Survival of the Slowest

counterintuitive adaptations

Education Guide

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Please note: although we have provided guidelines for grades, most activities found herein can be adapted for most grades between 1 - 8. We have provided extensions and adaptions throughout the actvities.

Introduction

When you walk into Survival of the Slowest, you enter the world of counterintuitive adaptations, where your preconceptions about adaptation and survival may be challenged, where we learn that there is no overall 'best' in the real world, as environments change and pressures vary, one creature's best is another's weakness. Exploring this exhibit, students will be introduced to adaptation, energetics, costs and trade-offs, and how they all come together in seemingly perplexing ways in the star of the exhibit, the Sloth.

Fat, Fur, and Feathers: The role of insulation

Grade 2-6

Objectives

- Animals that live in extreme environments had to develop adaptations to help them survive there
- Body coverings and insulation are more than decorative, serving an important function
- Fat, fur, and feathers all serve as adaptations (insulation) to a similar environmental pressure (temperature)
- Both fat and air can act as insulators
- Thermoregulation (control and management of body temperature) is important to animal survival
- Humans may not have the same levels of fat or air insulation as these animals, but we use winter clothing, which follows the same principles

Exhibit Links

- Warm-Blooded Panel
- Cold-Blooded vs. Warm-Blooded Panel
- How Adaptations Help

Materials

- 6 x 1-Gallon freezer-strength zipper-lock bags (These will be the mitts)
- You can use quart size as long as hands can fit easily without stretching or tearing the bag
- 4 x Sandwich-size or 1-quart freezer-strength zipper-lock bags
- These will hold the "fat" layers
- 1 x 3 x 2 ft (0.9 x 0.6-m) Bubble wrap (to simulate feathers or fur)
- 8 cups (2 liters) of Vegetable shortening (to simulate fat)
- Roll of duct tape
- 1 x 5 gallon (19-Liter) bucket with handle
- 2.5 gal (9.5 liters) of an ice and cold water mixture
- 6 x Large binder clips (to secure the "hand-mitts" and labels to the bucket)
- Stopwatch (to time how long kids can keep their hands in the water)
- Towels (to keep the work area dry)

Please see Appendix A for photo description of experiment

Procedure

1. Before class, take one of the larger zipper lock bags and open it. Turn a second large bag inside out and place it into the first, so that the zip strips are matched with each other to provide a seal, and zip them together. Once this is done duct tape the edges of the openings together to make sure that they stay together and keep water out. This is the basic 'mitt'.
2. Fill the 4 smaller zipper lock bags with shortening, zip them shut, and flatten them out so that they are relatively even. These will simulate the body fat of a seal or polar bear.
3. Place these bags into one of the larger bags, then turn a second large bag inside out, and place it in the first bag, between the smaller bags of shortening, and zip the two bags together as before, forming a sort of mitt, this time, lined with fat. Again, use the duct tape to seal the two bags together. This will simulate the fat insulation of a seal or polar bear. (extra bags of shortening may be needed, as they will need to be replaced after 20 minutes or so)
4. Repeat the procedure, with the last two bags, but crumple bubble wrap between the two bags, creating air pockets to insulate the inner bag. This mitt will simulate the insulative properties of the air trapped by hair or feathers.

5. At the start of the lesson, talk to the students about the challenges of living in cold climates. Remind them that even though 'warm-blooded' animals can produce their own body heat, that the energy to create the heat has to come somewhere. In this case, it comes from burning calories. The more they have to warm themselves up, the more calories they will need, which means that they have to find more food, something that isn't always easy in the middle of winter.
6. Ask students how they might reduce the amount of heat that they would have to produce.
7. Suggest that there might be a way to conserve energy, just like we do at home when we are trying to be energy efficient. Guide the students toward the concept of insulation, whether in the form of jackets, clothes, fat, feathers, fur, or other sort of insulation.
8. Bring out the 5-gallon bucket and pour in the ice and cold water. Explain to the students that this is a lot like the cold waters of the arctic or Antarctic oceans.
9. Lower each mitt about ½ to ¾ of their length into the ice water, taking care not to let any water seep into them. Clip each mitt to the bucket and label them with a sign identifying what it is: "fat", "fur/feathers", "no insulation".
10. This activity can be done in groups, individually, or as a demonstration, depending on the number of students, age, and need for additional materials.
11. Explain to the students what each mitt represents, then have them place their hands into each mitt (with or without a thermometer to measure the temperature) and hold it there as long as they feel comfortable (or up to 1 minute).
12. Note: the individual bags of shortening may need to be replaced after about an hour as the fat itself gets cold. The ice water may also need to be replenished once the ice melts. In that case, pour out about a 1/3 of the water and add ice, taking care not to overfill the bucket or to get any water in the mitts.

Discussion

- Ask the students if the insulation made any difference between the different mitts. What difference did the different insulations make?
- Ask the students how and why they think that the different insulations work? (Fat has low thermal conductivity, so it takes much longer to lose heat through a thick layer of fat, fur and feathers trap air next to the skin. Since air is not dense, there is little mass that is available to transfer heat energy via conduction. Therefore, it is a poor conductor but an excellent insulator.)
- Do they think that they could survive in water that cold for very long? Remind them that people do live in some very cold places. How do we do it? (Clothes, insulation, and supplemental heat, we either mimic what the animals are doing by trapping air between layers of clothing, or we burn energy to produce more heat. We can shiver to produce some heat, but that would not be enough for very cold places, so we need external heat sources, like heat packs, radiators, and even other people.)
- Once the students understand how mammals use insulation to keep warm, ask them if they think that insulation would work for all animals? Would it work for cold-blooded (ectothermic) animals, like insects or reptiles? Why or why not? How might they solve the problem of living in cold places? (They may not live in extremely cold places, they might take shelter underground or underwater, where it may be cold, but it is still warmer than outside, above ground. They may huddle together for warmth, like the snakes at the Narcisse snake dens in Manitoba, Canada, where thousands of gartersnakes gather together to spend the winter underground in communal snake dens.)

