



Teacher's Guide for:  
**Polarized Light**

Note: All activities in this document should be performed with adult supervision. Likewise, common sense and care are essential to the conduct of any and all activities, whether described in this document or otherwise. Parents or guardians should supervise children. Rock-it Science assumes no responsibility for any injuries or damages arising from any activities.

**NOTE:** This is the transcript of a lesson that was videotaped during an actual Rock-it Science class with real students, not actors. The students' brainstorming comments are included on the video but are not transcribed here because they're not part of the lesson presentation.

## Contents:

### Quick Reference Sheets:

- Intro: .....page 2
- Demo: .....page 3
- Experiment: *Polarized Light*.....page 4
- Equipment List .....page 5
- Story, Part 1: *Jack & Jill and the Minion Squids* .....page 6
- Story, Ending.....page 7

### Video Transcript:

- Intro: .....page 8
- Story, Part 1 : *Jack & Jill and the Minion Squids*.....page 9
- Demo: .....page 11
- Experiment: *Polarized Light*.....page 13
- Story Ending .....page 14

---

## Title Page of Video

Polarized Light  
A Rock-it Science Lesson  
Filmed July, 2009

***Rock-it Science***  
2110 Walsh Ave, Unit F  
Santa Clara, CA 95050  
[www.rockitscience.org](http://www.rockitscience.org)

(c) 2013 Rock-it Science Educationally Useful Programs. All Rights Reserved

---

## Intro Quick Recap:



Student holds one end of a long flexible spring while Instructor twirls it.

- What's a pole? If someone hits you with a pole, do you become polarized?
- You can polarize light.
- Student and Instructor hold opposite ends of a long, flexible spring. Instructor rotates it like a jump rope to create waveforms, going faster and faster for the various colors.
- Red light makes a slow wave with one hump; Orange makes two humps; Yellow makes three; Green makes four; blue makes five, etc.
- Light is a mixture of two kinds of energy: magnetic and electrical.
- Electrical energy goes up and down; magnetic goes sideways; and when you put them together, it goes round and round.
- Black has no energy -- it doesn't move. White is a combination of all the colors, so it moves in all directions.
- Polarized light is just a way light vibrates. It can be polarized sideways, tallways, and at an angle.
- When we polarize light, it changes the way it acts.

## Demo Quick Recap:



Framed image without filter.



Framed image with filter.

- Instructor holds up a frame with some kind of a screen mounted in it diagonally and walks around so students can see it close up. It just looks grey.
- Instructor flips the screen over, and it still just looks grey.
- Instructor holds a polarizing filter (“sunglass material”) in front of his face. Asks if students can see him. Yes.
- Rotates filter 90 degrees, and students can still see him.
- Flips filter over, and students can still see him.
- Instructor puts the filter in front of the frame and walks around so students can see that the frame contains an image of a woman with a stop sign and some children. As he walks, he moves the filter up and down to show the image with and without the filter.
- Ask student what color was the woman’s dress. Black. Walk past again so students can verify it.
- Instructor claims the dress is really white and proves it by turning the filter 90 degrees and putting it in front of the image.
- Hold the filter in front of a laptop screen and show it hides or reveals the screen, depending on the angle of the filter.
- Instructor holds a filter in front of his face and students can see through it. Then he holds a second one about a foot in front, rotated 90 degrees, and they can’t see through. Then the assistant places a third filter between the other two, rotated at 45 degrees, and the Instructor’s face becomes visible again.
- Instructor holds a clear plastic food container above the students’ heads so they can look up through it at the ceiling lights.
- Then he holds a filter just beneath the container and walks around, and students can still see through it.
- The third time, an assistant holds a second filter below the container while the Instructor holds one above it and rotates the filter back and forth while the students look up through it at the light.
- Ask the students whether they see anything, but keep it a secret.

## Experiment Quick Recap:

- Give each student a stick of wood and two plastic clips. Have them glue one clip to each end of the stick.
- Then give them two small squares of polarizing filter, one for each clip.
- Have them move the filters around to make them look dark and light.
- Then have them look up at the ceiling lights to see what color they appear to be (purple).
- Ask if they see any rainbows anywhere. If they look at something plastic, they might see some.
- Give each student a clear plastic spoon so they can try to see the rainbows in it with their filters.
- Have students write their name on their stick with permanent marker. Students get to keep the device and the small filters.



