FOR THE FAMILY OF: ______

INVESTIGATING Astronomy CONNECTIONS

Investigating Tools of Astronomy

The star cluster below is named the Jewel Box, based on the description "*a casket of variously colored precious stones*"... *See story on page 2.*

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TERC® NSF ASTRONOMICAL SOCIETY OF THE PACIFIC NOAO

Family Features

Representing the Invisible with Color

Materials You'll Need

- 2 coffee mugs, one filled with hot water, the other filled with cold water and ice
- a metal cookie sheet
- 1-inch squares of colored paper in at least 5 different colors

Talk Like an Astronomer

CCD — an abbreviation for charge-coupled device. A silicon chip with an array of light- sensitive diodes used to capture images.

latitude — one of the two coordinates used to specify a location on Earth. The number of degrees North or South of the equator, from zero˚ to 90˚.

longitude — one the two coordinates used to specify a location on Earth. The number of degrees East or West of the prime meridian, from zero˚ to 180˚.

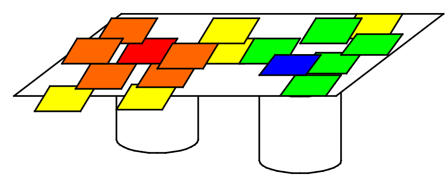
prime meridian — an arbitrary line that runs through Greenwich, England. This line establishes 0˚ longitude.

Our eyes are sensitive to a whole rainbow of colors, but there are kinds of light that have no color. How do we know something is there if we can't see it? We use different kinds of detectors. For instance, our skin detects UV electromagnetic radiation by turning red when we get too much sun. It's not the visible light we can see that burns us, but the more energetic ultraviolet radiation. On an electric stove, the heating element glows red, and you know it's hot. As it cools down, it can look black but still be hot to the touch. It is no longer glowing or emitting red light, but it is emitting less energetic infrared radiation. We don't see it, but we can feel it.

Astronomers use a wide variety of types of detectors to study the universe. In order to be able to show what would otherwise be invisible, they often use color to represent what we can't see. So that others can understand what is represented in such colorful images, a key is necessary. The key explains what each color represents. In this experiment, you'll use your hand as an infrared detector and create an infrared image of a cookie sheet.

Here's What to Do

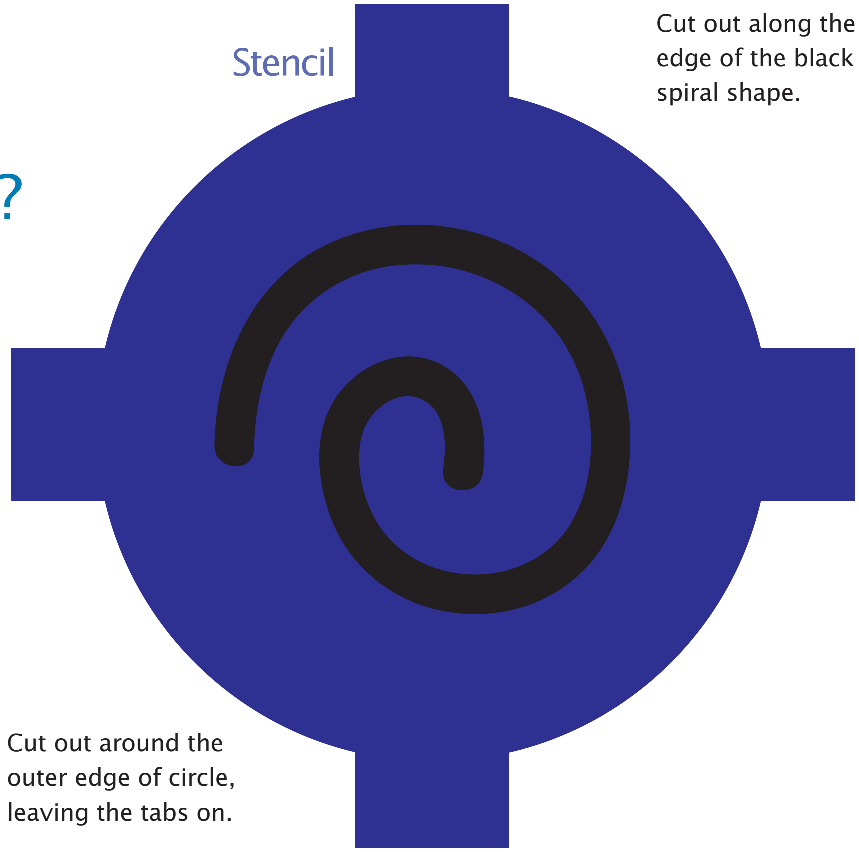
- Place the coffee mugs (one hot, one cold) about 4 inches apart on the table.
- Cover them with the cookie sheet.
- Ask family members to guess which mug has the hot water and which has the cold. Can they tell by just looking? If not, let them touch the cookie sheet and explain to them that the warm spots are emitting infrared (IR) light and the cool spots are too cold to emit IR radiation.
- Then have them create a map of what they felt. They can represent each temperature with a different color. Have them also make a key so others can understand their map. ★



