



We are used to seeing the world around us in visible light. However, there are many other types of light, including x-rays, gamma rays, ultraviolet, infrared, microwaves and radio waves, which we cannot see with our eyes. Each of these types of light gives us a unique view of the world around us. Infrared is emitted by any object which has a temperature. Infrared images give us special information that we cannot get from visible light pictures. In these lessons a special infrared camera was used to create infrared images which will be used to help students learn about infrared light. Infrared images of animals and everyday objects will provide students with a unique and interesting view of the infrared world. The Infrared Zoo activities encourage learners to investigate the differences between warm and cold-blooded animals by comparing sets of infrared and visible images.

**In this lesson:**

Learners explore how infrared images give biologists/zoologists detailed information on how warm-blooded and cold-blooded animals thermoregulate.

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## **I. GENERAL INFORMATION**

**Title:** The Invisible Zoo

**Brief Description:** Learners explore how infrared images give biologists/zoologists detailed information on how warm-blooded and cold-blooded animals thermoregulate.

**Primary Goal:** Use these activities to introduce learners to infrared imaging technology and the information that such images contain. Observation, compare and contrast, and reasoning skills are emphasized.

**Activity Description:** Learners become engaged in the lesson by discussing their favorite zoo animals and are led into a brainstorm of how animals survive in their natural habitats. Their first exploration gives them insight on the information that infrared images can yield. They take these understandings and apply them to infrared images of warm and cold blooded animals. They will explore how various animals in different habitats thermoregulate their internal temperatures and how this information can be discovered using infrared images. Various extensions into deeper content include characterizing habitats and animals of the future in the infrared, devising an “infrared story” about a “day in the life” of an animal in a given habitat, and becoming a consultant for a zoo design team and cold blooded animal habitat.

**Learning Goals:** Provided here are general learning goals for this entire lesson. You may have additional learning goals for your particular classroom and curriculum as these activities can be easily tailored to your own needs.

At the conclusion of this lesson set, your learners will be able to:

- ◆ Explain the differences between an infrared image and visible light image of the same object/scene.
- ◆ Explain that infrared light can be used to measure the temperature of an object. Furthermore, that this measurement is transferred to color codes when recorded by an infrared camera.
- ◆ Determine the warmer and cooler areas of an infrared image using a false-color map and a temperature scale.
- ◆ Demonstrate a few ways in which warm blooded and cold blooded animals differ when photographed with an infrared camera.

**Target Audience:** Grades 10-12

**Teacher Preparation Time:** 1-3 hours the first time, negligible time after initial use

**Estimated Activity Time:**

Day 1:

- Engage Your Learners: 10-15 minutes
- Explore Infrared Image Technology: 25-45 minutes

Day 2:

- Visiting the Infrared Zoo: 45 minutes
- Help Your Learners Explain: varies

Day 3:

- Extend and Apply Understandings: time varies

**Materials Needed:**

- ◆ Internet ready classroom with workstations
- ◆ (optional) Ability to print off the internet in color
- ◆ (optional) Ability to make multiple color copies

**Authors and Idea Makers:**

The ideas presented in this lesson are the collaborative effort of the teachers in the *Invisible Universe Online* course during the spring 2003 semester. This particular lesson has been organized and written by Adrienne Gauthier (Instructional Technology Specialist, University of Arizona) with the help of Linda Hermans-Killam (Spitzer Science Center/Caltech) and Doris Daou (Spitzer Science Center/Caltech). This lesson has been evaluated by the Origins Education Forum at the Space Telescope Science Institute.

**National Science Education Standards (NSES):****Changing Emphases (...More Emphasis On...)**

The NSES envision change through out the system. Below are descriptions of how this lesson supports the changing emphases:

- ◆ Understanding scientific concepts and developing abilities of inquiry.
- ◆ Learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science.
- ◆ Implementing inquiry as instructional strategies, abilities, and ideas to be learned.

