There is No Darkness
Multiwavelength Light

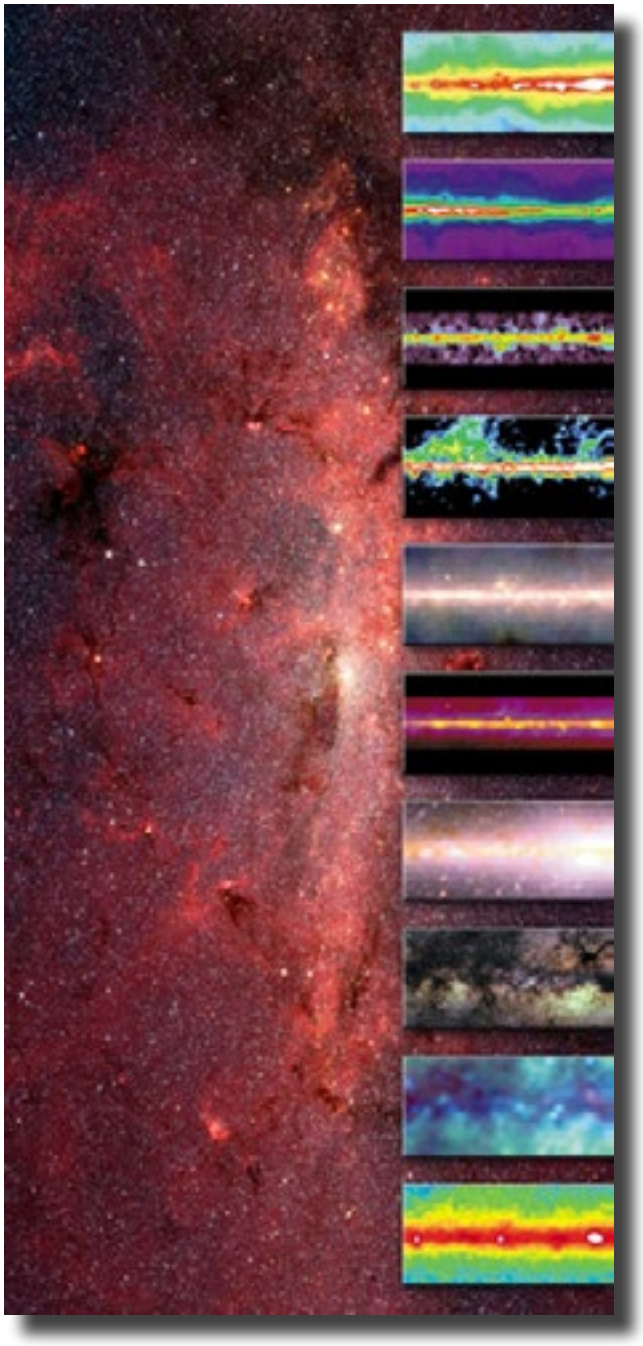
Lesson Plan by Rocky Alvey
and Katie Kendall

There Is No Darkness
Rocky Alvey/Beth Nielsen Chapman

There is no darkness
There is no night
There is no place
In Earth or space
Without the light
The great illusion
Our eyes can't see
There is no darkness
In you and me

When time began
When space was born
Before the stars came out to shine
And the worlds were formed
Before the mountains
And the Earth's blue sky
All the Universe
Was filled with light

There is no darkness
There is no night
There is no place
In Earth or space
Without the light
'The great illusion
Our eyes can't see
There is no darkness
For you and me



Images of the Milky Way in several wavelengths
IR background-NASA / JPL-Catech / S. Stolovy / Spitzer Space Telescope / IRAC
Multiwavelength Milky Way panels- NASA

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Lesson Overview –
This lesson features activities that expose students to the essence and nature of light, specifically light that is non-visible to the human eye.

Thermal image of steam locomotive
made by IR camera KT-384 from Sonel S.A.