Looking for rainbows in a plastic spoon.

## Equipment List: "Polarized Light"

### Items needed for Instructor:

- Spring, Long and Flexible
- Polarized picture in a frame
- Polarized plastic sheets, about 8" x 10" (3)
- Laptop computer
- Plastic clamshell container (half)

### Items needed for Students:

#### Consumables (per 4 students):

- Piece of Wood, approx. 1/4" x 1/2" x 6"
- Plastic Swivel Clip, 2 per student
- Polarizing filters, approx. 2" x 2" (2 per student)
- Clear Plastic Spoon
- Glue Stick

#### Other:

- Glue Gun
- Markers, Colored Permanent

### Prep Work:

- Cut wood pieces 1/4" x 1/2" x 6"
- Cut polarizing filters 2" x 2"



Long flexible spring.



Polarized Picture.

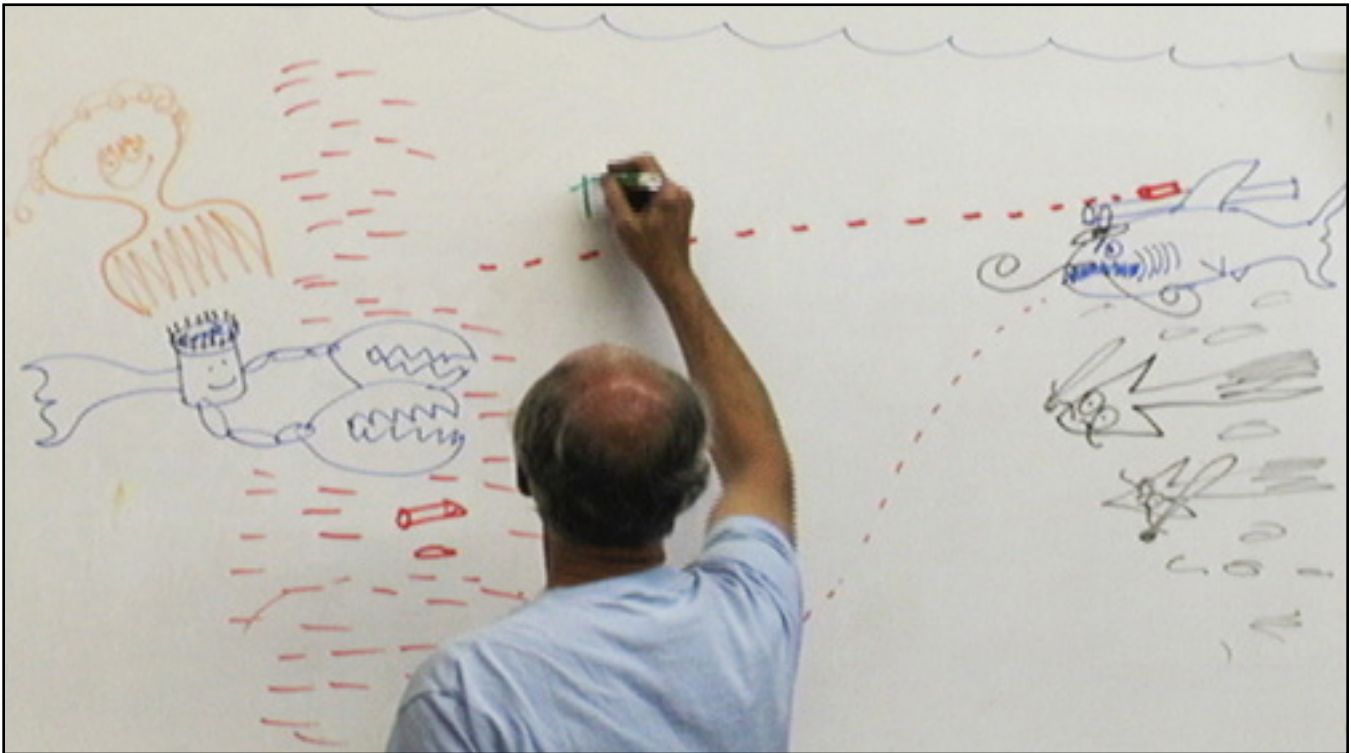


Gluing plastic clips onto wooden stick.