Alternatives, Adaptations, and Extensions:

- This activity can be condensed to just look at blubber as insulation, and the students can coat one finger in a thick layer of shortening, and can simply place an uncoated finger and a coated one directly into the ice water rather than using the bags. This setup may be a bit messier though.
- This experiment can be extended by inserting a thermometer into each mitt to see how much heat is lost over time with each system. Older students can calculate the number of calories they would have to burn to produce that much heat and relate that to how much additional food they would have to eat. This can turn into an entire lesson on calorie consumption.
- Have the students design an experiment to see what effects insulation might have on ectothermic animals, or to test some of the ideas that they came up with that might work for cold-blooded creatures.

Counting Calories

Grade 2-6

Objective

To understand the different energy requirements for fast and slow animals.

Exhibit Link

- What is a calorie?
- Not all foods are the same
- A Day's Calories
- Being Active Takes Energy

Background

Many of us understand that we, and all other animals, need food to give us energy. So how does it work?

Molecules are all around us, from the air we breathe, the water we drink (can use H_2O molecule to demonstrate), and of course the food we eat. Within the bonds of these molecules there is energy to be found. Our bodies can break these bonds in our food and use the energy in many different ways. Can have students list ways in which our bodies use energy (eg: running or jumping, breathing, pumping blood, keeping warm). Any excess energy our bodies do not use can be stored as fat for later. Think of fat cells like batteries.

We, and other mammals are **endotherms**. We use energy to regulate our body temperatures, keeping it at the same temperature whether it is cold or hot around us. Can have students list ways in which we do this (eg: shivering, sweating).

Reptiles are examples of **ectotherms**, animals that do not use food energy to regulate their body temperature. Instead they must use heat from the sun to warm up or bury down into the ground to stay cool.

Which type of animal do you think would need to eat more food if they were the same size? **Ectotherms** require about 10% less food energy than an **endotherm** of the same size.

Animals differ in their energy requirements in other ways as well. They can be slow (low metabolism) or fast (high metabolism). The more active an animal is, the more energy must be expended to maintain that activity, and the higher its metabolic rate. We can test energy usage for fast vs slow animals by counting calories with a kitchen scale.

Chewing gum is made up of three main ingredients: gum base (rubber), softener (glycerine), and sweetener (sugar+flavour). As we chew on gum the sugars are digested by our saliva over time leaving the gum base and softeners behind. The calories we consume from chewing gum are based on the sugar content as we are unable to digest the gum base. As the ingredients are well blended it is by the action of chewing that we release the sugar from gum. As we chew the gum and digest the sugars we can also measure a decrease in weight of the stick of gum which makes for a great experiment. How do "fast" species compare to "slow" species when we measure how calories are used.

Materials

- Kitchen scale (digital work best for precision)
- Chewing gum for each student (make sure it is all the same kind and not sugar-free. Brands like Hubba-Bubba or Bubblicious work best).
- Saved gum wrappers
- Timer

Procedure

1. Divide the class into two groups: fast animals and slow animals (the larger the sample size of each group, the better the experiment works).
2. Hand out chewing gum to each student.
3. Set your timer for 2 minutes and have all the students start chewing at the same time.
4. The "fast" group will chew their gum as fast as they can (be careful not to choke!) while the "slow" group will chew veerrrrryy slowly.

5. When the timer goes off you can have everyone spit out their gum onto their saved wrappers.
6. Weigh each piece of gum on the kitchen scale and record the results. It is good to involve the entire class as the larger sample size will give clearer results.

Disscussion

- Which group's gum weighs less and "used up" more calories?
- Which type of animals do you think need more calories to survive?
- How do you think using up less calories might be beneficial?

That’s Cold Blooded

Grade 2-6

Objectives:

- The student will be able to differentiate between ‘cold-blooded’ and ‘warm-blooded’.
- To get the students to understand the concepts of ectothermy, endothermy, poikilothermy, homeothermy, microclimate, and hibernation, as well as how they relate to the labels ‘cold-blooded’ and ‘warm-blooded’.
- The student will understand how some reptiles survive in their environment, even when the overall temperature may be outside of their normal range.
- The student will understand that humans can have a huge impact on the environment and the animals in that environment.
- To get students to develop hypotheses on the effects of human actions on reptiles as well as develop possible solutions to deal with these impacts (critical thinking and stewardship, open inquiry).

Exhibit Links

- Warm-Blooded Panel
- Cold-Blooded vs. Warm-Blooded Panel
- How Adaptations Help

Materials

- Digital infrared temperature gun or several thermometers
    - (Note: if you do not have a temp gun, place thermometers in each warm/cool spot and allow approximately 20 minutes for them to show the proper temperature. Extra thermometers may be given to students for them to explore the temperatures in other areas in the classroom)
- Lamps of varying wattages
    - (e.g. halogen or other incandescent 150W, 60W, compact fluorescent, LED)
- Heat rock or heat pad
- Cork bark, artificial shelter/shade, guinea pig hides, small buckets, etc.
- Blue ice packs or other cool surface (a fan blowing across a damp cloth works well)
- Animal Cards (Appendix B)

(Note: this activity may also be done outside on a sunny day provided that a variety of basking sites/temperatures are available for the students to examine. This may remove the need for additional heating and cooling devices)

Introduction

- Being ‘cold-blooded’ does not mean that reptiles’ blood is cold. If they have been basking in the sun, they may be much warmer than we would be in their place.
- Reptiles are ectothermic, meaning that they get their heat from outside of their bodies (or, at least not from their basic metabolic processes, shivering does not count). Human beings, like other mammals, make their own body heat. They are endothermic. It may be warm at the zoo, but our bodies are even warmer. Most of what we eat goes towards keeping us warm. Reptiles, like the ones in the survival of the slowest exhibit, use outside sources, like the sun, warm rocks, cool, moist soil, and shade to control their temperatures.
- Reptiles are also poikilothermic. That means that their body temperature can change. Our bodies are usually around 37C/98.6°F (unless we are sick and have a fever), that is why your parents take your temperature to see if you are sick. Many reptiles’ body temperatures can

change. If they are lying in the hot sun their bodies heat up and may feel warm to the touch. If they are trapped in a cold room, they may feel cold. Even though their body temperatures can change, cold-blooded animals have a range of temperatures at which they work best. If it is too cold, they slow down and may even have trouble eating and digesting their food. If it is too hot, they may overheat.

