You Light Up My Life

Purpose

Next, we want to determine the behavior of sunlight from observations outside and inside the classroom. We will learn about how light travels by using mirrors, prisms, and shadow makers. The National Science Education Standards state that the nature of light is an important topic to be learned in this age group, and the manipulation of tools is crucial. The vocabulary which can be introduced to help talk about our experiences are light, shadow, shade, opaque, transparent, translucent, waves, colors, mirror, rainbow, spectrum, and ray. For a new approach to learning some of these vocabulary words, visit **Word Lore**, an appendix dedicated to exploring the history of words pertaining to this curriculum.

Teacher Background

Light is a very odd thing, but a very special thing. It travels faster than everything else in the Universe. It defines how we measure everything we do, for it travels around, hitting objects and bouncing their images to our eyes. When the images of objects reach us, they allow us to judge the positions of those objects. In that way it is our only good means of determining time. If something moves from one minute to the next, we are most likely to notice this if we can see its image. We can only see its image, if light is bouncing around. Therefore, light can tell us about the world and its changes.

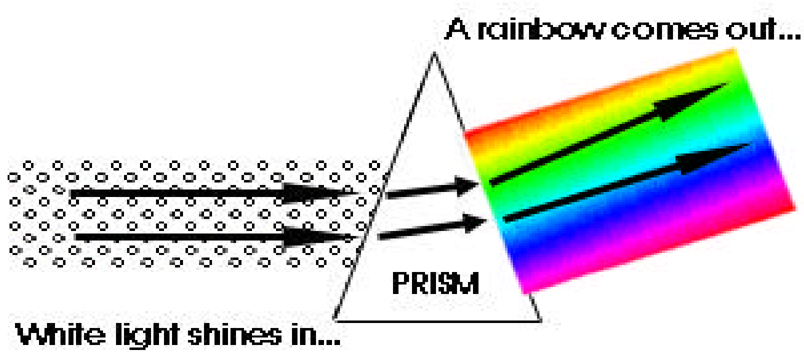
You will need: white paper and masking tape, pencils, crayons, mirrors, prisms, objects of differing transparency, garden hose or spray bottle, flashlights, overhead projector, water and clipboards.

A few sunny days would be good for experiencing this topic. Students will be developing theories about light and need a few chances to test them in the outdoors. Only a few periods of class time are required. (This Thread leads to another Thread about shadows which will take longer to explore fully but supports the same developing understandings.) Gathering materials will take time, as equipment may need to be reserved or ordered.

Our current scientific knowledge suggests that light can act in ways that are wave-like and ways that are particle-like. That light acts as a wave means it bounces off things or interacts with other lights similar to the way that waves in water do. That light acts as a particle means that when it bounces off things, it carries with it energy that can be transferred to the things it hits. An example of this is a sunburn, where sunlight has hit and been absorbed into the skin, burning the cells.

This wave particle thing called light travels in a very straight way, in *rays*, from its source. Anything in the path of the light ray will block the ray to some degree. If the object is very dense and dark, preventing the light from passing beyond it, it is called opaque. Beyond this object, then, on the side farthest from the light source, is what is know as a shadow – where there is an absence of the bright light. You can usually still see things in the shadow because there is other light scattered or bounced about the room or yard hitting that area indirectly. Some transparent objects like glass even let light travel almost completely through them. Objects which may allow only a little light to pass through, like colored plastics, are called translucent. However, the translucent materials often distort the light they let through. This is because light is a strange thing itself.

White light, or the common light from the Sun, is a tight tangle of all visible colors of light. The colors travel together all mixed up in a way that makes our eyes see the combination as bright whiteness. This combination can be untangled if you somehow crack open that tight mixture with a light bending tool. Thick clear things like glass and water are very good at this, but plain glass or water is not enough. They have to be in a shape which makes it tough for the tight light package to get through without breaking apart.