Target Grade Levels
5th, 6th, 7th, 8th, 9th

Unit/Topic/Theme/Subject matter
Nature of Light

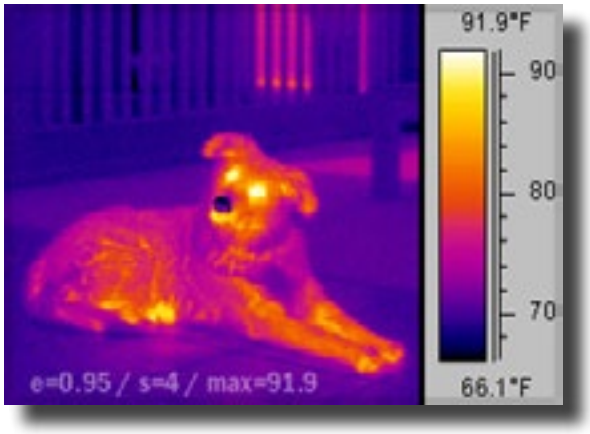
(2) 45 minute class periods or 1.0 full block

Interdisciplinary/Cross-curricular
Biological
- Plant animal interactions
- Structure and Function of the Eye

Engineering
- Instruments, instrumentation

Language arts
- Descriptive writing - Journaling, reporting, interviewing

Fine Arts
- Art self portrait, other images



FLIR thermal imaging camera

Standards and Benchmarks

K-12 Frameworks

PS4: Waves and Their Applications In Technologies for Information Transfer
- PS4.A: Wave Properties
- PS4.B: Electromagnetic Radiation

LS1: From Molecules to Organisms: Structures and Processes
- LS1.A: Structure and Function

LS4: Biological Evolution: Unity and Diversity
- LS4.B: Natural Selection
- LS4.C: Adaptation

Cross-Cutting:
- Patterns
- Cause and Effect
- Scale, Proportion, and Quantity

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- Systems and system models
- Energy and Matter
- Structure and Function
- Stability and Change

Science and Engineering Practices

- Asking questions and defining problems
- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations
- Obtaining, evaluating, and communicating info.

National Standards

- (Embedded) Inquiry (A)
- (Embedded) History and Nature of Science (G)
- (Embedded) Science and Technology (E)
- Physical Science (B)
  - Transfer of energy
  - Interactions of energy and matter (9-12)
- Earth and Space Science (D)
  - Structure of the Earth System
- Life Science (C)
  - Structure and function in living systems
  - Diversity and adaptations of organisms
  - Biological evolution (9-12)
  - Interdependence of organisms (9-12)
  - Behavior of organisms (9-12)

Benchmarks

- The Nature of Science
- The Nature of Mathematics
- The Nature of Technology
- The Physical Setting
- The Mathematical World
- Common Themes
- Habits of Mind

STEM 5 E Learning Cycle

- Components identified on individual teaching day

The Sombrero Galaxy in Infrared (top)
Spitzer Space Telescope
In visible light (bottom) Hubble Space Telescope
NASA/JPL-Caltech/R. Kennicutt (University of Arizona) and the SINGS Team. In visible NASA/STScI and the Hubble Heritage Team

Essential question/s

Are there different types of light that cannot be seen by the human eye? Can other animals see light differently than humans? What instruments have humans developed which have allowed us to see these forms of light? How do these instruments benefit humans?

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From the lyrics:
There is no darkness…there is no place in earth or space without the light…

Keywords
Light, electromagnetic spectrum, waves, wavelength, radio waves, microwaves, infrared, visible light, ultraviolet rays, x-rays, gamma rays, nocturnal, pollinators

Prior Knowledge Connection/Prerequisite Skill(s)
Light – different types of light – electromagnetic spectrum

Real Life Application
Life applications of light

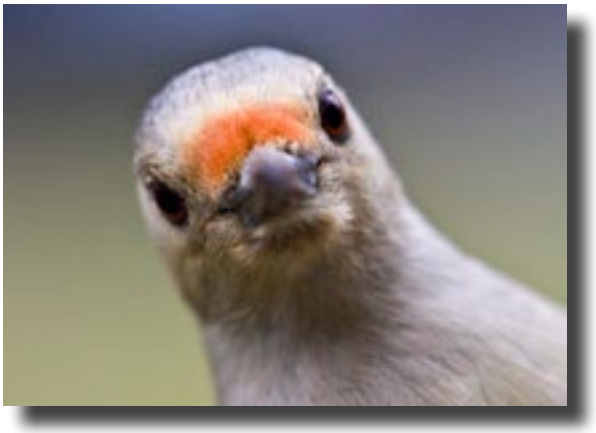
Career Fields
Astronomy, Thermography, Radiology, Nuclear Medicine, Dental, Physics, Meteorology, Biomedical instrumentation, Medical Imaging, Architectural, Building Surveyors or Inspectors, Electric Thermographer, Engineering and design, Zoologist, Veterinarian, Oceanographer, Environmental / Planetary Science

