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 will discover how certain snakes (pit-vipers) can find prey using a natural infrared sensor and will extend their understandings by exploring infrared technology applications.

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TABLE OF CONTENTS

I. GENERAL INFORMATION

Title: Dinner in the Dark

Brief Description: Learners will discover how certain snakes (pit-vipers) can find prey using a natural infrared sensor and will extend their understandings by exploring infrared technology applications.

Primary Goal: Use these activities to introduce learners to infrared imaging technology and the information that such images contain.

Activity Description: Learners think about small prey animals and how a pit viper snake will find them in the forest. They explore the physical characteristics of the animals as well as other survival skills. Learners are then presented with additional information on the pit viper and its infrared sensing organ. They receive a brief presentation on infrared light and explore everyday objects in the infrared. After this small exploration, they are ready to apply their knowledge of infrared "seeing" to how the pit-viper senses infrared light. This activity concludes with a more detailed investigation into human-infrared technologies and their impact on society.

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.

Target Audience: Grades 5-9

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

Estimated Activity Time:

Day 1:
- Engage Your Learners: 10-15 minutes
- Exploring Small Prey Characteristics: 20-30 minutes

Day 2:
- Exploring Infrared Image Technology: 25-45 minutes
- Color Coding Small Animals: 30 minutes
- Help Your Learners Explain: 30 minutes

Day 3:
- Extend and Apply Understandings: time varies

Materials 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

- Ability to photocopy worksheets in B&W for students
- Sets of purple/blue, pink, and orange/yellow/red crayons (1 for each group)
- Optional: Internet ready classroom with projection unit
- Optional: Powerpoint presentation capabilities and projection unit
- Optional: Internet workstations for extension activities

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 particular lesson has been redesigned and modified from an original lesson idea submitted by Mark Stephansky at Whitman-Hanson HS in Massachusetts. 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
- Ability to process information and draw conclusions based on this information
- Ability to perform tasks necessary for a individual/group research project

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.
- Basic small prey characteristics and familiarity with their natural habitats
- (optional) The basic differences between warm-blooded and cold-blooded animals

Preparation Work for the Instructor:

1. Print out and make laminated copies of the visible light images from **Image Appendix, Image Set 1, Exploring Small Prey Characteristics (Section VII, A)** - a separate MS word or pdf file. (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet1.doc) (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet1.pdf). Make enough of each image so that each group will have their own copy.

2. Print out and make laminated copies of the infrared images from **Image Appendix, Image Set 2, Color Coding Small Animals (Section VII, B)** - a separate MS word or pdf file. (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet2.doc) (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet2.pdf). Make enough of each image so that each group will have their own copy.

3. Gather purple, blue, pink, orange, yellow, and red crayons. Make enough sets for each learning group. Each set should consists of at least 3 crayons: (1) a “cool” color (purple or blue) (2) a pink (3) a “warm” color (orange, red, or yellow). Colored pencils are also a good option.

4. Copy **Worksheets, Worksheet 1 (Section VIII, A) -** a separate MS word or pdf file. (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_Worksheet1.doc) (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_Worksheet1.pdf) and **Worksheets, Worksheet 2 (Section VIII, B) -** a separate MS word or pdf file. (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_Worksheet2.doc) (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_Worksheet2.pdf). This activity requires that each learning group have 1 of each, however individual students may want their own copy.

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

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.

9. (optional) Arrange internet/computer time for your learners for the "extend" portion of this lesson.

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

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.

IR 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

SIRTF's Infrared Zoo
http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/l
- Go through the entire zoo to get background information on each animal's infrared signature.

How The Pit Viper Measures Radiation
http://www.exergen.com/industrl/irtc/technotes/technote_019.htm

The Eye Design Book, section on pit vipers
http://www.eyedesignbook.com/ch3/eyech3-f.html#Ryu%20Uchiyama

Hidden Worlds: That Extra Sense
http://www.caledonianrecord.com/pages/hidden_worlds/story/9d05266ca

Seeing Our World in a Different Light
http://coolcosmos.ipac.caltech.edu/cosmic_classroom/light_lessons/our_world_different_light/

III. DAY 1: A SNAKE IN THE WOODS

A. Engage Your Learners

Activity Time: 10-15 minutes

Image Sets used:

- **Image Appendix, Image Set 1, Exploring Small Prey Characteristics (Section VII, A)** - a separate MS word or pdf file.
  (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet1.doc)
  (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet1.pdf)

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 learner's curious about the topic and begin to ask questions that they will discover answers to in their explorations.