Looking through two filters.

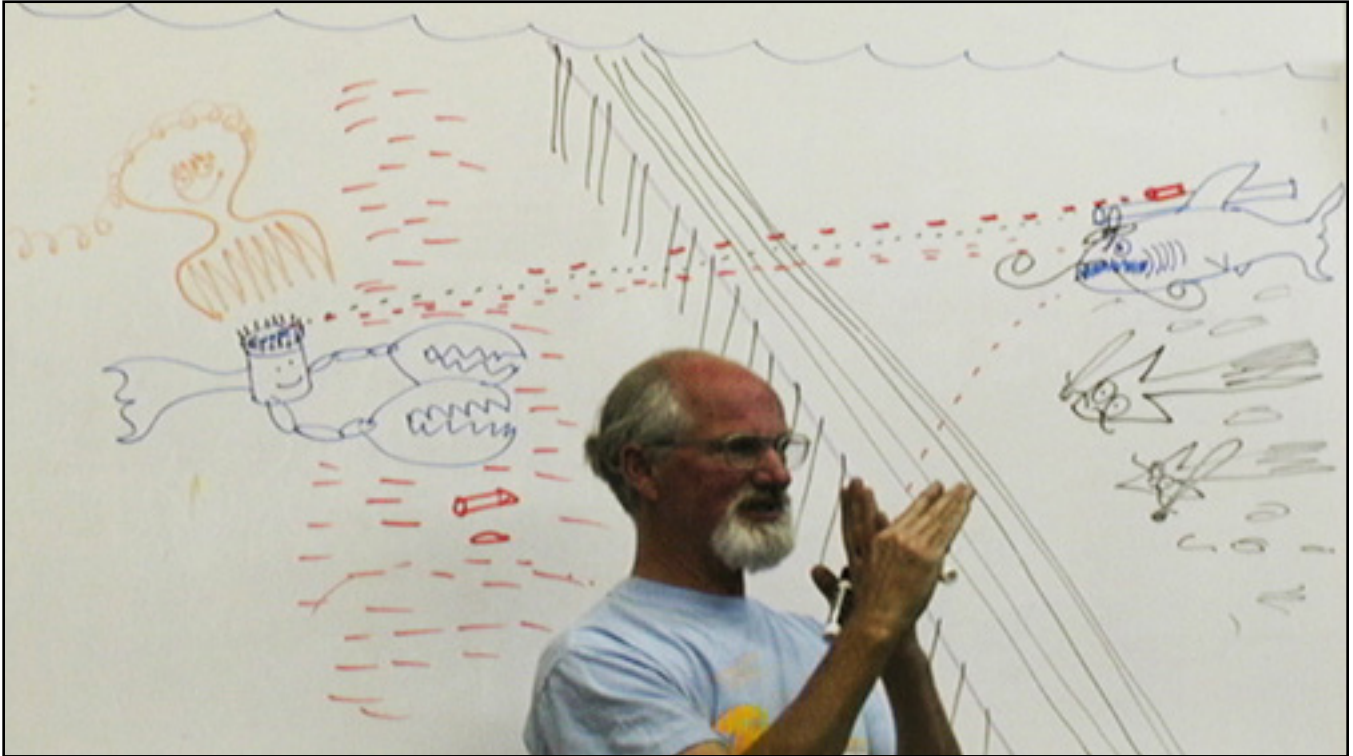
## Story Recap: "Jack & Jill and the Minion Squids"



### Part 1:

- Evil Mister Fred has transformed himself into a man-eating shark with a laser-guided bazooka on his back.
- His minions are squid with baseball bats.
- Jack is a grape jelly fish and Jill is an octopus.
- They're herding mackerel, which they call macaroni fish, leading them to Florida for a vacation at Disney World.
- Evil Mister Fred sneaked up on them and ate a bunch of the macaroni fish.
- Jack and Jill and the fish started swimming as fast as they could to get away from Evil Mister Fred and find someplace safe.
- Near Florida, there's a ledge that sticks out into the Gulf of Mexico. Jack and Jill waited there and decided to call the Acme Store of Everything and order something they could put in the way, so they could get through but Evil Mister Fred couldn't get through.