Changing emphases to promote inquiry:

- ◆ Investigations over extended periods of time.
- ◆ Communicating science explanations.
- ◆ Doing more investigations in order to develop understanding, ability, values of inquiry and knowledge of science content.
- ◆ Public communication of student ideas and work to classmates.

## II. GETTING READY

### **Pre-requisite Skills for Learners:**

Your learners should have the following skills in order to participate efficiently and smoothly in this lesson:

- ◆ Ability to work in small collaborative groups of 3-4 students each
- ◆ Ability to work independent of direct instructor facilitation as the instructor will be wandering the classroom and helping all groups
- ◆ Ability to communicate findings, reasoning, and work to others
- ◆ Cognitive ability to recognize patterns that have \*not\* been introduced/explained before hand
- ◆ Prior experience with inquiry-based and explorative learning
- ◆ Ability to navigate and mine the internet for images and information related to research project
- ◆ Familiarity with the Google search engine (<http://www.google.com>)

### **Pre-requisite Content Knowledge for Learners:**

Prior to this lesson, learners should be familiar with the following concepts:

- ◆ Temperature is a measure of the level of heat.
- ◆ Heat can move from place to place.
- ◆ Working definition and understanding of how warm blooded and cold blooded animals thermoregulate
- ◆ Knowledge of various animal habitats: grasslands (or savanna), temperate forest, tropical rain forest, desert, polar ice/tundra, tidepools, coastal regions, etc.
- ◆ (optional) Have already completed a unit or lessons on zoology and are familiar with a variety of animals (cold-blooded and warm-blooded)

### **Preparation Work for the Instructor:**

1. Reserve a computer classroom that has internet access and multiple workstations. Learners will be conducting research on the internet and will need access to the Infrared Zoo.

2. If you do not have internet access capabilities, you will need to print, in color, the Infrared Zoo animal pages from here: [http://coolcosmos.ipac.caltech.edu/image\\_galleries/ir\\_zoo/](http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/). Click on each animal name and print the entire page to include the written information. You will need to make enough color printed copies of the Infrared Zoo so that each learning group has its own copy. These will be referred to in the lesson guide as ***Infrared Zoo booklets***

3. Review the lesson and brainstorm modifications for your particular set of learners. Have ready some discussion questions and points that you want to cover for the lesson to fit into your existing curriculum and state science standards.

4. Design an evaluation rubric for this lesson based upon your learners, how you have tailored this lesson, and where this lesson falls into your curriculum. We do not provide an “evaluation” activity/rubric in this lesson, but we do provide sample learning goals generic to this lesson “as is”.

### **Background Knowledge and Resources for the Instructor:**

Provided below are some internet resources to help you get a better grasp on infrared light and image technology. Please note that we have compiled a **Cool Cosmos Teachers Guide to the Infrared** that can be found here: [http://coolcosmos.ipac.caltech.edu/image\\_galleries/ir\\_zoo/lessons/background.html](http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/background.html)

Infrared Tutorial

[http://coolcosmos.ipac.caltech.edu/cosmic\\_classroom/ir\\_tutorial/](http://coolcosmos.ipac.caltech.edu/cosmic_classroom/ir_tutorial/)

Video- Infrared: More Than Your Eyes Can See

[http://coolcosmos.ipac.caltech.edu/videos/more\\_than\\_your/](http://coolcosmos.ipac.caltech.edu/videos/more_than_your/)

## Heat and Temperature

[http://coolcosmos.ipac.caltech.edu/cosmic\\_classroom/light\\_lessons/thermal/](http://coolcosmos.ipac.caltech.edu/cosmic_classroom/light_lessons/thermal/)

## Learn About Warm and Cold-Blooded Animals Using Infrared Images

[http://coolcosmos.ipac.caltech.edu/image\\_galleries/ir\\_zoo/coldwarm.html](http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/coldwarm.html)

- This resource is the premise for this lesson. We suggest that you go through this part of our website before the activity in preparation for your learner's questions. It also makes a good wrap-up activity for learners to complete after the activity is finished.