1. Show a video clip of a wooded area that may have a mouse or rabbit as the topic. Try to find a video clip where the small prey blends into its surroundings. An alternate to a video is to project (via Powerpoint or overhead transparency) a few of the visible light images of the bunnies, mice, and squirrels in their natural environment. Some examples of these images can be found in **Image Appendix, Image Set 1, Exploring Small Prey Characteristics (Section VII, A).**

2. Set up a thinking scenario for your learners:

"Imagine that you are a boa constrictor (rattlesnake, or some common/local pit viper) slithering through the dense forest (or desert!) searching for food. The moonlight is blocked by a dark cloud and the forest (or desert) floor is dark. You are hunting for just the right prey, not too big and not too small. You rely on your senses to help you find your meal. Aaaahhh, here comes something now. You spring into action and attack! After a brief struggle you make away with your meal."

3. Give your learners few minutes to talk in pairs or three's about the scenario. What questions do they have about the situation? The snake? The prey? Below are some sample questions they will be able to investigate further into the lesson:

- How does the snake (pit viper) locate its meal in the dark dense forest (desert floor)?
- Once it locates prey, how does it determine if it would be a good meal?
- What sort of prey can it see in the dark?
- Why are we talking about "nighttime seeing" specifically?

Your engage activity/discussion will form a nice segway into the exploration activities.

B. Exploring Small Prey Characteristics

Total Activity Time: 20-30 minutes

Image Sets used:

- **Image Appendix, Image Set 1, Exploring Small Prey Characteristics (Section VII, A)** - a separate MS word or pdf file.
  (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet1.doc)
  (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet1.pdf)

This first exploration helps learners bring together their pre-existing knowledge of small prey characteristics and the natural environments they live in. It builds up a knowledge base for the activities that deal with infrared (IR) light.

1. Divide the class into small learning groups of 3-4 students each. Give each group a set of visible light images of small prey. The following images are in **Image Appendix, Image Set 1, Exploring Small Prey Characteristics (Section VII, A)**

- Turtles
- Frogs
- Lizards
- Mice
- Parrot & Parakeet
- Rabbits
- Squirrels

Ask your learners to complete **Worksheets, Worksheet 1 (Section VIII, A) -** a separate MS word or pdf file. (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_Worksheet1.doc) (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_Worksheet1.pdf)

Inform them that they will be presenting their work to their classmates. Basic directions for **Worksheet 1** are:

- Describe how the animal is camouflaged and also vulnerable in its natural habitat.
- Rank order the animals from "Most likely to be dinner" and "Most likely to live another day" according to the camouflage that it uses.
- Describe another method, besides camouflage, that the animal uses to increase it's survival. (Hints: physical characteristics of size, claws, teeth, where they live, where they can hide, speed of getaway, sense of smell or sight)
- Rank order the animals again, this time according to the new survival adaptation.

4. Hold a class discussion where groups can present their rankings and their reasons behind their decisions. Encourage them to ask lingering questions about the activity/animals. These learner questions will help guide the rest of the lesson.

5. If your learners are not familiar with warm-blooded vs. cold-blooded animals you should take some time to go over the basics. Specifically, they will need to understand that warm-blooded animals produce their and regulate their body heat internally while cold-blooded animals use their environment to help regulate body temperature. Cold-blooded animals normally take on the temperature of their immediate surroundings.

IV. DAY 2: LEARN ABOUT INFRARED LIGHT AND INFRARED IMAGE TECHNOLOGY

A. Exploring Infrared Image Technology

Activity Time: approximately 25-45 minutes

For certain, your learners will have lingering questions left over from the previous activity. Two of which may be:

- How does the snake (pit viper) locate its meal in the dark dense forest (desert floor)?
- Why are we talking about "nighttime seeing" specifically?

This section on infrared light and infrared image technology will help them get closer to finding answers. Before diving into this presentation, you should ask if anyone knows how snakes (pit-vipers) can sense their dinner in the dark. Their brainstorm answers will help introduce and make connections to the activity/presentation as certain snakes, like pit-vipers, can sense infrared light radiating from its prey.