## Story Recap (cont.)



### Ending:

- Jack and Jill built two fences, one made of vertical slats and the other made of horizontal slats.
- When Evil Mister Fred tried to get through, he got caught in the fence.
- The minions tried to break the fence with their baseball bats and accidentally hit the firing trigger on Evil Mister Fred's bazooka.
- The laser beam was pointed directly at Jack's head. As the projectile came toward him, he put his head down, and the laser was reflected off the mirrored top surface of his jelly jar.
- Since the laser was reflected back toward Evil Mister Fred, the projectile turned around and hit Evil Mister Fred between the eyes.

## Transcript: Introduction



Student stands on table and holds one end of spring while Instructor twirls the other end.

Do you know what a pole is? *[Student: It's a long rod.]* Yeah, you put a flag on a pole. You could put a birdhouse on a pole. What else can you do with a pole? Are all poles from Poland? No? If somebody hits you with a pole, do you become polarized? Well, it turns out, you can polarize light. Polarize means -- I guess I could show you more easily than I could tell you. So I need a spring. I can show you polarized light on a spring. *[Takes out a long flexible spring. A student stands on the table, and the Instructor stands at the opposite end, each holding one end of the spring.]* You hold with both hands and don't let go. You're just going to hold with both hands and don't wiggle your hands.

Regular light has different appearances. Red light is a big lazy wave, like that. *[Rotates the spring like a jumprope, spinning it faster and faster to represent each color.]*

Orange light has two humps, like that. Yellow light would look like three humps. A bright light would be big humps, and dim light would be small. Green light would have four humps. Light is a mixture of two kinds of energy. One kind of energy is magnetic energy, and the other kind is electrical energy. The electrical energy goes up and down like this. The magnetic energy goes sideways like that. When you put them together, it goes round and round and round to make what we call light. Blue light has five humps. *[Student: How many humps does black have?]* Oh, I can show you black. So that's most of the colors. You can just see as you go down the rainbow, you get more and more humps. You've got to watch very carefully to see black. *[Gradually stops rotating the spring until it's almost still.]* Are you ready? It's going to happen quickly. Ready, get set, go! Did you see it? *[Student: It doesn't move at all.]* You're right! Black has no energy, so it doesn't move. *[Student: What about white?]* We want to do white light. White light is a mixture of red, orange, yellow, green, blue, and violet -- everything. *[Speaking to student holding the spring]* You shake your end, I'll shake my end, and that's going to be white light. *[Student and teacher shake the spring in different directions, creating a chaotic pattern of humps.]* This is white light. Okay, you can stop.

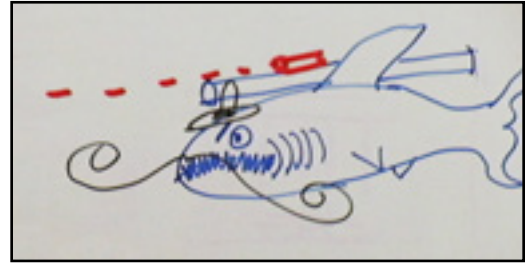


So polarized light is just a way that light vibrates. Polarized light can be polarized different ways. It can be polarized sideways [*swings spring from side to side*]; it can be polarized tallways [*swings spring up and down*]; it can be polarized at an angle [*swings spring diagonally*] between tallways and sideways. And when we polarize light, it changes the way it acts. Today we're going to do some experiments with polarized light. [*Stops moving spring and instructs student to let go and sit down.*]

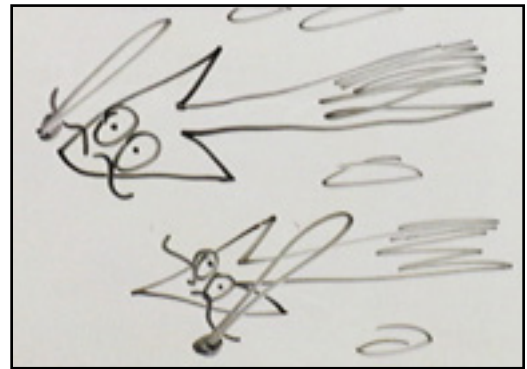
## Story: "Jack & Jill and the Minion Squids"

