



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:

Using infrared and visible light images of animals, learners will sort and categorize animals into broad categories based upon the learner's own reasoning and observations of the images. Further explorations reveal that warm and cold-blooded animals can be identified and characterized using infrared images.

Brought to you by:



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- B. **Image Set 2**, Exploring the Infrared Zoo, Visible (separate MS word or pdf file)
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http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet5.pdf

F. **Image Set 6**, External Thermostats (separate MS word or pdf file)

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet6.doc

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet6.pdf

I. GENERAL INFORMATION

Title: A Trip to the Infrared Zoo

Brief Description: Using infrared and visible light images of animals, learners will sort and categorize animals into broad categories based upon the learner's own reasoning and observations of the images. Further explorations reveal that warm and cold-blooded animals can be identified and characterized using infrared images.

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: The first exploration helps students understand infrared images and the information that is contained in such images. Then, learners explore the animal kingdom using infrared images and sort the animals into categories they define as a part of the exploration activity. Visible light images of the animals are then presented for them to modify their categories. Through a class discussion learners will explain their reasoning and work as a class to define better (content correct) categories of warm-blooded (feathered vs. furred) and cold-blooded (reptiles/amphibians vs. insects) species. This activity can be extended into deeper explorations of warm-blooded and cold-blooded animals. Learners can investigate the differences and similarities of feathered, furred, and bare skin areas of warm-blooded animals and the accompanying heat loss or conservation using infrared images. Learners can also investigate the differences and similarities between infrared images of cold-blooded creatures in varying temperature environments.

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 5-8

Teacher Preparation Time: 2-3 hours the first time, ½ hour after initial use

Estimated Activity Time:

Day 1:

- Engage Your Learners: 5-10 minutes
- Explore Infrared Image Technology: 25-45 minutes

Day 2:

- Engage Your Learners: 5-10 minutes
- Sorting Activity: 40-50 minutes
- Help Your Learners Explain: 30-45 minutes

Day 3:

- Extend and Apply Understandings: time varies

Materials/Instructor Skills Needed:

- ◆ Ability to download large files off the internet

- ◆ Ability to open, view, and print PDF files
- ◆ Ability to print in color (Resolution is at 72 dpi. PDF files are print-ready for any professional printing establishment (e.g., Kinko's or OfficeMax)
- ◆ Ability to laminate or otherwise protect printed images
- ◆ Large learning space for groups of students to work comfortably and not disturb each other
- ◆ Optional: Internet ready classroom with projection unit
- ◆ Optional: Powerpoint presentation capabilities and projection unit
- ◆ Optional: Chalkboard or wall
- ◆ Optional: Overhead projector w/ erasable transparencies and pens
- ◆ Optional: Large newprint, markers, and masking tape

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.

Content Standard A: Science as Inquiry

5-8 UNDERSTANDINGS ABOUT SCIENTIFIC INQUIRY :

- ◆ Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- ◆ Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

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

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.

Preparation Work for the Instructor:

1. Print out and make laminated copies of the infrared images from **Image Appendix, Image Set 1, Exploring the Infrared Zoo, Infrared (Section VI, A)** – a separate MS word or pdf file.

(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet1.doc)

(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet1.pdf)

Make enough of each image so that each group will have their own copy. We suggest using the numbers we have assigned to identify the images during the activity instead of using animal names. Some learners may sort using the animal names and may disregard the infrared image all together, thus missing the point of the activity.

Even though there is a large collection of animals in the Infrared Zoo, these particular images were hand-picked for this activity. Some of the images in the Infrared Zoo have the animals in sunlight or have just come from a cooler place so it emphasizes a different concept than we need.

2. Print out and make laminated copies of the visible light images from **Image Appendix, Image Set 2, Exploring the Infrared Zoo, Visible (Section VI, B)** – a separate MS word or pdf file.

(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet2.doc)

(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet2.pdf)

Make enough of each image so that each group will have their own copy.

3. In section **V. Extend and Apply Understandings**, there is a variety of optional activities. All the images used in this section are listed below. You may print out and make laminated copies of all the images or just the ones you choose. We recommend at least one copy of all of the images.

Note: These image sets are only available as separate MS Word or pdf files.