## Infrared Application: Animal Studies

[http://coolcosmos.ipac.caltech.edu/cosmic\\_classroom/light\\_lessons/our\\_world\\_different\\_light/animals.html](http://coolcosmos.ipac.caltech.edu/cosmic_classroom/light_lessons/our_world_different_light/animals.html)

## The Camera That Caught a Leopard

<http://www.pbs.org/wgbh/nova/leopards/camera.html>

## Cool Cosmos - Infrared Zoo

[http://coolcosmos.ipac.caltech.edu/image\\_galleries/ir\\_zoo/](http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/)

- Go through the entire zoo to get background information on each animal's infrared signature.

### **III. DAY 1 LEARN ABOUT INFRARED LIGHT AND INFRARED IMAGE TECHNOLOGY**

#### **A. Engage Your Learners**

Activity Time: 10-15 minutes

Here we describe just one of many quick ways to get your learner's attention and create curiosity about the topic at hand. The ultimate goal of conducting an "engage" activity is to get your learners curious about the topic and begin to ask questions to which they will discover answers during their explorations.

1. Start a discussion about the zoo. Ask you learners to write down their 3 favorite zoo animals.
2. Take a poll and form groups of 3-4 learners based upon their animal choices. Each group will discuss a common favorite animal.
3. Ask your learners this question: What makes your animal able to survive in its natural habitat? (e.g. A walrus has layers of blubber and fat that help keep it insulated in the icy waters). Give them just a few minutes to brainstorm.
4. Hold a brief discussion on the topic, but try to keep things vague so they become intrigued for the activity. An example of how to segway into the exploration: "*We can make assumptions about how blubber, thick fur, or bare skin help to keep an animal warm or help it cool off when needed. But, How can we scientifically determine and/or support our assumptions?*" You will most likely get a few scattered answers and some smart gem may actually know about infrared imaging for zoo/veterinary studies. Either way, you can lead them into the first exploration of infrared imaging!

#### **B. Exploring Infrared Image Technology**

Activity Time: 25-45 minutes

This lesson is a mini-exploration and serves as an introduction to infrared imaging. At the conclusion of this exploration, your learners should understand the following:

- ◆ Infrared cameras can detect how much infrared radiation/light an object is emitting
- ◆ Infrared images (like the ones here) show how much infrared light was detected by the camera. Infrared light is used to measure the heat emitted by these objects. This measurement is transferred to color codes and is equivalent to degrees Fahrenheit.
- ◆ The infrared image has been scaled to show the temperature of the various areas of the object using a false-color map.
- ◆ False-color maps, like the infrared images here, come with a legend that tells the observer which temperatures are associated with which colors. This is how someone can accurately interpret the image.
- ◆ By looking at or observing the images, one can determine warmer or cooler areas. One is unable to do this with visible light images.

***This activity is common to many of our lesson guides. Please go back to the website ([http://coolcosmos.ipac.caltech.edu/image\\_galleries/ir\\_zoo/lessons](http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons)) and choose Exploring Infrared Image Technology to access the lesson guide***

## **IV. DAY 2: WHAT CAN INFRARED IMAGES OF ANIMALS TELL US?**

### **A. Visiting the Infrared Zoo**

Activity Time: 45 minutes

In this activity your learners will explore the Cool Cosmos Infrared Zoo ([http://coolcosmos.ipac.caltech.edu/image\\_galleries/ir\\_zoo](http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo)) database and make connections between the animals characteristics/biology and their new understandings of infrared image technology.

1. Form learning groups of 3-4 members each. Set each group up at an internet-computer station with the Infrared Zoo website, or, hand out your *Infrared Zoo booklets* that you have printed from the internet. The Infrared Zoo booklets are described in the Getting Ready section of this lesson.

2. Learner task: Choose 4 animals (at least 1 cold-blooded and at least 1 warm-blooded) from the Infrared Zoo that come from at least 3 different habitats. For each animal, they are to discover answers to the following questions using the infrared and visible light image sets:

- ◆ How does the animal retain body heat?
- ◆ How does the animal lose body heat and cool off?
- ◆ What are the characteristics of the natural habitat?
- ◆ How can the animal get warmed if needed?
- ◆ How can the animal get cooled if needed?
- ◆ How has this animal adapted to its environment and how can you infer this from the infrared images?