A prism is a piece of glass shaped like a triangular solid, or a triangle stretched upwards to make a three-dimensional shape. The light travels into the triangle from a face of the triangle at a certain angle. Whenever light goes from one medium (air) to another (glass) the different colors of light bend slightly different. The pencil in the glass of water trick is an example of this. Usually, through a flat medium like a pane of glass, the light enters, colors bend by a specific amount, and then bend back into one another going out the other flat side. But the prism, because it is not flat but triangular, doesn't allow the colors to bend back into one another. Instead, it encourages more bending by the angle it has on its other side. So, the white light enters the glass and the colors bend and take different paths through the prism. When they reach the other side, instead of meeting up again with each other passing back into air, each color splits even more from the pack by the same angle again and takes a slightly different path out of the prism. We see the colors spread out in the beam. A spray of water will also make this happen as the little droplet shapes of water work like miniature prisms. You get a misty rainbow in the droplets as the white light package gets ripped open in the spray — exactly as it happens in the sky with real rainbows.

> "Imagination is more important than knowledge."
>
> —Albert Einstein

> "The tenets of skepticism do no require an advanced degree, as most successful used-car buyers demonstrate. The whole idea of a democratic application of skepticism is that everyone should have the essential tools to effectively and constructively evaluate claims to knowledge. All science asks is to employ the same levels of skepticism we use in buying a used car or in judging the quality of analgesics or beer from their TV commercials."
>
> — Carl Sagan

> "The most beautiful thing in the world is, precisely, the conjunction of learning and inspiration. Oh, the passion for research and the joy of discovery!"
>
> — Wanda Landowska

Kindergarten through Second Grade

Developmental Issues

This Thread will focus our experiences of shadows on what light is doing. The students will explore the direction of light and how it always makes a shadow behind an object. We will make it into a game called Sun/Blocker/Shadow which hopefully will root important scientific concepts in a fun game. Five- to eight-year-olds are not very adept at grasping the nature of light. Most undergraduate physics students have difficulty with the concept! However, being comfortable with the way light works is crucial for understanding shadows. Make sure that children understand that when someone says "there is no light" that it's different from how we talk about dark in everyday language. If a room is slightly darkened but they can still see, it is because there is light available! Providing the concrete experiences offered in this Thread helps children develop a strong base for the complete concepts they will learn when they're older.

Inquiry Introduction

What are shadows? Where do they come from? How do you make one? What things do you need to make a shadow? Could we make a shadow outside? Inside? In a dark room or at night? Under water?

Inquiry Investigation

Outside, the Sun lights up the world. But what happens when things get in the way of the sunlight? Does everything make a shadow? Where are our shadows? Can I walk up to someone and step on her shadow? Playing a game of shadow tag would be fun here. After the energy is released from play, gather the students around again.

Let's face the Sun and try to find our shadows. Are they in front of us? They are behind us. Let's face our shadows. Where is the Sun? It is behind us now. So, where are shadows going to be when the Sun is over there (point to the left)? Let's face that way. Our shadows would be behind us again, on the other side. So, where do shadows form? On the side of us away from the Sun. Is this true for any light? Can both the Sun and shadow ever be on the same side of us? Could we face the Sun and face our shadows at the same time? Why or why not? What is it about the Sun's light that is not making that happen?

The overhead projector in the classroom gives off a nice light. Turn it on and ask someone to stand in front of it with his eyes covered (otherwise it will hurt). Where is his shadow? He can't see it, but the class can see it behind him. Where should he move to see his own shadow? He turns around and there it is.

What is the Sun? What is the light? Are there things in our classroom which give off light? What are they? Could we think about the sunlight as we do the classroom light? Are there such things as portable lights? Could we use them to think more about light and blockers of light?

What about with flashlights? Could we shine a flashlight on something and make a shadow behind it? In pairs in the classroom, have students shine a flashlight on objects they have in front of them. You could give them wooden shapes and other things. Where are the shadows? Can they change the shape of the shadow or the size?

There seems to be some kind of lining up that has to happen: Sun, blocker of Sun, and the shadow. Could we find a tree and see if it works with a tree? Find a nearby tree and see if the same is true. What about a car or the school? Where is the Sun? Where is the shadow?

Emphasize "Sun/Blocker/Shadow" while pointing to each of these elements in the set-up. Move the flashlight to another spot and show again the different pieces of the Sun/Blocker/Shadow. Let them quiz each other with teams at their own desks. For the youngest grades this may require supervision. You may just want them to play with the flashlights, see if they can tell someone else one special thing they found out about the light and shadows.

A short assessment handout is included that you could use tomorrow to see how many have experienced this fact of light: Light travels in straight lines, so that shadows are directly away from the light source.This handout was created by a first grade teacher as part of the Everyday Classroom Tools curriculum. She had great success with it, and used it repeatedly to reinforce the ideas.