- If we take the temperature of one student, what would it be? What if we take the temperature of another student? A third? Humans tend to have a relatively constant body temperature. We are homeothermic. If our body temperature changes much, something is wrong. We might have a fever or have hypothermia, but our bodies do not tend to work well outside of a very narrow temperature range. Thankfully, our bodies can produce heat to help us keep a constant body temperature when it is cool out, though we may have difficulties if it is too hot.
- So, if reptiles can't make their own body heat, how do they survive? What do they do?
- Students come up with suggestions (hypotheses) for ways that reptiles may stay warm and healthy. Do they see reptiles out in the winter? Why not? Explain that snakes and other reptiles in cold climates may need to hibernate during the winter because it is too cold for their bodies to function properly. Ask them if they have ever stood in the sun to warm up or moved to the shade to cool down. Guide them towards the idea that in any given area there are smaller areas with slightly different temperatures (microclimates). When they have reached this point, introduce the following activity, which will put them in the place of a reptile.

Setup

Place lamps/heat sources of different heat intensities/wattages and warm rocks throughout the room and place some cold packs in shaded areas. Try to make use of naturally occurring spots, like places where the sun shines through a window or a spot near an air conditioning or heating vent. If you are using thermometers instead of a temp gun, place a thermometer at each spot. Try to ensure that you have a spot in each of the following temperature ranges:

- 15° – 20°C / 60° – 70°F
- 20° – 25°C / 70° – 77°F
- 26° – 30°C / 78° – 86°F
- 30° – 40° / 86° – 100°F

Procedure

1. Divide the students into groups. Provide each group with an animal card (mountain horned chameleon, savannah monitor, banded gecko, and gartersnake) and an infrared thermometer/temp gun. (if you placed thermometers at different spots throughout the room, the temp gun is not necessary.)
2. On the animal cards, students will find information about the animals, including where they live and what temperature ranges they prefer. Have the students place each card in a spot in the room where the temperature would be appropriate for the animal on that card.
3. Once all the cards have been placed, check to make sure that each animal is in its preferred range and ask the students why they selected those spots. Did they pick that spot first because of something that they noticed? Did they use trial and error, checking spots until they found one that worked? Ask them how they think that reptiles decide where to sit.

Discussion

- Ask the students if any of them have seen reptiles in the wild. If so, where were they? Often, we will see reptiles basking on rocks in the sun in the morning, or hiding in the shade at the base of bushes or in the rocks in the heat of the day.
- Ask the students what the temperature of the room was. Were all the spots in the room

the same? Discuss how it is similar in the wild. Have the students ever stood in the sun to warm up on a chilly day? Or sat in the shade to cool down. Reptiles do the same. They pick different spots to sit at different times of the day and at different times of year, to help to keep themselves in their preferred temperature zone.

- Explain that changes in behaviour can also be adaptations to the environment. Ask the students if they can think of other examples of changes in behaviour that might help animals adapt to their environment.

Extensions

Ask the students what human activities might affect the animals' choices. Possible answers include habitat loss, loss of den sites, global warming, artificial heat sources (snakes laying on warm roads after dark where they may be run over). Brainstorm possible solutions to these problems and ways that they might become involved to make the world a better place for both people and other animals.

Why Hibernate when you can Estivate?

Grade 4-6

Objective

- To understand how special adaptations can allow species to survive in harsh climate conditions
- To understand how species can overcome natural limitations in some pretty fascinating ways

Exhibit Link

- Horned Toad

Background

Estivation is similar to **hibernation**. It is a dormant state an animal assumes in response to adverse environmental conditions, in this case, the prolonged dry season of certain tropical regions. Several species of frog are known to estivate. Two of the better-known species are the ornate horned frog (Ceratophrys ornata) from South America and the African bullfrog (Pyxicephalus adspersus). During **estivation**, an animal becomes dormant during a dry period to better conserve water or keep cool. Think of it like the dry weather counterpart to cold weather hibernation.

The water-holding frog (*Litoria platycephala*) of western Australia is also a prime example of **estivation**. Western Australia is prone to dry spells lasting months or even years. When rain does come, it's usually in the form of tropical moisture, which means a lot of it and all at once. The water-holding frog takes advantage of this short breeding period to lay their eggs in the pools that form. A convenient hole in the skin near the nostrils allows the frog to breathe slowly waiting out the next rainy period. These herpetological mummies remain in their cocoons for the duration of the dry season. When the rains return, the frogs free themselves of their shrouds and make their way up through the moist soil to the surface.

Aborigines discovered that these frogs could be used as an emergency source of water by squeezing the frog and emptying the almost fresh water for drinking. This doesn't immediately kill or harm the frog, but it does make it harder for them to survive to the next rainfall.

Around the world, there are other species of frogs that estivate in the same or similar manner to the water-holding frog. These include the African bullfrog (*Pyxicephalus adspersus*), cane toad (*Bufo marinus*) and plains spadefoot toad (*Spea bombifrons*). All three species are currently listed as "Least Concern" by the International Union for Conservation of Nature.

Despite their incredible ability to survive dry seasons, there is a limit to how much stress these frog species can handle. Climate change is likely to increase weather extremes, both floods and droughts. Increased drought length or severity could push some of these frogs to the edge where parasites or diseases could severely impact an already weakened population. In order to save all frog species, we'll have to look high, low and even underground in some pretty dry places!

Materials

- 2 cups (per student or per group)
- Silica gel (you can purchase bags of silica in most grocery stores sold as an alternative to kitty litter)
- 2 hydrated warblettes (Orbeez) per student or per group
- Cheesecloth
- Water
- Timer

Procedure

1. Each student (or group) will cut out a double layer of cheesecloth (about 2 in x 4 in) and soak it in water and then gently wring it out

2. Wrap one of the warblettes in the wet cheesecloth
3. Place the wrapped warblette in one cup and the bare warblette in the other cup
4. At the same time cover each warblette with silica sand and set timer for 20 minutes
5. When the timer goes off have each student remove the warblettes gently and carefully remove any stuck silica and the cheesecloth covering
6. Discuss differences in the covered vs uncovered warblettes

Both the cheesecloth and the warblettes allow water to pass through them making them ideal for a comparison to amphibian skin as it is also porous. The cheesecloth is representative of the extra layers of skin shed by the Horned Frog and the silica gel allows us to examine desiccation on a faster scale.

