperature (^{0}C) _______________ Electricity _________________

   (b) Check the data output for a cloudy day and record both the average temperature and amount of electricity generated.

   Cloudy Day: Temperature (^{0}C) _______________ Electricity _________________

   (c) Compare the temperature reading of the panel on a sunny day to the reading on a cloudy day.

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