Image Appendix, Image Set 3, Characterizing Warm Blooded Animals (Section VI, C)

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet3.doc

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet3.pdf

Image Appendix, Image Set 4, Where Have You Been? (Section VI, D)

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet4.doc

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet4.pdf

Image Appendix, Image Set 5, Sunlight and the Color of Fur (Section VI, E)

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet5.doc

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet5.pdf

Image Appendix, Image Set 6, External Thermostats (Section VI, F)

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet6.doc

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet6.pdf

4. Visit the Infrared Portrait Gallery at Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_portraits.html and choose various portrait images to show to your learners in the *Engage Your Learners!* section. You can consider projecting them via a Powerpoint-like presentation or from the Internet, having them visit the website in a computer lab, or using color transparencies of the printed images.

5. Prepare the **Exploring Infrared Image Technology** lesson which can be found at the following website:

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/ .

6. 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.

7. 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” in the General Information section for this lesson.

8. Arrange the classroom for group work. Each group of learners will need to have a desk, table, or floor space to spread pictures out and discuss their group’s work without disturbing other groups.

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 at http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/background.html

Infrared 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/

Heat and Temperature

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

- 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

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/

- 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: 5-10 minutes

In this section you will use some unique and unusual images to engage your learners in the first exploration. Your learners are not likely to have seen an infrared image of an object before. The most unusual infrared images are the Infrared Portraits. Project one or more of these images at the beginning of class to get your learners curious about the funny faces! You will find portraits here:

http://coolcosmos.ipac.caltech.edu/image_galleries/ir_portraits.html. The goal is get them asking questions about what they are seeing, which will lead into the next exploration.

B. Exploring Infrared Image Technology

Activity Time: 25-45 minutes

This lesson is a mini-exploration and serves as an introduction to infrared imaging. It is necessary to complete this lesson before moving onto the exploration of the Infrared Zoo animals. 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/) and choose Exploring Infrared Image Technology to access the lesson guide.

IV. Day 2: EXPLORING THE INFRARED ZOO

A. Engage Your Learners

Activity Time: 5-10 minutes

Thus far, your learners have become curious about infrared portraits of people and have learned about the special cameras and technology that make the infrared images possible. To help reengage them in the lesson you can start the class with a casual discussion about “***What would my pet _____ look like in an infrared image?***” The common pets will be mammals and your learners will start to make connections to the Infrared Portraits of people. Hopefully, someone in the class will have a fish or snake to talk about. If not, you will need to talk about a snake “you once knew” and are curious to see what it would look like. Bringing in cold-blooded pets to the discussion will help you seg-way into the actual activity and provoke them to ask questions through the exploration.

B. Sorting Activity

Activity Time: 40-50 minutes

Image sets used – Note: these image sets are only available as either a separate MS Word or pdf file:

- ◆ **Image Appendix, Image Set 1, Exploring the Infrared Zoo, Infrared (Section VI, A)**
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet1.doc)
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet1.pdf)
- ◆ **Image Appendix, Image Set 2, Exploring the Infrared Zoo, Visible (Section VI, B)**
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet2.doc)
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet2.pdf)

You can introduce the activity to your learners by showing them a few of the Infrared Zoo pictures from **Image Appendix, Image Set 1, Exploring the Infrared Zoo, Infrared (Section VI, A)**. No doubt they will be anxious to see all of the animals in the “odd” colors! After handing out **Image Set 1** to each group you will ask them to make observations about each infrared image, create two categories for sorting, describe the criteria for each category, and present their categories to the class.

1. Form small groups of 3-4 learners each and spread the groups out in your learning space so that there is enough room to spread out the images and discuss without disturbing other groups.

2. Explain the task to your learners. It may help to have the task written on a chalkboard or on an overhead projector. Here are the main points to cover:

- ◆ Each group will be given a set of infrared images that have various animals/insects/creatures on them.
- ◆ Each group’s task is to sort the images/animals/creatures into TWO main categories based upon what they see in the infrared image.
- ◆ Each group needs to summarize the criteria for each category.
- ◆ They will have only 20 minutes to do this!
- ◆ Each group should be ready to present how they sorted the images to the whole class.

3. Explain the method of exploration briefly to your learners. It may help to have the task written on a chalkboard or on an overhead projector. Here are the main points to cover:

- ◆ Quickly review each image.
- ◆ Brainstorm how some are similar and some are different.
- ◆ Determine specifics on how some are similar and some are different --- these will be the criteria used for categorizing.
- ◆ Optional Hint: Look at what areas of each creature are warmer or cooler. Look at whether the creature is warmer or cooler, when it is compared to its surroundings in the picture.