Tales about Tails: What do you do with a tail like this? / Engineer an Alien

Grade K-8

Objective

- The students will be able to recognize particular adaptations
- The student will be able to hypothesize functions for structures that they observe in animals
- The student will be able to draw connections between adaptations and the environment

Exhibit Links

- What is Fitness
- How Adaptations Help
- Everything in Nature Costs Money
- Adaptation & Fitness
- Size Matters
- The Cost of Being Big and Strong
- The Pressure of Environmental Change
- Slow Adaptations

Materials

- The book: *What do you do with a tail like this?* By: Steve Jenkins and Robin Page
- Magazines with photographs of animals that you don't mind having cut up.

Procedure

1. Read the book aloud with the students. (Though aimed at younger audiences, this book can be appreciated by all ages and can be used at multiple grade levels)
    - Post-reading engagement discussion:
    - Following the reading, have a brief discussion with the class about physical adaptations and how they help organisms survive in the wild.
    - Ask students to come up with other species and identify particular features on those animals that help them to survive where they live.
    - Ask the students how a scorpion's "tail" would work to brush flies away like the giraffe's tail, or how the giraffe's tail would work to hang in the trees like a monkey.
    - Ask the students which tail is the 'best'. Guide them to the concept that there is no single best kind of tail, or nose, or eyes. They all have costs and drawbacks. The eyes of an eagle are good at spotting prey far away, but the eyes on a deer give them better peripheral vision, helping them to see predators sneaking up on them. Underground cave dwelling fish and salamanders, since they live in constant darkness, don't really need well developed eyes, and since it takes energy to grow them and keep them working, they don't waste the energy to produce them, instead investing in other sensory systems to make their way around.

Engineer an Alien

1. Tell the students that they are the head scientists on a terraforming project, seeding another planet with life. With genetic editing tools, they are able to combine genes from different creatures to create new species with special adaptations to help them survive in the new alien habitats.
2. Provide the students with the magazines and ask them to find photos of at least three animals each.
3. Have the students identify a different structure on each animal that they want to incorporate into their created creature, then cut these structures off of the animals and paste the parts back together onto the body of another animal, creating their new creature.

4. Once they have created their creature, have the students describe the animal's new habitat and how the adaptations they selected will help their animal survive.

Discussion

Ask the students which tail is the 'best'. Guide them to the concept that there is no single best kind of tail, or nose, or eyes. They all have costs and drawbacks. The eyes of an eagle are good at spotting prey far away, but the eyes on a deer give them better peripheral vision, helping them to see predators sneaking up on them. Underground cave dwelling fish and salamanders, since they live in constant darkness, don't really need well developed eyes, and since it takes energy to grow them and keep them working, they don't waste the energy to produce them, instead investing in other sensory systems to make their way around.

Alternatives, Adaptations, and Extensions:

- If no magazines are available, students can either draw their creations, or can use the creature creator website (http://www.blueplanetdiaries.com/createacreature/create_creature.html Flash needs to be enabled).
- This activity can be extended with a language arts activity in which students write a story involving their created animal in which it utilizes each of the adaptations in its daily life.
- Ask students to think about what might happen if humans also moved to this new planet and began to change things the way we have altered our own planet, affecting climate patterns, deforesting habitats, and converting many habitats to agricultural use or urban settlements. How might their creations survive or adapt to these changes given their unique physical structures? What effects might this have on the new world?

Burning Calories!

Objectives

- Recognize that food is literally fuel and that calories are units of energy
- The student will understand that a calorie is the amount of energy required to heat one gram of water by one degree Celsius at a pressure of one atmosphere (small calorie or cal).
- Recognize that what we call "calories" when we talk about food in Canada and the United States, are 'food calories' (Cal) or kilocalories (kcal), which is the amount of energy to heat one kilogram of water by one degree Celsius at a pressure of one atmosphere
- Understand that different foods have different calorie content
- Explain the processes that allow a calorimeter to measure the energy stored in food.
- Use a homemade calorimeter to measure and calculate the energy content of a food item.
- Explain the relationship between calories, energy, energy expenditure, and good nutrition

Exhibit links

- What is a Calorie?
- Not All Food is the Same
- How Often Do Animals Eat?

Background Information

While we all hear the word calorie and know that it has to do with food, most people don't fully understand what a calorie really is. The term calorie as we use it when talking about food is more appropriately called a kilocalorie (kcal) or a food calorie, and is the measure of energy required to heat one kilogram of water by one degree Celsius at one atmosphere of pressure (roughly the air pressure at sea level)

Calories are a unit of energy. And food provides energy. Therefore calories are a measurement of the energy (fuel) available to us via food. Students will see that as they literally burn fuel (food)Scientists determine how many calories something has in it by burning the item in a closed system and measuring the heat. They call this device a calorimeter. In this activity, we will build a homemade calorimeter and use it to look at the relative calorie content of different foods.

Construction of the calorimeter may be difficult to picture for some, but a similar construction with diagrams can be found at https://www.wikihow.com/Build-a-Calorimeter

Materials

- A large tin can, 6 3/16 inches by 7 inches; top and bottom removed
    - Punch two holes on opposite sides of the top of the can (these will be used to attach the wire suspending the inner soda can) and several holes along the bottom of the can to allow air to flow in (these can be made with a hammer and nail)
- Two aluminium (soda) cans
    - Cut the top half off of one of the cans and punch two holes on opposite sides of the top edge of this can. (This will be the container to hold the water, and the holes will be used to suspend this can in the larger tin can using the wire.)
    - Cut the second can so that it is just the bottom 1 inch of the can. (This will be the food tray to hold the food being tested.
- One cork (this will be used with the needles to hold the food tray)
- Four heavy sewing needles
- An aluminum pie pan, 8 inches in diameter (this will be the base of the calorimeter
- Two 10 inch pieces of heavy craft wire or wire coat hanger strong enough to suspend the aluminium can full of water from the larger can.

