THE WEATHER CLASSROOM®

THE SKY SHOW

Preview

The colors of the sky change from deepest blues to dazzling reds and oranges, then surprise us with bright and frightening flashes of light and swirling winds of dust and water. Our atmosphere gives us the colors of the spectrum and puts on a spectacular show for all of us, if only we "Look Up!" and take the time to ask "Why?"

This lesson addresses the following National Standards:

Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Physical Science Standards
- Light, electricity & magnetism

Earth & Space Science Standards
- Structure of the earth system
- Earth in the solar system

Language Arts
- Written & oral presentations

Visual Arts
- Color wheel

Geography
- Latitude
- Location & travel itinerary

Weather Fact

Moonbow

Rainbows aren't the only "bows" in the sky. When the moonlight refracts in raindrops and causes a pale colored bow, the results are moonbows. An example of this phenomenon is the mist emitted from Kentucky's Cumberland Falls during a full moon on a clear night. A moonbow can be seen at no other falls in the Western Hemisphere.

Weather Terms

All glossary terms can be found at http://www.weatherclassroom.com

atmosphere	aurora	corona
dust	dust devil	electromagnetic spectrum
halo	ice crystals	lightning
rainbow	reflectivity	refraction
scattering	sun dog	sun pillar
sunrise	sunset	visible light
waterspout		

Q & A

Start Talking

Why is the sky blue?

Answer: When light from the sun streams down to Earth, it passes through our atmosphere which is filled with tiny "obstacles", such as — air molecules, dust particles, and water vapor. When these particles are hit, light "scatters". As a result, small particles with the shortest wave lengths are greater at the end of the spectrum but because our eyes are less sensitive to violet and indigo, we see blue, the next color in the spectrum. There are decreasing amounts of green, yellow and red but, taken as a whole, the sky appears blue.

Teaching Note: See "Sky Show Optical Demonstrations" in Hands On.

Why are clouds white?

Answer: There are millions of water droplets and particles within a cloud so there are millions of surfaces to scatter and reflect all the light. The sum of all the colors of the spectrum in the scattered light makes the clouds appear white although they are nearly transparent.

Going Further:

Demonstration: Ask students to tell you the color of sugar or salt. Pour a small pile of sugar or salt to demonstrate that it truly does appear "white." However, these crystals are actually transparent; they just appear white because the light does not penetrate through the pile. As in a cloud, all of the light is scattered and reflected to make the pile appear "white."

Our Weather Classroom reporter had some difficulty finding people who could explain why the sky is blue. Challenge students to hypothesize the percentage of people within their school community who will know the correct answer. Then, have them take a poll and see if the people in your school — teachers, administrators and students —do better than the Las Vegas tourists in the video.

Although we now know scientifically why the sky is blue, ancient people did not. Create a class definition for the word "myth." and discuss how myths were used in the past?

Answer: A myth is a story told to explain natural phenomena. There is usually a good deal of symbolism in a classic myth. Ancient myths often developed around gods or goddesses, explaining their role in the world and what we experience.

Have students write and share orally or through illustrated narratives myths that explain the color(s) in the sky.

Create a class concept map beginning with the central concept "Sky." Have students free associate to brainstorm as many terms as possible that relate to the central term. Stop the brainstorm and guide students to classify their terms — celestial objects, weather events, colors, etc. Jack Borden, the founder of "For Spacious Skies," says that every aspect of life can be related to the sky. Ask students to consider their concept map and Jack Borden's challenge. Can they think of ways to connect everything on Earth to the sky?

Q & A

Going Further:

Have students consider the subjects they study in school (geography, history, literature and writing, science, mathematics, art and music, etc.) and discuss whether the sky (atmosphere) and its phenomena be part of their coursework? Why or why not?