Science overview
Embedded

Higher Order Thinking Key Words

Compare	Contrast	Explain
Identify	Analyze	Categorize
Compare	Conclude	Examine
Infer	Survey	Assess
Determine	Prove	Test

Materials/Technology
Internet access, paper, pencil, colored markers or crayons



Do animals "see" as humans do? Do they see colors differently? Do they see things humans cannot? R. Alvey

Be Safe!
Warn students never to expose body parts, especially the eyes to direct sunlight or other light instruments (lasers, UV lights, black lights, microwaves)

Warn students to never go outdoors during a thunderstorm or other severe weather conditions.

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Lesson Activities – Day One
Engage/Foundation Activities

Make copies of the lyrics, "There Is No Darkness", and hand them out. While students are looking at the lyrics play the song.

Open a class discussion, by stating this song declares there is no darkness in the Universe. Refer them to the lyrics, *"There is no darkness. There is no night. There is no place in Earth or space without the light. The great illusion our eyes can't see, there is no darkness in you or me."*

Ask them, "Are these statements true"?

Allow all answers/opinions. Depending on the prior knowledge of the students, other forms of the electromagnetic spectrum may be mentioned. If not, tell the students this scenario…

> You can go into a very deep cave, turn off your flashlight,
> and it certainly seems dark. Is there light in the cave, even
> when it is so dark you can't see your hand in front of your face?

Allow students to articulate their thoughts…tell them the hint in the song is the phrase "Our eyes can't see" … If this is true, there must be different kinds of light that our eyes cannot see.

Have students try to think of and then list places they think there is no light. Offer other probing questions like - What kind of light can you detect in the deepest, darkest cave? What kind of eyes would you need to see it? Can you think of anyone in your community who would use a detector that would see in the dark? How about firemen, police, machinery and equipment inspectors (such as high pressure pipe inspectors, airplane inspectors). All of these are examples of work activities that use IR (infrared) detectors.

Exploration/Application/Revision
Explanation/Direct Instruction
Explain that we see different things when we use different kinds of detectors. Show students the poster included of the Multiwavelength Milky Way. These are images of the Milky Way galaxy in different kinds of light across the entire electromagnetic spectrum. The poster may also be found at this website *http://mwmw.gsfc.nasa.gov/index.html,* as well as the short video, "Infrared More Than Your Eyes Can See" *http://www.spitzer.caltech.edu/video-audio/145-ask_ir-Infrared-More-Than-Your-Eyes-Can-See?autoplay=true&limit=20* .
Other examples of light which we cannot see with our eyes includes: x-rays of bones, what animals look like in infrared, or radar images, etc. (See web resources included.)

If possible, invite firemen or machinery/equipment inspectors to come to class to demonstrate their IR camera/detector. If time allows, arrange a field trip to their place of work to see how they would use this technology in real life applications.

When students have understood the concept of seeing different things in different wavelengths of light, show students a practical application in nature. For example, show students online photos of flowers showing their structure in the ultra-violet (see link in web resources). Ask, "Why would flowers have different patterns which appear in the UV versus visible light"? Allow all answers. Guide students to understand that insect eyes can see patterns in the ultra-violet. Some animals such as snakes use a different part of the spectrum and "see" infrared images.

Ask students, "Why would flowers want to guide insects to a particular place"? Answer: pollination. Flowers with these patterns have the advantage of pollinating faster than non-marked flowers. Why would animals such as snakes need to see infrared (thermal) images? They hunt in the dark, IR alows them to detect their prey. Just like the flowers, this multi-sensory ability gives them a survival advantage.

Lesson Activities – Day Two

Elaboration

In a computer lab, have students study real-time infrared weather images versus real-time radar to predict the location and severity of thunderstorms. (See Weather Web Resources.) This could be a one day activity or it could be extended over a period of time as a journaling project. Have students choose a single location and monitor infrared images versus real weather conditions.