4. Give each group **Image Appendix, Image Set 1, Exploring the Infrared Zoo, Infrared (Section VI, A)**. Walk around the class and offer assistance only where needed. It is good to let them struggle a bit. Offer hints when a group becomes too off-track or if they “hit a wall”.

...AFTER 20 MINUTES...

5. Have a brief question and answer break about the infrared images and their observations. This will give them an opportunity to voice their questions and receive guidance on seeking answers in the rest of the activity.

Some areas to discuss:

- ◆ What information are the infrared images giving us about the animals?
- ◆ What areas are cooler – why? Warmer – why?
- ◆ Have you found anything strange or confusing?
- ◆ Are any of the images not what you were expecting?

6. Give each group **Image Appendix, Image Set 2, Exploring the Infrared Zoo, Visible (Section VI, B)**. They can match up the image number on the visible light image to the image number on the infrared image. Give them 20 more minutes to review their categories and determine if they need to modify their sorting. The visible light images may help them see “feathered/furred” vs. “reptile/amphibian/insect”. Remind your learners that the infrared images and visible light images together give them more information. Comparing the images will help them modify their categories and their sorted animals.

Brief discussion question suggestions:

- ◆ How are the visible light images different than the infrared images?
- ◆ What is unique about each type of image?
- ◆ Are there patterns between the infrared and visible light images? Similarities vs. differences.

7. Optional: Some learners may be able to sort into 4 categories after seeing the visible light images: Birds, Mammals, Reptile/Amphibian, and Insect.

C. Help Your Learners Explain:

Activity Time: 30-45 minutes

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. This is where you can introduce specific content on warm-blooded and cold-blooded animals either through discussion or lecture. It is preferred that this “explain” session is done promptly after the “explore” activity, though it can be saved for the next class meeting.

1. Have another brief question and answer period about the infrared and visible light images of the animals. Learners may have questions about the different colors, the differences between the bare skin and furred areas, or why the furry/feathered animals are colorful while the reptiles are uniform in color. During this explain section you will help them find the answers to their questions.

2. Have groups present their sorting categories and the animals within those categories. How you accomplish this will depend on your classroom teaching style. Some ideas are:

- ◆ Use large poster paper and have groups write down their categories and 3 main criteria. Tape up on wall or chalkboard.
- ◆ Use chalkboard space and chalk to write down categories.
- ◆ Have oral presentations and you record “good points” on the chalkboard or overhead transparency.
- ◆ Have the class decide/debate on two solid categories and then have an open discussion/debate about how the animals are sorted into each. You can act as the facilitator and record on the chalkboard or overhead transparency the categories and sorted animals.

3. Using your own style of class discussion, help the class come to a consensus on good criteria for sorting. Help the learners describe the similarities and differences in the infrared images and between categories.

Some obvious points to cover:

- ◆ The cold-blooded animals are the same temperature (or very close) to the background temperature of the image.
- ◆ The warm-blooded animals are fairly uniform in temperature when one disregards the eye/ear/nose areas.
- ◆ Furred/feathered areas are cooler than bare skin and the lighter furred/feathered areas like eyes, ears, and noses.

In this explain session you can add in any lecture or reading about warm-blooded vs. cold-blooded animals that you need to cover for your own science standards. Take note though, not to give “too much away” so that the “extend” portion of this lesson is still valuable and still an exploration to get them thinking at a deeper level.

D. Instructor Solutions and Comments

Below are comments on the images and how they can be categorized. The two main groups are warm-blooded (birds and mammals) and cold-blooded (reptiles/amphibians/insects).

- ◆ BIRDS: Chicken, Cockatiel, Macaw, Owl
 - Warmer areas are near eyes and head (barer skin)
 - The beak area is cooler
 - Feathered areas are somewhat uniform in temperature and are generally cooler than bare skin areas.
 - Similar patterns to the furred mammals
- ◆ MAMMALS: Baboon, Cat, Dog, Giraffe, Boy, Puppy, Seal, Sheep
 - Similar patterns to bird images
 - Warmer areas are the bare skin areas and head areas
 - Cooler areas are covered in fur or hair
 - The Seal is a hard one and may get sorted into cold-blooded since his body heat is well insulated by thick blubber.
- ◆ REPTILES/AMPHIBIANS: Alligator, Chameleon, Collared Lizard, Gecko
 - Uniform temperatures (in general) for the whole animal
 - Animal is close to the same temperature as the background of the image
 - Similar patterns to insects
- ◆ INSECTS: Caterpillar, Millipede, Scorpion
 - Uniform temperatures (in general) for the whole animal
 - Animal is close to the same temperature as the background of the image or to what it is in contact with. For example when a person holds a cold-blooded animal, the warmth from the person's hand can cause the body temperature of the animal to increase near or where it is being held.
 - Similar patterns to reptiles/amphibians