"Mistakes are the portals of discovery."
—James Joyce

Second Grade through Fourth Grade

Developmental Issues

This Thread allows teachers to direct questions towards the nature of light through repeated experiences with it and objects which block it. These students can juggle ideas such as the seen and the unseen. This will help us to get a firm enough grasp of what light is doing that we will be able to predict some things about both it and shadows. Try getting them to notice the world around them, especially things that don't seem to make sense. Encourage them to take the next step in problem solving by coming up with the kinds of questions they would ask to solve the mysteries. Be aware: they will come up with questions that they may not be able to completely answer! Encourage your students to write their questions down in a journal where they could call upon them as they gain further understandings.

Inquiry Introduction

What are shadows? What is shade? Are they the same? What is light? Where does it come from? How is it made? Let's go outside and think more about this. Grab stuff you want to see shadows of and maybe some paper if you want to draw shadows to show people later. Does anybody think there is something which does not make a shadow? Bring it along.

Inquiry Investigation

Outside, find a place where there is space to spread out clipboards and people without overlapping shadows. It may be better to do this closer to mid-day when the shadows are shorter. Have everyone place their test objects on the paper. What do we see? Which objects make really good shadows? Which make weirdly colored shadows? Why might this be so?

In all of this, where is the Sun? Look again at the shadows. Which way do they point in relation to the Sun? Is there anything we could do to change that? Trace the shadow there right now. Then try to find some way to make the shadow look different on the paper. Some will move the object, some will move their position on the ground, others will twist their paper a bit. Draw the shadow again. Whose shadow looks different? Why? What happens when you move the object itself? How did the shadow change? Is it pointing in a different direction? Where is the Sun? What about when you move to a different place? Where and how did you move? How might that have affected the way your shadow looks? Where is the Sun? What about those of you who twisted the paper? Where is your new shadow? Is it still pointing away from the Sun? But where is it on the paper? The paper moved and not the Sun, right?

Why are shadows always pointing away from the Sun? How is light working to do that? How does the Sun know the wooden block is there? Light is somehow hitting the block and making that shadow. What is that area behind the block and away from the Sun? Is there light in there? Not as much as there is around it. So, when light hit the block, did it go through the block? A shadow must be the area behind an object facing the Sun which can get no direct light.

Why is it cooler in the shade? Is the Sun warm? What happens in the shade? It is not getting as much light and so is not as warm. Cool. Exactly.

"Children and scientists share an outlook on life. 'If I do this, what will happen?' is both the motto of the child at play and the defining refrain of the physical scientist...The unfamiliar and the strange—these are the domain of all children and scientists."

—James Gleick

"All men by nature desire to know."

— Aristotle

Fourth Grade through Sixth Grade

Developmental Issues

This Thread offers fourth through sixth grades the opportunity to tackle the theory of light through different and more serious experiences outdoors. They are ready to ask and be asked some deep questions which will hopefully open their analytical minds to the possibilities of even deeper questions for real understanding. Providing them with tools and time is all we need for them to create a fairly good theory of the nature of light. Even if they don't come up with the same theory that scientists currently hold, they are learning about *theory generation*, how we come up with the best explanations that we can until we learn something new to help us generate a better explanation.

Inquiry Introduction

Why can we see the world around us? What outside conditions cause us to see worse or better? Students will mention the weather and amount of light. Why does the weather affect our view? It will become obvious that the weather can block light, such as on a cloudy or rainy day. So, really, the only factor is light. What is this light stuff? Where does it come from? Does it only come from the Sun? What other things give off light? Fire and friction are good examples, friction being what causes light bulb filaments to glow. (This may be new to this age group. If so, it would be useful to have all of the class rub their hands together and tell you what happens to the temperature. Can they think of other familiar objects that produce heat in this way?) Phosphorescence is another way of making light, but a very confusing way at that. How does that little sky spot of the Sun make the whole town light up? What is light doing? How might we figure out more about it?