Answers will vary, but may include:

- Geography—how weather affects the people of...; sunset and sunrise colors depend on particles in the air; terrain is affected by weathering over the years
- History—weather played an important role in wars in...; drought caused the migration of...; annual flooding caused...
- Literature and Writing—mythology and folklore feature or explain the atmosphere and atmospheric phenomena
- Science—properties/characteristics of weather and its impact on human life and activity; the physics of weather phenomena; weather safety
- Mathematics—graph the weather; find percentages, differences and sums based on rainfall, numbers of cloudy days, amount of sunshine
- Art and Music—find landscapes and seascapes that portray the sky, its many "moods" and colors; find music that relates to storms and seasons; create the "sounds" of sky phenomena

Weather Classroom Break

What are the three types of sky phenomena? Explain.

Answer: Optical, wind and electrical. Optical phenomena have to do with light and vision; wind phenomena, or air in motion, to temperature changes; and electrical phenomena are caused by the Earth's electromagnetic field, which produces lightning and the magnificent aurora.

If light from the sun (and incandescent bulbs) is white, how does the sun produce a rainbow?

Answer: White light is composed of all possible wavelengths of light. Each color represents a different wavelength. A wave of white light represents a combination of all the colors of the spectrum, but it appears white. When light passes through a raindrop, it refracts (bends). Each wavelength bends differently—violets/blues bend most, yellow/greens next and orange/reds the least. The effect is "dispersion" and it causes the colors of the rainbow to appear in refracted light.

Why do you have to be between the sun (light source) and the shower (refracting raindrops) to see a rainbow? Have students talk about times and places they have seen rainbows. Which were the most awesome? Why?

Answer: Rainbows are made from two refractions and a reflection. We can see the rainbow because the sunlight is not only refracting and dispersing in the raindrops, but also reflecting, or bouncing off, the raindrops.

Q & A

Going Further:

Check Resources to find and read "Rainbows" online at Patterns in Nature: Light and Optics.

Teaching Note: See "Sky Show Optical Demonstrations" in Hands On below.

What other colorful, optical sky displays do reflection, refraction and scattering light cause besides rainbows? Describe each and have students tell about times they have observed any of these light phenomena. Have their observations differed from those pictured in the video? Explain.

Answer:

Halo: This ring of light encircles the sun or moon when it is veiled by thin cirrus clouds. Unlike rainbows, the light passes through ice crystals rather than raindrops, and the clouds refract the light. The most common halo forms at a 22-degree radius.

Corona: A pastel halo forms around the sun or moon, created by the diffraction of water droplets. The color display sometimes appears to be iridescent. sun dog: These two colorful and luminous spots, at roughly 22 degrees on both sides of the sun, are caused by refraction of sunlight through ice crystals. Sun dogs are most common during winter in the middle latitudes.

Sunrise/Sunset: When the sun is lower on the horizon, light must travel farther to get to you; so, more light is reflected and scattered. When less light reaches you, the sun appears orange or red because the shorter wavelengths — blues and greens — are scattered and you perceive the longer wavelengths — oranges and red. The more particles of dust, ash or water in the atmosphere, the more beautiful the sunset or sunrise, with different amounts of oranges and reds, even pinks.and can be as small as two feet high or as large as a thousand feet tall. Fortunately, they are never as damaging or intense as real tornadoes.

Q & A

Going Further:

"A ring around the sun or moon means rain or snow is coming soon." Why might this saying have a basis in truth?

Answer: Haloes and coronas form when light reflects from ice within cirrus clouds, sometimes warning of advancing cold fronts that can bring severe storms.

What sky show phenomena are caused by the wind? Explain.

Answer:

Waterspout: When a column of air starts to rotate rapidly over water, a waterspout forms much like a tornado. Except for a small area of spray at the base, the water in the spout is not pulled up from the surrounding water, but is the result of condensation caused by low pressure inside the spiral.

Dust devil: This rapidly rotating column of wind is made visible by the dust, dirt or debris it picks up. Dust devils usually occur in dry environments such as deserts and can be as small as two feet high or as large as a thousand feet tall. Fortunately, they are never as damaging or intense as real tornadoes.

Weather Classroom Break

What are the electrical phenomena of the sky show? Explain how each occurs.

Answer:

Lightning: Lightning forms when the negatively charged base of a storm cloud passes over and, through electrical leaders, seeks out a positively charged object on the ground. When the two meet, an electrical current is formed with a flash of light and heat. Heat generated by lightning can exceed 40,000 degrees F (22,000 degrees C). The superheated air around the lightning bolt causes the thunderous sound that follows a lightning flash.