On the Cover

The great variety of star colors in this open cluster, which is in the constellation known as the Southern Cross, underlies the cluster's name—Jewel Box. The cluster was named the Jewel Box based on its description by a 17th century astronomer as "a casket of variously colored precious stones," referring to the way it appeared in a small telescope. One of the bright central stars is a red supergiant, in contrast to the many blue stars that surround it. The cluster contains just over 100 stars and is about 10 million years old. It lies about 7500 light-years away, so the light that we see today was emitted from the cluster before the Great Pyramids in Egypt were built. (Credit: NOAO)

Stencil



Cut out along the edge of the black spiral shape.

Cut out around the outer edge of circle, leaving the tabs on.

How do CCD's Work?

With the popularity of digital cameras, CCDs are in common use. However, most people don't have a clue as to how they work. Here's a simple demonstration you can do to give your friends and family the general idea. It just takes a little prep work.

Materials You'll Need

- Paper cup
- Scissors
- Tape
- Salt or sugar

Prep Work

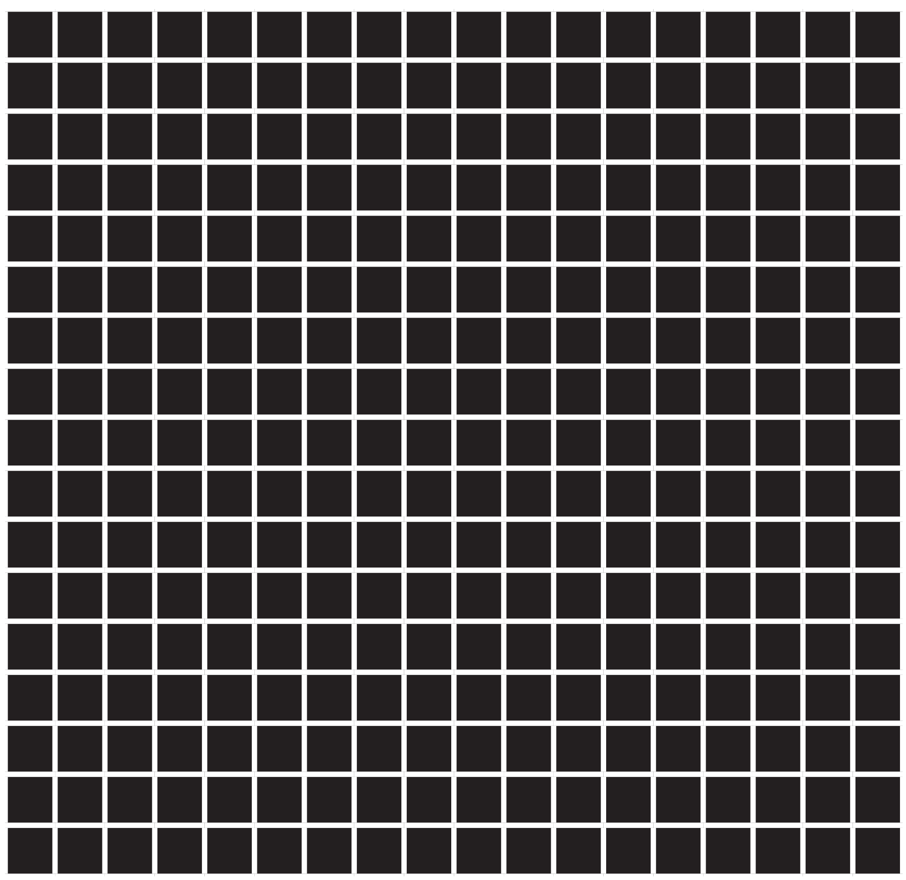
- Cut the bottom out of the paper cup
- Trace and cut out the stencil, leaving tabs for fastening
- Tape the stencil to the cup's now open bottom