- One 250mL plastic graduated cylinder (to measure water)
- An immersion thermometer
- Safety glasses for the demonstrator and all students
- Water
- Long matches or a long BBQ lighter
- Oven mitts (to handle the potentially hot cans and food tray.
- Four to five pieces of a food item to test. Include one that is rich in fats like nuts, and one that is lower in fat but rich in refined sugar like marshmallows.
- Examples of interesting foods to use are
    - Nuts (cashews, peanuts, etc.)
    - Dry dog or cat food
    - Marshmallows
    - Croutons
    - Croissant
    - Oat cereal (e.g. Cheerios®)
    - Popcorn
- The nutrition label from the food items.
- Cloth or paper towels (to clean the food tray between food types)
- Calculator
- To prepare ahead, you will need:
- A can opener

Introduction

Place the pie plate on a non-flammable surface. This will be the base of our calorimeter.

Setup

1. Use the wire/coat hanger pieces to suspend the aluminium can in the larger tin. (Be careful after opening as the edges may be sharp)
2. Place the four needles into the cork, angling them outwards so that the ends are roughly 1 cm away from each other. (These will be used to hold the food tray and food)

Safety Review

Go over the safety rules for using an open flame:

a. Work on a non-flammable surface.

b. Long hair needs to be tied back.

c. All students must wear safety glasses.

d. Always use oven mitts to handle items that may be hot.

Procedure

1. Place the pie plate on a non-flammable surface. This will be the base of our calorimeter.
2. Measure 100 ml of water and pour it into the soda can. Insert the immersion thermometer and measure the temperature of the water. Record this temperature.
3. Then place the cork needle side up on the pie plate (if it does not stand up, you can attach it with either a hot glue gun or melted wax from a candle)
4. Place the short bottom section of aluminium can onto the needles, adjusting their spacing as needed to hold it level.
5. Place ~10g of the food item being tested into the food tray. (about 1.5 regular marshmallows, about 6-7 pecan halves, or about 7 Cheerios) – using a larger amount helps to make sure that any differences are measurable.
6. Place the two-can apparatus over the pie plate / cork / food tray construction, making sure that the bottom of the hanging soda can is at approximately 1 inch (2 cm) above the top of the

food tray

7. Using the long match or a BBQ lighter, light the food item and allow the flame to completely consume the food item. If it goes out, re-light it with the lighter or a new match.

8. Once the food item has been consumed check the temperature of the water in the can. Record this temperature along with the food that was being tested.

9. Once the item has been burned and the temperature recorded, wash and dry the food tray and the water can and repeat the procedure with the next food item, cooling the water can each time and taking new measurements.

10. When all of the data have been gathered, subtract the initial water temperature from the final temperature for each food item to see how much difference the burned calories made in terms of heated water.

Discussion

- Did the different food items heat the water different amounts? If so, what were the differences?
- Ask the students why they think that the water temperature changes were different for the different food items.
- Were there any similarities between the food items that heated the water more? What about the ones that had less effect?
- Ask the students if they think that they could calculate the actual number of calories from the temperature difference. Why or why not? (Guide the students to the concept that the homemade calorimeter wasn't very efficient and that some of the heat was lost to rising hot air or other complicating factors, and the heat of the match or lighter might also have affected the numbers. Explain that calorimeters used by scientists are carefully designed to take these issues into account, but that the one constructed in class was effective enough to see relative differences in calories between the food types.
- Ask the students how they think the differences in energy they observed when burning the food items translates into differences in how each item would fuel them.
- Compare the nutritional information from the labels to the amount that the water was heated. Were there any things on the label that seemed to be correlated with a greater or lesser change in water temperature. Discuss the relation of calories and calorie density in food to a healthy diet / good nutrition.

You Need a Jacket – No I Don't!

Grade 3-6

Objectives

- The student will understand the concepts of ectothermy, endothermy, insulation, and thermoregulation.
- The student will understand how some reptiles survive in their environment, even when the overall temperature may be outside of their normal range.
- The student will understand that humans can have a huge impact on the environment and the animals in that environment.
- To get students to develop hypotheses on the effects of human actions on reptiles as well as develop possible solutions to deal with these impacts (critical thinking and stewardship, open inquiry).

Exhibit Links

- Cold-Blooded Panel
- Cold-Blooded vs. Warm-Blooded Panel
- How Adaptations Help

Materials

- Digital infrared temperature gun or several thermometers
  - (Note: if you do not have a temp gun, place thermometers in each warm/cool spot and allow approximately 20 minutes for them to show the proper temperature. Extra thermometers may be given to students for them to explore the temperatures in other areas in the classroom)
- Brooding lamp, radiator, or other heat source
- A box of freezer pops (frozen, ideally a mix of colours)
- Fleece, faux fur, or a warm jacket
- Two quick reading thermometers
- A black rock and a white one

Background Information

- In the Fat, Fur, and Feathers activity, we learned how insulation helps endothermic animals stay warm longer in cold climates. We also identified how we use clothing and other similar items (like blankets) to mimic this to help keep us warm despite the fact that we do not have thick fur or a solid layer of blubber like many other mammals that live in extremely cold climates.
- Reptiles don't have feathers, fur, or even blubber. Possibly because these animals look very different than us, there are many different misconceptions regarding their temperature control or thermoregulation. Some people believe that reptiles lack fur and feathers because they are primitive or have not "evolved them yet". Other people believe that because reptiles are 'cold-blooded' they like it cold or that they feel cold. These ideas are certainly not true.
- 'Cold-blooded' is a bit of a misnomer. When we use that term, it actually implies two different things. First, reptiles are ectothermic, meaning that they get their heat from outside of their bodies (or, at least not from their basic metabolic processes, shivering does not count). Human beings, like other mammals, make their own body heat. They are endothermic. Most of what we eat goes towards keeping us warm. Second, reptiles, like the ones in the survival of the slowest exhibit, use outside sources, like the sun, warm rocks, cool, moist soil, and shade to control their temperatures.
- Reptiles are also poikilothermic. That means that their body temperature can change. Our bodies are usually around 37C (98.6°F) (unless we are sick and have a fever), that is why your parents take your temperature to see if you are sick. Many reptiles' body temperatures can change. If they are lying in the hot sun their bodies heat up and may feel warm to the touch. If they are trapped in a cold room, they may feel

cold. Even though their body temperatures can change, cold-blooded animals have a range of temperatures that they work best at. If it is too cold, they slow down and may even have trouble eating and digesting their food. If it is too hot, they may overheat.