Teaching Note: Pause the video at the lightning graphic and have students narrate the explanation.

Aurora: Earth is a magnetic field, which is why a compass works. When the sun gives off radiant energy (light), electrically charged, and fast-moving particles, the particles come into the Earth's magnetic field and interact with the upper atmosphere over the middle and high latitudes that are closest to the poles. This intense electric interaction creates an incredible display of shifting curtains of light and luminous color. In the Northern Hemisphere, the lights are called the aurora borealis or Northern Lights; in the Southern Hemisphere, the phenomenon is called the aurora australis.

Teaching Note: Review the video demonstration of the aurora with the sound off. Have students explain how each part of the demonstration illustrates Earth's magnetic field, the sun's rays and the subsequent optical phenomena.

Q & A

Going Further:

We are still exploring and finding out more about Earth's magnetic field. Click into Resources to find out about NASA's missions to study the interactions of Earth and Sun.

Are there sky shows in space? Explain.

Answer: In space, not peering through our atmosphere, the Sun would appear white, rather than yellow, and space would appear black, rather than blue. Our Sun is a variable star, that goes through 11-year sunspot cycles. These sunspots spew out billions of tons of electrically charged particles into the solar system. Sunspots affect communication on Earth, but we don't really understand the phenomenon or its effects. The Sun produces "space weather" with these huge explosions that pack power greater than 100 million atomic bombs.

Why is it important to know about weather in space and on other planets?

Answer: Sunspots, solar winds and other extremes within space can affect travel and communication to and from space. Planets humans wish to explore, such as Mars, may also have weather that will affect when or how we explore them. For example, Mars can have swirling dust storms so large that they completely engulf the planet. Humans and/or the machines we send to the planet must be ready for such occurrences.

Going Further:

Use the Internet to keep up with weather in space. Check Resources to find daily space weather reports from NASA.

Hands On

Sky Show Optical Demonstrations

Teaching Note: The following hands-on presentations can be used as classroom demonstrations or group activities, depending on your students' abilities and your time frame. If possible, the activities should be divided among teams of students who will then set up and perform their assigned demonstrations for the whole class, providing scientific explanations in a Q & A period.

Distribute the Student Handouts:
Sky Optics—Blue Sky, Sunset and Sunrise; Rainbows.

1. Provide teams with the necessary material and time to form their hypotheses, set up projects, and practice their demonstrations.
2. Have teams research necessary terms or explanations for the phenomena they will demonstrate, and prepare a class presentation of the activity and the explanation.
3. Provide time for team demonstrations and Q & A period that compares and contrasts the optical demonstrations and the sky phenomena they represent.

Extension: Have students recreate their demonstrations for younger students in a classroom "traveling" Sky Magic Show.

Answers: Blue Sky, Sunset and Sunrise

Demonstration 1:

Refraction–Bending Light: When the light wave passes from the air to the water, the light "bends" or refracts. This refraction can be seen as a change in the angle of the light beam. Analysis: When light from the sun enters Earth's atmosphere it passes through gas molecules and bends or refracts.

Extension: The change of angle or "bend" of the refracted light is actually associated with a change in velocity and wavelength. Challenge students to find and compare the angle when light enters water and other liquids—oils, glass, etc. For example, in linseed oil, the velocity of light decreases 66% compared to its velocity in air.

Going Further:

Challenge students to use Resources to find out more about the mathematics of refraction.

Demonstration 2:

Scattering Light: When looking down on the light or from the side of the glass dish, the milky water appears blue; when looking at the light from the farther end, the water has a yellowish/orange tinge. Analysis: Blue light has a shorter wave length. When it hits air molecules, some of it is absorbed and is reradiated, or "scattered" in a different direction, causing the predominant blue color of the sky. The oranges and reds of the white light have a longer wavelength. When the sun is on the horizon, at sunset or sunrise, the light takes a longer path to reach our eyes. Most of the blues have been "scattered" out of the light and we can now perceive reds and oranges.