V. Day 3: EXTEND AND APPLY UNDERSTANDINGS

Activity Time: varies

Image sets used – Note: these are only available as a separate MS Word or pdf file:

- ◆ **Image Appendix, Image Set 3, Characterizing Warm Blooded Animals (Section VI, C)**
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet3.doc)
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet3.pdf)
- ◆ **Image Appendix, Image Set 4, Where Have You Been? (Section VI, D)**
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet4.doc)
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet4.pdf)
- ◆ **Image Appendix, Image Set 5, Sunlight and the Color of Fur (Section VI, E)**
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet5.doc)
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet5.pdf)
- ◆ **Image Appendix, Image Set 6, External Thermostats (Section VI, F)**
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet6.doc)
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/TripToIRZoo_ImageSet6.pdf)

The learners can now apply their base knowledge from the explore and explain 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 simple extensions and leave deeper details for you to tailor. Completion of all of these activities is not required. Please choose the activity or activities that suit your classroom best.

The two objectives of these extension activities deal with how warm-blooded animals insulate themselves and/or expel excess heat and how cold-blooded creatures warm or cool themselves. There are many avenues from these basic objectives that you can take your learners down.

Presented below are some “brain storm” ideas for you to construct more in-depth extension activities and worksheets from. Pick and choose what you need! If you have a creative idea that worked well in your classroom, please email Cool Cosmos (outreach@ipac.caltech.edu) and we will add your idea to the resources.

A. Characterizing Warm-blooded Animals

Study in detail any one mammal. Ask your learners to describe “where” the animal loses heat and conserves heat. Using the Infrared Zoo Image Gallery from the Cool Cosmos website, ask them to determine if this is true for all mammals. Does the feather or fur thickness matter? Some thought-provoking images we recommend can be found in **Image Appendix, Image Set 3, Characterizing Warm Blooded Animals (Section VI, C)**.

- ◆ Baboon 1 & Baboon 2
- ◆ Cat
- ◆ Chicken
- ◆ Dog
- ◆ Giraffe 1 & Giraffe 2
- ◆ Macaw
- ◆ Parrot 1 & Parrot 2
- ◆ Pig
- ◆ Puppy
- ◆ Sea Lion
- ◆ Terrier

B. Design a Mammal (Evaluation Idea!)

Pre-requisite: Completion of Activity A of section V: Day 3 (Characterizing Warm-blooded Animals)

Each group is to “design a new mammal” and draw it as seen by our own eyes (visible light image). They need to include such details as hair/fur/feather thickness, bare skin, and other features for it’s body. On a new sheet of paper they are to redraw the outline of the animal and color it like the false-color infrared images.

C. Where Have You Been?

Pre-requisite: Completion of Activity A of section V: Day 3 (Characterizing Warm-blooded Animals)

In Activity A the learners have examined images of mammals and birds as they are photographed in relatively neutral environments, shaded areas. Some animals in the zoo have been photographed in the sun, after just coming out of the sun, or coming out of the water. Don’t tell your students this! Here they will hypothesize why the animals and birds do not look like they do in Activity A! Some thought-provoking images we recommend can be found in **Image Appendix, Image Set 4, Where Have You Been? (Section VI, D)**.