As a further extension, you may want to become involved with the NASA S'COOL Project, which involves students (ages 5-20+) in real science, making and reporting ground truth observations of clouds to assist in the validation of NASA's CERES satellite instruments.
See website: *http://science-edu.larc.nasa.gov/SCOOL/index.php*

New Vocabulary

Light, electromagnetic spectrum, waves, wavelength, radio waves, microwaves, infrared, IR, visible light, ultraviolet, x-ray, gamma ray, nocturnal, pollinator, thermal

Extension Activities

Now that students have looked at images of different objects in various kinds of light, and understand that each wavelength shows different features, assign one or all of the following activities:

1. Create a self-portrait using a type of light other than visible. Allow them to reference other spectrum examples. Have them explain why they selected that part of the spectrum and why they appear the way they do.

2. Create an art piece or written project describing themselves living in a world where they can only

see infrared light. How would they see their room, house, neighborhood, city, school, friends, family members? Remind them that rates of infrared radiation are related to surface temperatures. The higher the surface temperature, the higher the radiation, the lower the surface temperature the less radiation, so objects above the surface would appear cooler. Have them either describe in words this world or do a piece of art work.

3. Draw a picture of a piece of equipment that has been running for a long time. Depict what an infrared image of it would look like. Include a color key.

4. Interview or invite an architect to the classroom to discuss how they design structures based on managing infrared energy. Ask them to explain why some products such as windows and doors are more efficient than others.

5. Interview or invite a health care professional to the classroom to discuss the latest in medical imaging equipment and techniques (MRI, CT, PET, US, XRAY, Nuclear).

6. Write a report or create a visual artifact (poster, Powerpoint) about an animal which sees a different part of the spectrum than humans. Research how it benefits from its unique adaptation.

Evaluation
Discussion participation
Computer lab attention to detail
Extension activity/activities
(Journaling weather predictions vs. actual)

Application/Revision activities
Round robin – questioning and discussions
Guided Practice – observation of satellite imagery, calculations

Family involvement component - Lesson Extensions "at home"
Invite an infrared building surveyor to find "hot spots" in your home – IMPORTANT: This is usually a fee-based service, make sure you preface your invitation by stating this is for a school project and ask if they would do the survey at no charge.

Take a tour of a local fire department and ask to see a demonstration of their infrared camera.

Teacher: Mental Notes/Reflections
What went well? What would you do differently the next time you approach this lesson?

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Web Resources

NASA:
The Multiwavelength Milky Way
http://mwmw.gsfc.nasa.gov/index.html

Spitzer Telescope Mission pages
http://www.spitzer.caltech.edu/

SOPHIA websites:
http://www.nasa.gov/mission_pages/SOFIA/
http://www.sofia.usra.edu/Edu/materials/edu_materials.html

NASA has created "special eyes" that astronomers use to study the "light" hidden from our eyes. These telescopes have been referred to as the "Great Observatories".
http://www.nasa.gov/audience/forstudents/postsecondary/features/F_NASA_Great_Observatories_PS.html

Cosmic Background explorer (COBE)
http://lambda.gsfc.nasa.gov/product/cobe/c_edresources.cfm

HEASARC
http://heasarc.gsfc.nasa.gov/docs/objects/objects.html

Incredible video explaining infrared light
http://www.spitzer.caltech.edu/video-audio/145-ask_ir-Infrared-More-Than-Your-Eyes-Can-See?autoplay=true&limit=20

Cool Cosmos
http://coolcosmos.ipac.caltech.edu/cosmic_classroom/classroom_activities/herschel_experiment.html

The Hubble Space Telescope
http://www.stsci.edu/hst/

The Compton Gamma Ray Telescope
http://heasarc.gsfc.nasa.gov/docs/cgro/index.html