Optical Brain Tickler: The gas molecules of the atmosphere are smaller than the wavelengths of visible light. When light passes through the gas molecules of the atmosphere, the shorter wavelength (blue light) is refracted or scattered. The dust particles and water droplets within a cloud are much larger than the wave lengths of visible light. When light hits the greater aggregation of large water droplets and dust particles within a cloud, light is reflected from these many surfaces and bounces off in different directions. These uncounted surfaces scatter almost all the light; therefore, the many colors within the white light are reflected in the same way among the particles, no one wavelength is scattered more than another. The reflected light has all the colors still within it; therefore, clouds, although mostly transparent, will appear white.

Answers: Rainbows

Demonstration 1:

"White" Light: When white light passes through a prism we see the colors of a rainbow. Analysis: When light from the sun passes through a mist of water particles, different water droplets absorb, refract and reflect different wave lengths of light. All of the wavelengths are represented in the spectrum—red, orange, yellow, green, blue, indigo, violet. (Often remembered as "Roy G. Biv.")

Going Further:

Challenge students to use Resources to find out more about the mathematics of rainbows.

Demonstration 2:

Make a Rainbow Indoors: Reflected onto the posterboard, at an angular distance from the fishbowl of about 42 degrees, is a circular rainbow, with red on the outside and violet on the inside. Analysis: When light from the sun passes through a mist of water particles, different water droplets absorb, refract and reflect different wavelengths of light. All of the wavelengths are represented in the spectrum—red, orange, yellow, green, blue, indigo, violet. A rainbow is made of two refractions and a reflection and the reflected light is what we see. To see a rainbow, you have to be standing facing away from the sun and between the sun and the rain. The rainbow reflected on the posterboard is a circle; the rainbow we see from the ground is an arc. However, all rainbows are complete circles, but the horizon blocks our view. From a mountain top or airplane it's possible to see the entire rainbow.

Demonstration 3:

Make a Rainbow Outdoors: Looking into the mist, you can see a rainbow. Analysis: The fine mist provides many water drops to refract and reflect the light. (See "Analysis" for Demonstration 2.)

Rainbow in Reverse: Have students prove that the colors of a rainbow, when combined, can produce white. Provide teams with the following:

- color paint chips that represent the colors of the rainbow (Roy G. Biv) or appropriate color markers
- paste or glue
- circle of white posterboard
- a small, plastic toy top

Procedure:

1. Draw lines to divide the circle into 6 equal sections, as if cutting a pie.
2. Pasting on paint chips or using markers and going in order (Roy G. Biv), color each section of the "pie" one of the colors of the spectrum.
3. Put a hole in the center of the posterboard circle and place it over the turning stem of the top.
4. Twirl the top. What happens? Why?

Answers: As the top spins quickly, the posterboard circle appears white. All the colors blend and blur and when all the colors of the spectrum are mixed, we see white.

Extension: Have students experiment to get varying effects with color filters. For example, if you stack together (one behind the other) filters of the three primary colors (red, blue and green) and shine a flashlight through the filters, the light you produce will be white. Challenge students to find other ways to mix and make new colors and/or find white.

Sky Frames (For Younger Students)

Teaching Note: Paint chips are freely available from hardware or paint stores. Before beginning this activity, gather an ample supply of colors within the blue, white/gray, pink, red orange and yellow families.

Help students track changing sky colors.

1. Create a class list of colors students have seen in the sky. Challenge them to use as many different color words as possible to describe more fully the differences in colors—mauve, aqua, lemon, copper, fiery orange. Have students describe the times of day or season in which they saw these colors.
2. Provide each student or pair of students with rectangles of posterboard, about 5x7 or 8 x11 inches. Have them fold the cardboard in half lengthwise and cut out a center rectangle, leaving about a 1 or 2 inch frame. Have students cut paint chips and paste them around the frame by color gradients. One side might be blues, one white/grays, one yellow/oranges, one pink/reds. Or, provide chips and posterboard for two different frames, one for blues and grays and one for yellows, oranges and reds.
3. At different times of the day, have students go outside to check the sky color against their frames. Which colors are most prevalent? How does this change depending on the time of day? The time of year? The weather?
4. Have them turn their ongoing data into seasonal charts and graphs of sky colors.