Demonstration

To show how light is collected by a telescope and builds up on a CCD to create an image:

- Place the cup (telescope) stencil side down on the grid (CCD).
- Sprinkle salt or sugar (photons) into the cup. These photons represent the light coming from the object in space.
- Remove the cup with its stencil carefully to view the image on the CCD.

The more photons there are in each square, the brighter the image will be. Start with a short exposure (sprinkle for just 3 seconds). Then remove the cup. Can you recognize what it is an image of? Try a longer exposure (sprinkle sugar for 5 seconds). Remove the cup and see if the image is more recognizable. Try a 10 second exposure. Is it overexposed? ★



Hot Link http://hubblesite.org/sci.d.tech/behind_the_pictures/meaning_of_color/index.shtml

Star Witness

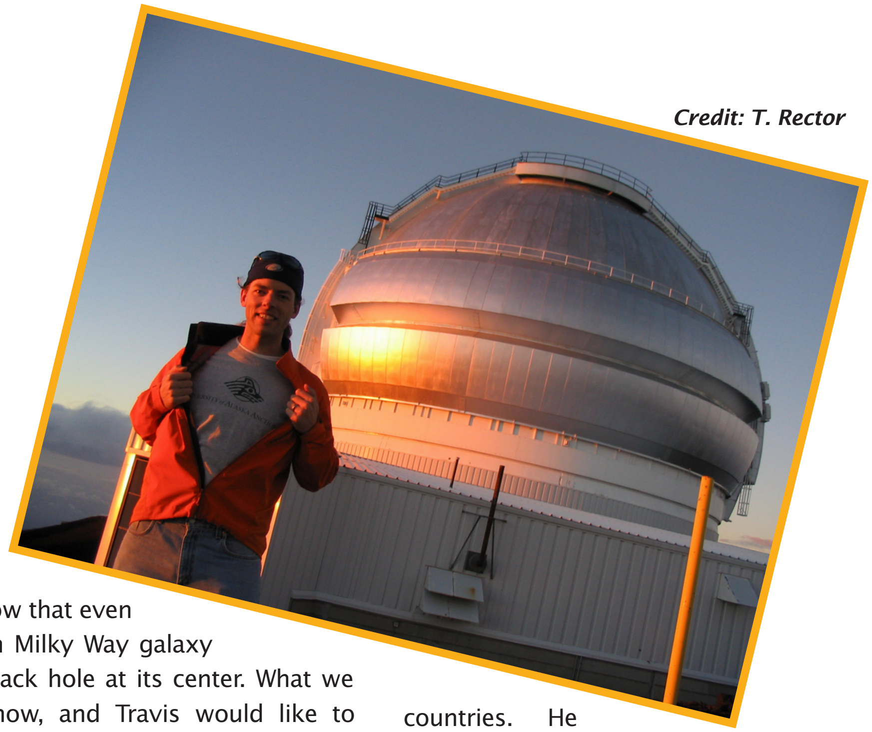
Travis Rector

Assistant Professor, University of Alaska Anchorage

Travis Rector was probably destined to be a scientist. As a kid, he loved math and science and even had a poster of the periodic table hanging on his dining room wall. His mother was a professor at the University of Wisconsin, and one day while he was in high school, Travis went to the university with her. He walked into the office of an astronomer and asked, “How can I do what you do?”