3. During this time, take a few minutes to survey the groups to see which animals they are choosing to explore. Compile the list and decide which animals you will be discussing as a class during the next portion of this lesson. Due to time constraints, each animal may not be covered. Some good ones for discussion:

- ◆ Long/thick hair vs. short/sparse hair --- baboon vs. pig/elephant
- ◆ Rainforest vs. temperate forest --- parrot vs. duck
- ◆ Warm temperatures vs. cold temperatures --- sea lion vs. tiger
- ◆ Shade vs. Sun Bathing --- alligator, collared lizard, turtle in shade vs. the same animal in sunlight

### **B. Help Your Learners Explain (possible Day 3)**

Activity Time: varies

Here you will help your learners bring together everything they have discovered and at the same time get them all "on the same page" in regards to the content presented.

Hold a class discussion/presentation on their discoveries and to reinforce content. The following points are important to cover:

- ◆ Cold-blooded animals externally regulate their body temperature. The body temperatures are directly related to their metabolic activity. For example: a snake warms itself in the sun to increase its energy before hunting. These "ectotherms" regulate their temperature by seeking warmer places or cooler places, like shade, water, or mud.
- ◆ Warm-blooded animals thermoregulate internally. However, sometimes they seek help with this by seeking warmer places or cooler places to dissipate excess heat. Some areas of their bodies are designed to keep body heat in while others may have less hair/fur to help release body heat. Example: A baboon who is trying to keep warm will curl-up in a fetal-like position trapping body heat. This same baboon can get hot in mid-day and will sprawl out under the shade of a tree letting the body heat escape through the thin hair of the belly and underarms/legs. (see infrared image)
- ◆ Infrared imaging helps us see these things. Some observations and information cannot be gathered by just looking at an animal in visible light wavelengths.

## **V. DAY 3: EXTEND AND APPLY UNDERSTANDING**

Activity Time: varies

The learners can now apply their base knowledge from the previous activities to a new scenario to deepen their understanding and discover something new. The extent to which you take this new exploration will depend on your learner's abilities and your own curriculum goals. Here, we present some simple extensions and leave deeper details up to you. Completion of all of these activities is not required. Please choose the activity or activities that suit your classroom best.

### **A. Design An Animal**

Devise some "natural habitats of the future" for your learners. For a given habitat, they need to "design an animal" that will survive and prosper. You can also use natural habitats of today's world. In their exploration, they should characterize the habitat and then characterize the animal in infrared and visible light wavelengths to help explain its adaptations. In their presentation of their animal/habitat, they should demonstrate their understandings of thermoregulation in ectotherms and endotherms and how infrared images can show information that visible light images cannot.

### **B. A Day in the Life**

Learners can build an "infrared" story of a particular animal. They can follow the animal from morning to nighttime in its habitat as it hunts, eats, plays, and sleeps. For each of these stages an infrared image would be different. They can construct these infrared images and a story about "a day in the life" of the given animal. Alternate scenarios could be "a year in the life" as they follow an animal through the seasons of its habitat. Cold-blooded animals work particularly well for this activity.

### **C. Design a Zoo Habitat**

Learners act as consultants for a zoo designer. Their task is to design/evaluate a zoo habitat for a cold-blooded critter (of their choice). They will need to research the animal to find out the optimal temperatures that it functions in for various life processes. They should design the zoo habitat in both visible light and infrared. The Cool Cosmos Infrared Image Gallery ([http://coolcosmos.ipac.caltech.edu/image\\_galleries/our\\_ir\\_world\\_gallery.html](http://coolcosmos.ipac.caltech.edu/image_galleries/our_ir_world_gallery.html)) contains infrared images for rocks, cacti, how colors absorb heat, mountains, trees, and plants. They should also design a way to "test" the animal in the habitat to ensure that it is a good environment.