Extension: As students record their sky color data, be sure to have them use descriptive sky color words. (They might choose the names used by the paint companies or create their own descriptive names and phrases.) Have students turn their data into sky color poems that describe the sky, the season and/or the time of day.

In Search of the Aurora

Have students discuss the basics of an aurora.

- How are they formed? (Auroras are the effect of an interaction between the Earth's magnetic field and the charged particles from the Sun.)
- Where do they form? (We see auroras closest to the North and South Poles, in regions known as auroral ovals. Earth's magnetic field is strongest at the poles, where it goes into and out of the Earth. At lower latitudes, the charge is weaker and there is no entrance or exit, the field is "locked.")
- When do they form? (There is a strong relationship between solar flares, which produce solar winds of charged particles, and the appearance of auroras.)

Based on their discussion, have students plan a trip to see either the aurora borealis or the aurora australis. Where do they go? When do they go? And, how do they find out?

Have students work together to use Resources from NASA and other sites to discover aurora predictions. Then, challenge them to use airline and other travel sites to find the best way to get to their chosen destination on time. They should include the cost and the time frame for leaving and returning. What other modes of transportation must they book? Have students present their completed itineraries to the whole class.

Extension: Have students create travel brochures for the aurora. They should include fascinating pictures, personal "testimonials" and creative myths and legends to lure the would-be eco-tourist

Demonstration 1

Materials:
- clear glass baking dish
- water
- flashlight

Demonstration 2

Materials:
- clear glass baking dish
- water
- flashlight
- milk or powdered milk

Student Handout:
Sky Optics–Blue Sky, Sunset & Sunrise

You and your team of scientists are planning a demonstration and Q & A at a sky symposium for fellow scientists. Consider and complete your hypothesis, prepare your demonstrations and be ready to present your findings and scientific analyses.

Demonstration 1: Refraction–Bending Light

Purpose: Demonstrate how light waves "bend"

Hypothesis: When a beam of light passes through the air into water...

Procedure:

1. Fill the baking dish with water.
2. Shine the flashlight at an angle into the water.
3. Illustrate and describe your observation.

Analysis: How does this represent what happens to light waves as they travel through the atmosphere?

Demonstration 2: "Scattering" Light

Purpose: Demonstrate why skies are blue and sunsets and sunrises are yellow/orange/red

Hypothesis: When a beam of light...

Procedure:

1. Fill the baking dish with water. Add and mix in milk to create a white trans-parent color through which you can clearly see the light pass.
2. Darken the room and shine the flashlight down onto the water.
3. Illustrate and describe your observation.
4. Shine your flashlight from one end of the baking dish.
5. Illustrate and describe your observation as you look at the beam from the side of the baking dish.
6. Illustrate and describe your observation as you look at the beam from the opposite end of the baking dish.

Analysis

1. How does this illustrate why the sky is blue?
2. How does this illustrate why sunrises and sunsets are yellow, orange and red?

Optical Brain Tickler

Purpose: Apply data to propose an hypothesis to explain why clouds appear white

Data:

- Atmospheric gas molecules are smaller than the wavelength of visible light.
- Dust particles and water droplets are larger than the wavelength of visible light.
- White light from the sun contains all the colors of the spectrum.
- Clouds are made up of uncountable dust particles and water droplets.
- Uncountable dust particles and water droplets create uncountable reflective surfaces.
- Particles and droplets within clouds are nearly transparent.

Hypothesis: Clouds appear white because...

Student Handout:
Sky Optics–Rainbows

You and your team of scientists are planning a demonstration and Q & A at a sky symposium for fellow scientists. Consider and complete your hypotheses, prepare your demonstrations and be ready to present your findings and scientific analyses.

Demonstration 1

Materials:
- prism (piece of crystal from a chandelier, etc.)
- light source (bright, intense flashlight or sun)

Demonstration 1: "White" Light

Purpose: Demonstrate that white light actually consists of all colors of visible light

Hypothesis: A beam of white light...