- We know that reptiles specifically choose where to sit or bask to help regulate their temperature, keeping themselves in their preferred temperature range. In fact, some reptiles, like Nile crocodiles, have been shown to maintain a fairly constant body temperature (within 1/2° C, even when outside temperatures fluctuated by as much as 10°!) by selecting their basking sites and modifying their behaviour. But this takes effort and can require the animals to move around or may force them to select sites where they may be more exposed to predators. As a result, people may wonder if having a fur coat, feathers, or even blubber might help them. In this activity, we will explore that possibility as well as explore the different ways that reptiles may make the most use of their environment.

Setup

- Make sure that the freeze pops are frozen and all at the same temperature
- Have a warm spot set up (temperature 30°C / 86°F or higher) for the insulation portion of the activity
- Find a sunny spot to conduct the second part of the experiment, or set up a desk lamp with a high wattage incandescent light bulb (halogen will work)

Procedure (including ongoing discussion)

1. At the start of the activity, place both the light rock and the dark rock in the sun or under the light, telling the students that we will get back to the rocks later.

   Discussion:

   - Ask the students what they learned in the Insulation activity, reviewing the concepts of endothermy/ectothermy and homeothermy/poikilothermy.
   - Ask the students how they think insulation would work with 'cold-blooded' animals. Listen for signs of the misconceptions referred to in the background information section, then prompt the students with questions that will encourage them to think about what would happen if reptiles had fur or wore jackets.
   - Remind the students that, since reptiles don't produce their own body heat, when they first wake up in the morning, they are probably significantly cooler than they would be at peak activity, and that they need to warm up for their bodies to function best.
   - Ask the students what they do to wake up and get ready for the day, then ask them how they think reptiles get ready to go about their days. Guide them to the idea that most reptiles bask in the sun or on warm rocks to warm up so that they have the energy to go about their business.
   - Tell the students that, in the following activity, they will explore how reptiles control their body temperature or thermoregulate.

2. Remove two freeze pops of the same colour (ideally dark ones) and explain to the students that these will represent cold lizards, waking up in the morning.
3. Ask the students if they'd ever been told to wear a jacket before going out so that they could stay warm? Then, tell the students that they are going to see what would happen if a lizard had fur or put on a jacket.
4. Take one of the freeze pops and place a thermometer next to it and wrap it and the thermometer together up in the faux fur, fleece, or jacket. With the readable end of the thermometer exposed so that it can still be read.
5. Place this wrapped bundle and an unwrapped freeze pop in the sun or other warm area. This

will be the equivalent of these lizards basking to warm up.

6. While the two 'lizards' are basking, ask the students what they think will happen and if they think that there will be a difference between the two lizards, and if so, what they think the difference will be and why.

7. As you talk and discuss, the exposed freeze pop should begin to melt/warm up. Once you see this, draw the students' attention back to them. If is not melted yet, draw the students' attention to the rocks that were previously placed under the light. Remind the students of the activity in which the animals selected their ideal microclimate. Explain to them that reptiles will often bask or lie on rocks that have been warming in the sun to speed up the process of warming themselves. Ask the students if they have ever done anything like that. Have the students feel the two rocks and take note of any differences in temperature between them. Ask the students why they might be different. Ask the students if they ever felt the asphalt on a road on a hot day compared to the white concrete. Explain to them that the dark colour absorbs the light shone on it as well as the energy carried by that light, meaning that they warm up more quickly.

8. By this point, the exposed 'lizard' (freeze pop) should have melted. Check the temperature of that pop, then unwrap the other 'lizard' and check its temperature. There is a good chance that it will still be frozen, or at least notably colder. Ask the students why they think that this happened. Guide the students to the idea that insulation prevents the movement of heat across it, slowing down the cooling of warm objects inside it, as well as the warming of cool objects inside it. Ask the students what they think this means to the lizards in the wild.

9. Help the students to recognize that, while some adaptations may work for some animals, there is no single best way to go and that different animals may deal with similar challenges in very different ways. Just like some species use speed to avoid predators, while others may lie still, using camouflage, different animals deal with heat in different ways.

10. How might human impacts affect this system? Some changes might make things easier for some species (e.g. heated areas or shelters), while others might negatively affect others (e.g. loss of habitat or basking spots)

Extensions

- Discuss some of the other factors that might affect how quickly a reptile might warm up or stay cool in the wild, including the temperature of the animals themselves. As a group, gather some of these ideas and ask the students to work together to design experiments to explore how their ideas might affect the lizards. Guide the students to feasible activities that can be tested using the materials at hand.

- Ask the students to set up their activities, gather data, and share these results with the class and how that affected the animals compared to what they thought would happen as well as how this might affect animals in the wild.

Animals in Space

Grade 3-8

Objective

- To encourage students to research animal adaptations from all over the world in differing environments
- To allow students to apply researched knowledge to formulate new animals adapted to life in some really "far out" environments
- To encourage creative problem solving in an exercise with no right or wrong answers
- To utilize a variety of mediums to encourage students to apply artistic strengths to a scientific exercise

Exhibit Links

- Survival of the Slowest

Subjects

- Biology
- Astronomy
- Art
- Creative Writing

Materials

- Animals in Space Handout - Background Information (Appenidx B).