- ◆ Chicken 1 & Chicken 2
Why is the head and back so hot?
These areas are in sunlight and have been externally heated
- ◆ Eagle
Why is the back so hot?
This area has been in the sunlight and has been externally heated.
- ◆ Emu 1 & Emu 2
The emu is photographed in the shade. What is “not quite right” about the infrared image? Where has the emu come from?
The emu came from an area where there was sunlight and the feathers were heated. It went into the shade and has retained the heat from the sunlight.
- ◆ Flamingo 1 & Flamingo 2 compared with Flamingo 3
Why are they different?
Flamingo 3 is in the sunlight and various areas are being externally heated.
- ◆ Macaw
Why is the underarm so hot? Has the bird been flying upside down to get sunlight? What’s going on?
Like the armpits of humans, these are areas that are warmer and where heat can be released to cool off (wings up) or stay warm (wings tucked in). These armpit areas in birds have thinner lighter feathers.
- ◆ Parrot
Why is the underarm so hot? Has the bird been flying upside down to get sunlight? What’s going on?
Like the armpits of humans, these are areas that are warmer and where heat can be released to cool off (wings up) or stay warm (wings tucked in). These armpit areas in birds have thinner lighter feathers.
- ◆ Elephant 1 & Elephant 2
Why are they different?
The elephants in Elephant 1 are in the sunlight and are being externally heated.
- ◆ Seal 1 & Seal 2
Why are they different?
Seal 1 just came from the cold water.
- ◆ Sea Lion
Why is the underside cooler?
The topside is being externally heated by the sunlight and the underside has stayed cool from being covered.
- ◆ Sea Lion
Where did they just come from?
They came from the cold water.

D. Sunlight and the Color of Fur

There are a few pictures in the zoo where one can see how the color of fur affects the infrared image. You can extend this concept into how certain animals get warmer and cool off in the sunlight. White or lighter colored areas are cooler than black or darker areas. An analogy for your learners can be summertime clothes. Have them reflect back to a time when they were wearing a black t-shirt and standing in sunlight as compared to

wearing a white t-shirt. Some thought-provoking images we recommend can be found in **Image Appendix, Image Set 5, Sunlight and the Color of Fur (Section VI, E)**.

- ◆ Zebra
- ◆ Giraffe & Giraffe 2
- ◆ Swan 1, Swan 2, Swan 3 & Swan 4 (Note that the white body is above water!)

E. External Thermostats! Cold Blooded Animals

In the Infrared Zoo resource are many images of cold-blooded creatures who have been photographed in warm environments and also in cold environments. Using the color legend learners can determine the creatures temperature. Such sets of warm vs. cold images can be used to spawn class discussion and serve as an extension activity. Some thought-provoking images we recommend can be found in **Image Appendix, Image Set 6, External Thermostats (Section VI, F)**.

- ◆ Lizard 1 & Lizard 2
- ◆ Frog 1 & Frog 2
It appears that the frog is warming up by being held!
- ◆ Gecko 1, Gecko 2 & Gecko 3
- ◆ Python 1, Python 2 & Python 3
Look for the handprints!
- ◆ Turtle 1 & Turtle 2
- ◆ Caterpillar
Where is it the warmest? What do you think the underside looks like?
It is warmest nearest the hand that is holding it because the human hand transfers some of its heat to the animal's body. If held long enough, the underside of the animal is most likely the same "color" as the hand!
- ◆ Worms
Why aren't the worms the same temperature as the background?
The worms have been externally heated by the hand that is holding them.

F. Drawing a New Infrared Image

Using your creativity and native wildlife, you can arrange a scenario where the learners will have to draw a particular creature as if it were photographed with an infrared camera. Such scenarios could be:

- ◆ Lizard in the hot desert sun vs. lizard in the shade of a rock.
What would it look like if its tail were still in the sunlight?
The part of the lizard in the shade of the rock would be about the same temperature as the air/shaded ground. However, it's tail that has been in the sunlight will have been heated and will be a significantly higher temperature.
- ◆ Snake coming out from it's burrow to sun itself before hunting.
Use "time shots" of 0 seconds after coming out, 5 minutes after coming out, 30 minutes after coming out, and then 1 hour of being in the sunlight.
At 0 seconds it would cool be about the same temperature of the burrow. After 1 hour it would be significantly warmer from being externally heated by the sunlight.
- ◆ A frog that has just jumped out of the cool water and onto a sunny rock.
What would the image look like of the frog on the rock (include the rock in the image)?
The frog would be about the same temperature/color of the water and the rock would be much hotter "in color".
- ◆ A frog that has been sunning itself and jumped in the cool water. Seconds later it resurfaces and floats.
What does the infrared image look like of the frog in the water (include the water in the image)?
The water would be significantly cooler than the areas of sunlight on the ground/rocks near the water. The frog would have been very warm from sunning itself. It takes time to dissipate the body heat, so, in the infrared image the frog would stand out (warmer color) from the water (cooler color).