The Chandra X-Ray Telescope
http://chandra.harvard.edu/

National Radio Observatory
http://www.nrao.edu/index.php/learn/gallery

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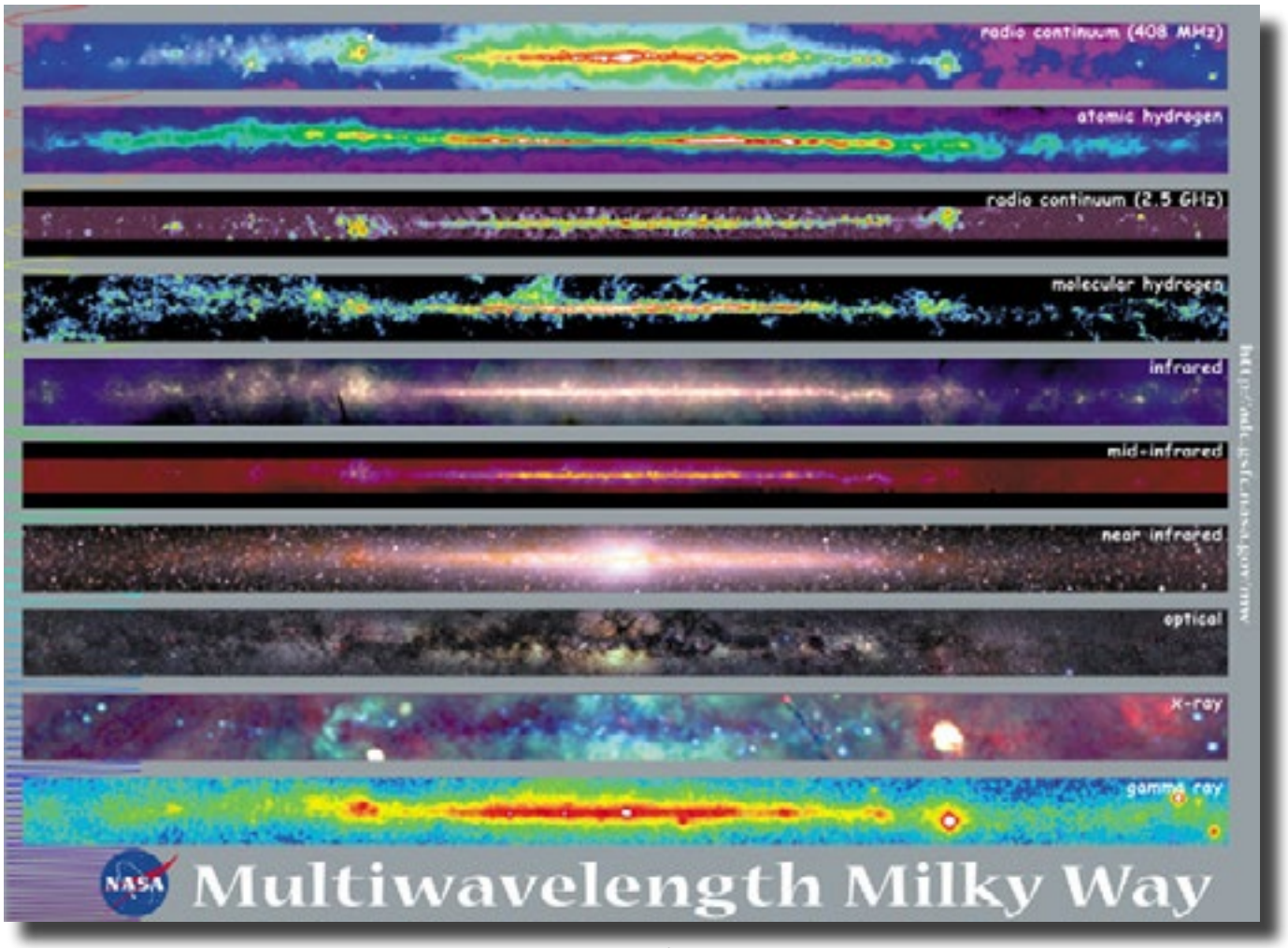
THE MIGHTY SKY ™

Weather:
National Center for Atmospheric Research-Research Application Program
http://weather.rap.ucar.edu/satellite/

GOES Satellite Imagery
http://rsd.gsfc.nasa.gov/goes/
http://www.goes.noaa.gov/

Exhaustive resources regarding earth systems, oceanography, satellite imagery, geological, atmospheric interactions and biological data
http://www.ametsoc.org/amsedu/DS-Ocean/home.html

Ultraviolet photos of flowers: (others can be found doing a simple internet search)
http://www.dailymail.co.uk/sciencetech/article-473897/A-bees-eye-view-How-insects-flowers-differently-us.html



Find poster at http://mwmw.gsfc.nasa.gov/mmw_sci.html