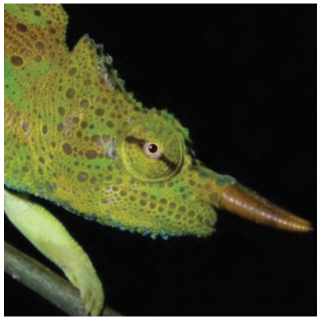
Project

Students will be divided up into 7 groups and each assigned a planet in our solar system with the exception of earth. Students will learn about the unique attributes of each planet and must create a creature based on animals on earth and their special adaptations that could live on their world. Students are encouraged to utilize a variety of mediums such as paint, pencil, clay, etc. to bring their creation to life. Students must also write up a brief, museum type information panel to describe specific attributes and behaviours of their animal.

1. Begin the lesson with a discussion of adaptations, asking the students to come up with adaptations that help various animals to survive in their environments here on Earth. Encourage discussion of the mechanisms and possible costs of these adaptations.
2. Tell the students that they are the head scientists on a terraforming project, seeding another planet with life. With genetic editing tools, they are able to combine genes from different creatures to create new species with special adaptations to help them survive in the new alien habitats. Explain that we call these 'mash-ups' chimeras. (see Background for an explanation)
3. Break the students into 7 groups, and assign each group one of the planets in our solar system and provide them with the planetary descriptions from the Background section and task them to create a **chimera** that would be adapted to the habitat of their assigned planet.
4. Once they have created their creature, have the students design a museum-style information panel describing the animal's habitat, its peculiar attributes, and how the adaptations they selected will help their animal survive.

Appendix A - That's Cold Blooded Cards

Monty the mountain horned chameleon *Trioceros montium*

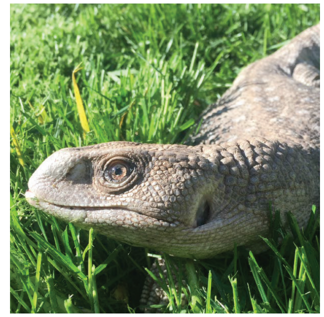


These lizards live high in the mountains in Cameroon, Africa. The forests that they live in are so high up that they are often covered in clouds. These clouds keep the forests and the chameleons cool. In these forests, they eat grasshoppers and other insects which they catch with their sticky tongues.Even though they are reptiles, they like it cooler than most, preferring temperatures from 15º – 27ºC (60º – 80ºF).

Cool Fact:

Despite what you see in cartoons, most chameleons do not change colour to hide. Instead, they use colour to tell each other how they feel, just like we do when we blush.

Smaug the savannah monitor *Varanus exanthematicus*



Smaug is a monitor lizard and is related to Komodo dragons. She comes from the savannahs and grasslands of Africa. As Smaug hunts for insects, spiders, snails, scorpions, and eggs, she soaks up the heat of the sun to get warm, and avoids getting too hot by resting in the shade and in burrows.She likes temperatures between 29º – 39ºC (85º – 100ºF)

Hot Fact:

Savanah monitors like Smaug can grow to a meter in length but still usually to eat small prey items, like caterpillars, grubs, and spiders to get the calories they need.

Noodle the Eastern garter snake *Thamnophis sirtalis*

Noodle, the Eastern garter snake, could live in your backyard. Gartersnakes are found across North America, in forests and fields, and hanging out by ponds, lakes, and streams. Garter snakes are often seen lying on rocks in the sun to warm themselves before they head off to hunt for frogs, salamanders, fish, and worms. By choosing warm basking spots and keeping active, they try to keep their temperatures between 20º – 37ºC (68º – 98ºF).

Cool Fact:

In winter, it can get very cold where they live. To deal with the cold, garter snakes often spend their winters underground in large groups to keep warm, coming out in the spring when things warm up.

Bandit the banded gecko *Coleonyx variegatus*

Bandit, the banded gecko, comes from the deserts of the southwestern United States and northern Mexico. To avoid the hot sun, these lizards spend their days shelterd in burrows in the ground, coming out at night, when it is cooler, to look for food. They prefer temperatures around 24º – 32ºC (75º – 90ºF)

Hot Fact:

Many geckos have specialized toe pads to climb and are able to walk up walls! Banded geckos don't have these pads, but they do fool some possible predators into leaving them alone by holding their tails over their body to look like a scorpion with a painful sting.

A chimera is a creature from Greek mythology that had the head of a lion, the body of a goat, and a serpent's tail, and the name is commonly used today to describe things that are combinations of several different things (e.g. creatures, genes, or cells). In this activity, students will create a chimera of their own adapted to each planet's environment.

Mercury is the closest planet to the Sun and is also the smallest of the eight planets in our solar system. Mercury is a terrestrial planet which is made primarily of rocks or metals. The terrestrial planets are the inner planets which are the ones closest to the Sun. Mercury is one of five planets that are visible to the naked eye. Mercury is very dense because it is composed mainly of heavy metals and rock. The planet has just 38% of the gravity on Earth. Mercury isn't able to hold the atmosphere it has and it instead gets blown away by solar winds. Mercury is only the second hottest planet. (Mercury has no atmosphere to regulate temperature). Mercury does not experience any seasons. Mercury has a weak magnetic field whose strength is about 1% of the magnetic field on Earth. Mercury has extreme temperatures with a low of -180° C and high of approximately 430° C. Mercury has the largest range of surface temperatures found on any planet. Mercury's core is shrinking and so is the planet as a whole.

- Animal examples for Mercury's chimera include desert animals that are well adapted to extreme swings in temperatures or animals found in rocky environments

Venus is the second planet from the Sun and the third brightest object in Earth's sky after the Sun and Moon. It is sometimes referred to as the sister planet to Earth, because their size and mass are so similar. Venus is also the closest planet to Earth. Venus is a terrestrial planet which is made primarily of rocks or metals. The terrestrial planets are the inner planets which are the ones closest to the Sun. Venus is the second brightest natural object in the sky. One day on Venus is longer than one year on earth. Billions of years ago, the climate of Venus may have been similar to that of Earth. Venus once possessed large amounts of water or oceans. Venus is the hottest planet in the solar system. Venus doesn't tilt on its axis which means there are no seasons either. The temperature on Venus doesn't vary much between night and day. Small asteroids entering the atmosphere of Venus are crushed by immense pressure. Venus has a very weak magnetic field. Venus surface is produced by the planet's
volcanic activity.