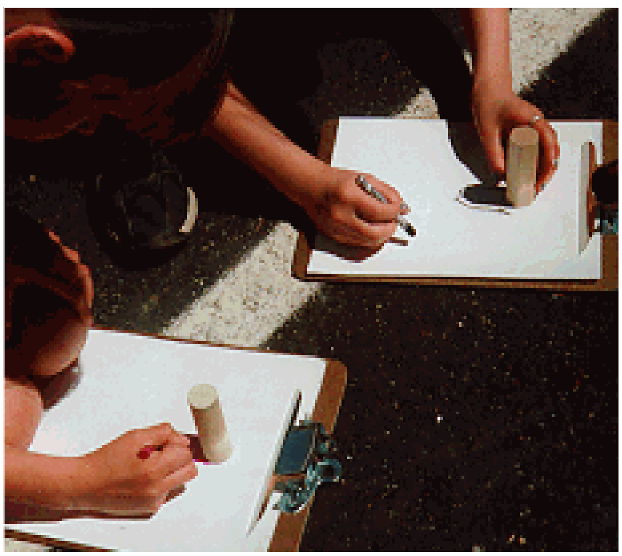
Have the class make strategies for learning more about the Sun. Brainstorm about ways to test theories. For example, one hypothesis might be that the sunlight glows in the air. How could we test that? Is there a way? One way might be to get a clear container of air and shine a light in it, then turn the lights off. If the air is still glowing inside, that could be interpreted as evidence for the theory. What other thoughts might they have about how light works? Now might be good time to talk about reflection.

Inquiry Investigation

Bring outside (on flat ground or pavement with paper) all of the things they might need to discover properties of light. We suggest you bring mirrors, objects of varying opacity, closed boxes, flashlights, paper, tape, etc. (Please note: It is an unfortunate fact that children outside with mirrors will try to aim the bright sunlight into the faces of others. You should consider using mirrors indoors with flashlights, which are weaker, or mentioning that mirrors will be taken away if students cannot behave properly with them.) Encourage your class to build devices for trapping or analyzing light.

Why are shadows on only one side of an object outside? Do they ever move? Why or why not? Most will say that the Sun is shining and hitting the object on one side of it, and the shadow forms because the light can't get through to the other side of the object, so there's no light there. Trace the shadow on the paper. Twist the paper. Where is the shadow on the paper? Where is the Sun? Is the shadow still pointing away from the Sun? But where is it on the paper? Did the Sun move? But the shadow changed because what we were measuring it on moved. Keep this in mind when we do the Sun stick measurements in *This is a Stickup!*

Why can you still see the pavement in that shadow? Surely there must be some light coming from somewhere? What is happening? What happened to the light that hit the block? Did it get sucked into the block? Did it bounce off the block? How can light bounce? What other things can bounce like that? Many will say playground balls or something like that. Is light made of little balls of bright stuff? If so, what could we do to test that? Here is where the mirrors come in.



It is hard to see the light bouncing from the block, but easy to detect light which is being bounced from a mirror. Can we bounce light around the yard? How far can we get before it is difficult to catch the beam of light? If light can bounce so well off mirrors, might it not bounce around off other things, but not as well? Probably. That is why it still gets around the whole yard, even the pavement inside a shadow, when the Sun is in one place in the sky. This is why it gets bright out in the morning even before the Sun rises. And that it is still light just after the Sun sets. Light indeed travels in very straight lines, but light itself can bounce though it still travels in straight lines from object to object.

Phases of the Moon

Phases of the Moon are not caused by the Earth's shadow. They are due to a change in our viewing perspective as the Moon orbits around us as it is lit by the Sun. We are looking down at the Earth, Moon, and Sun in the diagram below. The Sun lights up half of the Earth and Moon, drawn here as the white side, just the same way a flashlight lights up one half of a ball. The Earth spins in the light, so that the entire Earth gets to be lit at some point each day. Even though the Moon is always half-lit like the Earth is, sometimes we on the Earth see only a tiny bit lit, other times completely lit, depending on where the Moon is in its orbit around the Earth.

The Moon's orbit is a little bit tilted, so sunlight shining around the Earth reaches the Moon when the Moon's tilt puts it above or below the plane of the Earth's orbit. Otherwise, the Moon would be eclipsed every month when it moved into the Earth's shadow! You can demonstrate phases by turning a ball around in a circle above your head as you stand in the beam of an overhead projector.

A question to think about is can you see the Moon in the daytime? Look at Day 7. What time of day is it for our little guy? Is he in light? Could he see the Moon in the light? Where would the Moon be in the sky?