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.

V. DAY 2: SEEING IN THE DARK

A. Color Coding Small Animals

Time: 30 minutes

Image Sets used:

- **Image Appendix, Image Set 2, Color Coding Small Animals (Section VII, B)** - a separate MS word or pdf file.
  (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet2.doc)
  (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet2.pdf)

The prior activities in small prey characteristics and infrared imaging technology come together here. The primary goal of this activity is for learners to explore and begin to appreciate the information gleaned from infrared images.

1. As a starting reference, show the learners the infrared and visible light image of the baboon from **Image Appendix, Image Set 2, Color Coding Small Animals (Section VII, B)**. Point out the areas of skin, light hair, and heavy hair. This will give them a reference when thinking about the infrared "signatures" of the prey animals. At this point, you should remind your class about the difference between warm and cold blooded animals. Specifically, they will need to understand that warm-blooded animals produce and regulate their body heat internally while cold-blooded animals use their environment to help regulate body temperature. Cold-blooded animals normally take on the temperature of their immediate surroundings.

2. Hand **Worksheets, Worksheet 2 (Section VIII, B) -** a separate MS word or pdf file.
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_Worksheet2.doc)
(http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_Worksheet2.pdf).
to each group and ask them to complete the top portion first. They should color the silhouette/outline drawings of the prey animals with colored crayons/pencils using the following false-color mapping:

- Purple/blue = coolest
- Pink = neutral, between warmer and cooler
- Yellow/Orange/red = warmest

3. Ask your learners to complete the following tasks using **Worksheets, Worksheet 2 (Section VIII, B)**:

- Color code each animal using the color crayons/pencils according to what you believe the infrared image will look like.
- Rank order the prey animals from coolest to warmest.
- Rank order the prey animals again from Most likely to be dinner" and "Most likely to live another day" according to their infrared image. Note: it may not necessarily be the same as the coolest to warmest ranking!
- Describe your reasoning for the infrared ranking.

4. Inquire at the conclusion of the activity if they have any questions about the color-coding or about the animals. This will help lead into the Explain activity and give you a better guide for facilitation.

B. Help Your Learners Explain

Activity Time: 30 minutes

Image Sets used:

- **Image Appendix, Image Set 2, Color Coding Small Animals (Section VII, B)** - a separate MS word or pdf file.
  (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet2.doc)
  (http://coolcosmos.ipac.caltech.edu/image_galleries/ir_zoo/lessons/DinnerInTheDark_ImageSet2.pdf)

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.

1. Hand out to each group the actual infrared images from **Image Appendix, Image Set 2, Color Coding Small Animals (Section VII, B)**.

2. Ask your learners to reassess their work on **Worksheets, Worksheet 2 (Section VIII, B)** and make necessary changes.

3. Hold a class discussion where groups can explain their ranking/reasoning. Ask questions that will help them understand the differences and similarities between infrared and visible light (what the eye sees) images.

4. Conclude this activity by having your learners brainstorm possible “applications” of “seeing in the infrared”. This will lead into your extension activities.

VI. DAY 3: EXTEND AND APPLY UNDERSTANDINGS

The learners can now apply their base knowledge of infrared light from the snake's perspective to a new scenario in order 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 a simple extension and leave deeper details up to you!

A. Learner Investigations of Infrared Technologies

Time: varies

This activity can be done as a class-time Webquest or a take-home project. There are many useful ways that infrared imaging has helped society. Spitzer's Cool Cosmos maintains some basic information on the following areas at this website:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/light_lessons/our_world_different_light/

- Astronomy
- Oceanography
- Meteorology
- Geology, Vegetation, Soil
- Animal Studies
- Archaeology
- History and Art
- Monitoring the Environment
- Medicine
- Firefighting
- Search and Rescue
- Military
- Law Enforcement
- Maintenance of Mechanical Systems
- Inspection of Electrical Systems
- Detecting Heat Loss in Structures
- Navigation
- Food Industry

From this starting point, learners can choose an application of infrared technology and then seek more information to complete a written or verbal report. As an instructor, you may find particular applications that serve better for your own curricular goals. The Cool Cosmos resource can help this lesson become multidisciplinary.