The guidance Travis received set his path for the next few years. He was told that there are many ways to become an astronomer, but the usual one is to study physics as an undergraduate in college, then focus on astronomy in graduate school. His area of study is astrophysics, which is the application of physics to astronomy questions. Astronomy is much broader than astrophysics, and can include planetary science, atmospheric science, geology, and astrophysics. Travis’s path was a pretty standard one, but some of his colleagues followed a more roundabout way. One came from art; one was a blues DJ; one was a professional cyclist—before they decided to go into astronomy.

What fascinates Travis now is active galaxies and quasars and how they are related to each other. We now know that most galaxies have super massive black holes at their centers. How supersized the black hole is depends on the size of the galaxy—if the galaxy is really big (massive), so is the black hole. We’re uncertain about the little ones. Dwarf galaxies may not have black holes at their centers, or we may just not have been able to detect them yet.



Credit: T. Rector

We know that even our own Milky Way galaxy has a black hole at its center. What we don’t know, and Travis would like to help figure out, is which came first, the galaxy or the black hole. In other words, we don’t know if the galaxy forms first and then, as it gets crowded at the center, a black hole forms or if the black hole forms first and the rest of the galaxy forms around that. Understanding this may help us discover how active galaxies are related to both the quieter galaxies like our Milky Way and to the super-energetic quasars.

To explore these questions, Travis has been using data from radio, optical, and x-ray observatories and recently even some infrared observatories. This practice is new in astronomy. Astronomers were often classified by the range of the electromagnetic spectrum that they observed in. Today, astronomers don’t specialize in a wavelength, but in a phenomenon, like active galaxies, star formation, or planets. The different wavelengths of electromagnetic radiation serve as tools in the astronomers’ toolbox. Galaxies can be dusty places that block optical light, so Travis uses both the high- and low-energy ends of the spectrum (x-ray and radio) to see through that dust.

Travis also says that if you have a global perspective and like to travel, astronomy is a great career. Observatories are all over the world, and by partnering with astronomers from around the world, you’ll always have friends to visit in other countries. He has used observatories in New Mexico (VLA), Arizona (Kitt Peak), Hawaii (Gemini North), Chile (Gemini South), California (Palomar), the Canary Islands off the coast of Africa (Nordic Optical Telescope) and Australia (Siding Spring Observatory). During the World Cup, Travis was in the Canary Islands observing—all the astronomers wanted to talk about was soccer, not the stars!

Travis Rector is now an assistant professor of astronomy at the University of Alaska in Anchorage. He wanted to be in Alaska, and all the computing power he needs is in his laptop. He can collect his data at observatories around the world, download it to his computer, and take it home with him.

Travis wants students to be aware that this is truly a golden age in astronomy. The level of technology is fantastic; however science education does not seem to be producing that next generation of astronomers who can continue the vital and interesting work. Astronomy is still a competitive field and takes lots of effort, but many who might enjoy it are choosing other career paths. So Travis wants to encourage those who enjoy astronomy to seek out research opportunities and hopes it will get them hooked. With the advent of remote telescopes, high school students can do research from their home computers. ★

Sky Watch

The Colorful Sky

"Colorful" is not an adjective usually used to describe the night sky. The daytime sky, of course, can consist of many beautiful shades of blue, with brilliant white clouds or threatening gray storm clouds, not to mention the rich colors of sunset. But at night, we think of a dark sky (if we live far from city lights) dotted with sparkling stars. We don't usually notice the colors of the stars, and that is a consequence of two things: 1) how our eyes work, and 2) how far away the stars are.