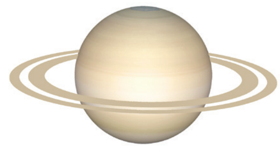
- Animal examples for Venus's chimera include animals from the equator where there is no winter or summer, animals from very hot climates, animals found in very high pressure environments like the deep sea, animals that can go a long time without sunlight or animals that are very long lived.

Mars is the fourth planet from the Sun and last of the terrestrial planets. Mars is a terrestrial planet which is made primarily of rocks or metals. The terrestrial planets are the inner planets which are the ones closest to the Sun. The landmass of Mars and Earth is very similar because water covers about 70% of Earth's surface.

The surface gravity of Mars is about 37% the gravity found on Earth. This means that on Mars you could in theory jump 3x higher than you could on Earth. The tallest mountain known in the solar system is on Mars. Mars experiences huge dust storms – the largest in our solar system. Mars experiences long and mild summer because the northern hemisphere points toward the Sun. This is compared with a cold and lengthy winter in the south. With the exception of Earth, Mars is the most hospitable to life. It takes Mars 687 Earth days to orbit the Sun. Mars is the only other planet besides Earth that has polar ice caps. Water ice has also been found under the Mars ice caps. Mars has seasons like Earth, but they last twice as long. Mars has two moons. Mars does not have a magnetic field.

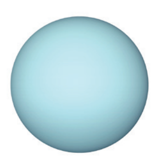
- Animal examples for Mars' chimera include animals that are good jumpers, animals found in mountainous regions, animals that live in polar regions

Jupiter is the largest and most massive planet in the Solar System. It would take 11 Earths lined up next to each other to stretch from one side of Jupiter to the other and it would take 317 Earths to equal the mass of Jupiter. Jupiter is a gas giant, which is a large planet at least ten times the mass of Earth and made mostly of gas such as hydrogen and helium. Gas giants are located in the outer solar system, farthest from the sun. Jupiter has 67 confirmed moons orbiting the planet. Jupiter has the shortest day of the eight planets. One orbit of the Sun takes Jupiter 11.86 Earth years. Jupiter has a faint ring system around it. Its ring is mostly comprised of dust particles. Jupiter has a very strong (and largest) magnetic field. This is around 14 times stronger than the magnetic field found on Earth. Jupiter is the fourth brightest object in our solar system. One of the five planets which can be seen by naked eye from Earth. Jupiter has a very unique cloud layer. The upper atmosphere of the planet is divided into zones and cloud belts which are made of ammonia crystals, sulfur and a mixture of these two compounds. Jupiter does not experience seasons like other planets such as Earth and Mars. Jupiter's Great Red Spot is an enormous storm that has been raging for over 300 years. This storm is so wide that three Earths would fit inside of it.



Saturn is the sixth planet from the Sun and the second largest planet of the Solar System in terms of diameter and mass. Saturn is a gas giant, which is a large planet at least ten times the mass of Earth and made mostly of gas such as hydrogen and helium. Gas giants are located in the outer solar system, farthest from the sun. Saturn is one of five planets able to be seen with the naked eye. Saturn is "The Ringed Planet", the rings are mostly made from chunks of ice and carbon dust. It takes Saturn 29.4 Earth years to orbit the Sun. Saturn has the fastest winds of any other planet in our solar system, approximately 1,800 km per hour. Saturn is the least dense planet in the solar system. Made mostly of hydrogen and has a density which is less than water – which technically means that Saturn would float. Saturn has 150 moons and smaller moonlets. All of these moons are frozen. Saturn is the flattest of the eight planets. This is because of the planet's low density and fast rotation speed. The magnetic field on Saturn is slighter weaker than Earth's magnetic field. Saturn is known as a gas giant, but scientists believe it has a solid rocky core surrounded by hydrogen and helium. The interior of Saturn is very hot, reaching temperatures of up to 11,700°C.

- Animal examples for Saturn's chimera include flying animals, animals adapted to extreme wind conditions, and animals living in areas prone to forest fires.



Uranus is the seventh planet in the Solar System. It is the third largest planet by diameter, yet fourth most massive. Uranus is a gas giant, which is a large planet at least ten times the mass of Earth and made mostly of gas such as hydrogen and helium. Gas giants are located in the outer solar system, farthest from the sun. The mass of Uranus is about 14.5 times the mass of Earth, making it the lightest of the four gas giants of the outer solar system. Uranus is often referred to as the "ice giant". Uranus has an icy mantle which surrounds its rock and iron core. Uranus is the second least dense planet in the solar system, after Saturn. Uranus is the coldest planet in the solar system. The minimum temperature on Uranus is -224°C. Uranus has 13 presently known rings composed of both ice and considerable dust and debris. A collision may have caused the unusual tilt of Uranus. The theory is that an Earth-sized planet may have collided with Uranus which forced its axis to drastically shift.

- Animal examples for Uranus's chimera include animals that can fly and animals that are adapted to the extreme cold

Neptune is the eighth planet from the Sun and last of the known planets. Neptune is a gas giant, which is a large planet at least ten times the mass of Earth and made mostly of gas such as hydrogen and helium. Gas giants are located in the outer solar system, farthest from the sun. It takes Neptune 164.8 Earth years to orbit the Sun. Neptune has the second largest gravity of any planet in the solar system – second only to Jupiter. Neptune has a storm known as the Great Dark Spot and is roughly the size of Earth. Neptune also has a second storm called the Small Dark Spot. This storm is around the same size as Earth's moon. Neptune spins very quickly on its axis because Neptune does not have a solid body. The climate on Neptune is extremely active. In its upper atmosphere, large storms sweep across it and high-speed solar winds track around the planet at up to 1,340 km per second. Neptune has many rings system but its rings are very faint. They are made up of ice particles and grains of dust. Neptune has 14 known moons. Neptune has an average surface temperature of -214°C – approximately -353°F.

- Animal examples for Neptune's chimera include animals adapted to extreme weather conditions, animals with a light anatomy such as those with hollow bones to withstand the strong gravity