Procedure:
1. Hold the prism to the light and follow the beam through the prism.
2. Illustrate and describe your observation.

Analysis:
1. How does this represent the basic concept behind sunlight and rainbows.
2. What are the colors of the visible light spectrum?

Note: If you don't have a prism, you can get the same effect by letting sunlight stream through a glass of water placed on a table. What do you see? Where do you see the colors?

Demonstration 2

Materials:
- fishbowl or other spherical container
- water
- focused light source (bright, intense flashlight or sun)
- small cardboard shield to fit over the light source, with a slit in its center
- tape
- large piece of white poster-board with a hole in its center

Demonstration 2: Make a Rainbow Indoors

Purpose: Demonstrate how a rainbow forms

Hypothesis: We see rainbows when...

Procedure:
1. Fill the fishbowl with water.
2. Tape the cardboard shield over the flashlight.
3. Place the fishbowl on one side of the piece of white posterboard.
4. From the other side of the posterboard, shine the flashlight through the hole onto the fishbowl.
5. Illustrate and describe what you observe on the "fishbowl side" of the posterboard.

Analysis:
1. In what way does the demonstration illustrate how a rainbow is formed?
2. Why does the rainbow appear on the posterboard and not on the other side of the fishbowl?
3. What does this tell you about location's role in relation to the rain and sun in viewing a rainbow?
4. Is this rainbow different from the ones you've seen in the sky? Explain

Student Handout:
Sky Optics–Rainbows

Demonstration 3: Make a Rainbow Outdoors

Demonstration 3

Materials:
- garden hose or sprinkler
- sunny day

Purpose: Demonstrate how a rainbow forms

Hypothesis: We see rainbows when...

Procedure:
1. If it's a sunny day outside, turn on the hose and spray a large, fine mist of water.
2. Stand so that the sun is directly behind you and look into the mist.
3. Illustrate and describe what you observe.

Analysis:
1. How does this experiment illustrate how a rainbow is formed?
2. Why must there be high water flow sprayed in a fine mist?
3. What does this tell you about where you must be in relation to the rain and the sun in order to see a rainbow?

The Sky Show Internet Resources

"Rainbows": Patterns In Nature —Light and Optics

http://acept.la.asu.edu/PiN/rdg/rainbow/rainbow.shtml

Why is the Sky Blue? —Science Made Simple

http://www.sciencemadesimple.com/sky_blue.html

Why is the Sky Blue? —Patterns in Nature

http://acept.la.asu.edu/PiN/act/sky/sky.shtml

Circles of Light: The Mathematics of Refraction

http://www.geom.umn.edu/education/calc-init/rainbow/refraction.html

Optical Phenomena —Weather Window

http://www.astrophys-assist.com/ wilobs/weathwin/weathwin.html

Atmospheric Haloes

http://ds.dial.pipex.com/lc/halo/halosim.htm

Earth's Magnetic Field

http://www.gsfc.nasa.gov/GSFC/SpaceSci/sunearth/imagescience.htm

Auroras: Paintings in the Sky

http://www.exploratorium.edu/learning_studio/auroras/index.html

The Aurora: The Basics, Briefly

http://www.pfrr.alaska.edu/~ddr/ASGP/STRSCOOP/AURORA/SUMMARY.HTM

Living with a Star: —The Sun-Earth Connection

http://sec.gsfc.nasa.gov/lws.htm

Solar Data Analysis Center

http://umbra.gsfc.nasa.gov/

Space Weather Reports —NASA

http://www.spaceweather.com/

Martian Dust Devil Trails —Astronomy Picture of the Day

http://antwrp.gsfc.nasa.gov/apod/ap000317.html

Large Martian Dust Devils Caught in the Act —Mars Global Surveyor

http://www.msss.com/mars_images/moc/7_1_99_devils/

Thunder and Lightning —The Storm Encyclopedia

http://www.weather.com/encyclopedia/thunder/light.html

Lightning—The Exploratorium

http://www.exploratorium.edu/ronh/weather/weather.html