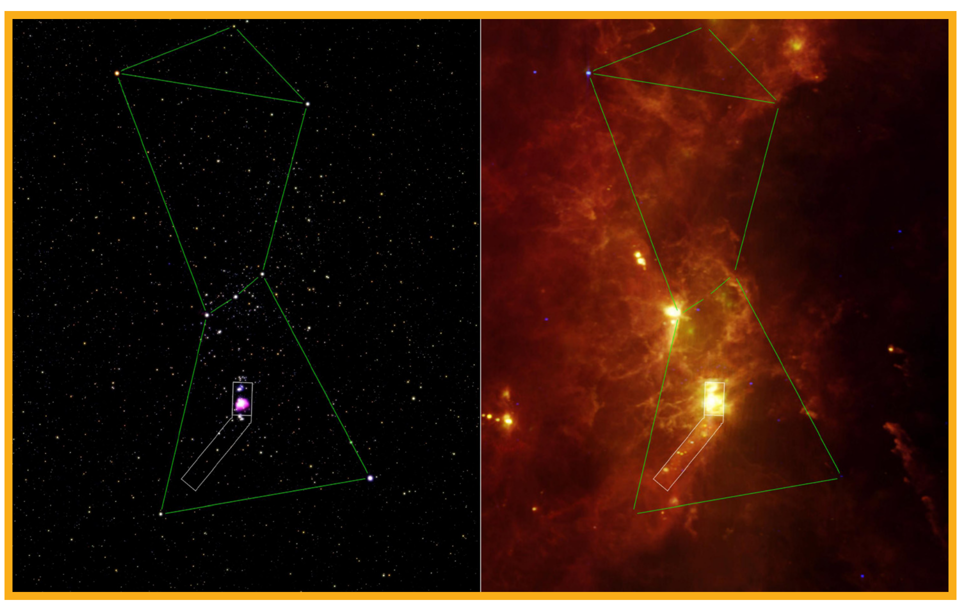
Our eyes have two different kinds of detectors. One set detects color (cones), and the other detects contrast (rods). The color detectors are not very sensitive and require quite a bit of light to perceive the color. That's why people tend to leave the house with mismatched socks in the winter when they are dressing in the dark. Try looking at your favorite color photo in dim light and notice how much color you do and do not see.

Stars come in a wide range of sizes and temperatures; they are not "one size fits all." If we could put them all at the same distance, this would be immediately obvious. Just by looking up at the sky, you cannot tell which stars might be like our sun or which might be brighter or dimmer. What is for certain is that all stars are quite distant, and it's this distance that makes them appear not as other suns, but as twinkling lights in the night.

Combine the lack of sensitivity of those cones with the distances to the stars, and it's no wonder that the brighter stars are the ones we must look at to see color in the night. The constellation Orion offers a particularly good example. The constellations' simple pattern of a rectangle with three stars in the middle is easy to spot, even in urban skies. Upon closer inspection you might notice that one of his shoulders is reddish (Betelgeuse) and one of his knees is blue (Rigel). These colors are an indication of the temperature of the stars.

But what if we could see with eyes that are sensitive to different kinds of light? The infrared image of Orion reveals lots of warm gas and dust clouds glowing between the bright stars. The x-ray image shows lots of bright hot stars in this region, but in a very different pattern. ★

Credit: NASA/IRAS



An image of the constellation Orion in mid-infrared wavelengths, as imaged by the Infrared Astronomical Satellite. (Credit: NASA/IRAS)

Cultural Connections

Telescopes Around the World

Location of Large Telescopes and Their Altitudes Above Sea Level

Telescope Site	Latitude (º)	Longitude (º)	Altitude (m)
South Africa	32 S	20 E	1759
Kitt Peak, Arizona	31 N	111 W	1894
Cerro Tololo, Chile	30 S	71 W	2200
Canary Islands, Spain	29 N	18 W	2400
Hawaiian Islands	20 N	155 W	4205
Mt. Graham, AZ	32 N	109 W	3191
Mt. Wilson, California	34 N	118 W	1742
Sliding Springs, Australia	31 S	149 E	1164

Plot the location of each telescope on the map given below.

Can you see a pattern of where large telescopes are situated on Earth? What do their locations have in common? What is different about their locations? Do you think there is a reason they are placed where they are? ★