Once upon a time, there was an ocean. And there was a vicious man-eating shark. They usually have an eye, like that. And they've got some gills. And they have a fin that sticks up like that. And they have a tail, and probably various other fins. And they've got lots of teeth. And this shark carries a bazooka on his back. And a laser-guided system, like that. And he goes out through the ocean, searching for things to kill. It's his job. And he's got a mustache and a hat. He's an Evil Mister Fred shark. Evil Mister Fred found a cardboard box that said "transmogriifier" on it. And he jumped into the box and said, "I wonder what this box does." He jumped in and poof! -- turned himself into a shark. And then he called the Acme Store of Everything to get the underwater bazooka with the laser guidance system.

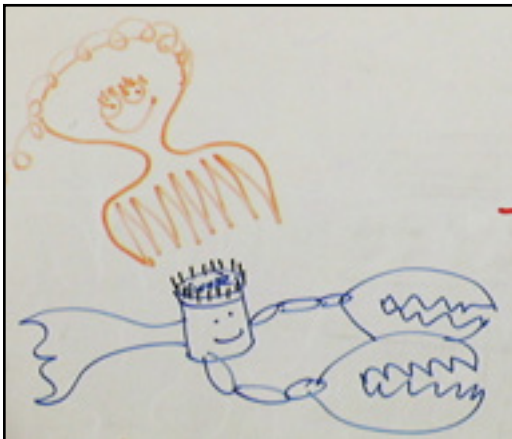
And now he's zooming all over the place, but he misses his minions. And he needs some sort of a minion thing that can swim as fast as him but that's kind of dumb. So he got some squid. Squid minions. There, squid minions, all over the place. Oh, yeah, they need baseball bats, huh? [*Student: No, get them spearguns.*] No, they'd kill each other. They're only good with baseball bats. There. There are squids all over the place, following Evil Mister Fred around, terrorizing the ocean.



Evil Mister Fred as a shark.



The minion squids.



Jack as a grape jelly fish, Jill as an octopus.

And Jack and Jill were down there. What should Jack and Jill be turned into? Jellyfish? Okay, Jack and Jill are jellyfish. Jack is a grape jellyfish. He's a jar of grape jelly. And he must have a tail of some sort, and he needs some claw-like hands from a crab. And Jill can be something different because, you know, you can be anything you want. Okay, Jill can be an octopus. [*Draws an octopus with long curly hair.*] Oh, Jack needs to have hair. [*Adds short straight hair to the grape jelly jar.*] There.

And Jack and Jill are herding mackerel. But they call them macaroni fish. So you have all these macaroni fish, like tubes.



Macaroni Fish.

They're taking the macaroni fish for a vacation in Florida. They've been up by Alaska where it's really cold and there are lots of whales. They're going to go to Florida and go to Disney World. Evil Mister Fred is chasing after them because he likes macaroni. And he wants to zoom through there and just swallow them all up -- arrrrrgh! And Evil Mister Fred came zooming by, and out from behind some algae and some rocks and some seaweed, and ka-chonk! -- ate a whole bunch of macaroni fish. And Jack and Jill said, "Ohh! Evil Mister Fred, how'd you get down here? What are you doing?" Evil Mister Fred said, "Just came to make your day a little bit more enjoyable." And Jack and Jill said, "That's not enjoyable. You just ate some of our friends." And Evil Mister Fred said, "Buurrrp! Yep, they're good, too."

And Jack and Jill started to run as fast as they could, to try to swim away from Evil Mister Fred. And they went over hills and down into dales, through portholes in sunken ships and everywhere they could go, trying to get rid of Evil Mister Fred. And Evil Mister Fred followed them wherever they went. And Jack and Jill said, "We've got to go someplace that's safer, some place that Evil Mister Fred can't go." On the way to Florida, Florida makes kind of a ledge that sticks down into the Gulf of Mexico. And they said, "We'll call the Acme Store of Everything, and we'll put something in the way so we can get through and Evil Mister Fred can't get through." If you were Jack and Jill, what would you put in the water to stop that Evil Mister Fred?

### Imagination and Brainstorming Time

*[Students make suggestions]* (THERE ARE NO WRONG ANSWERS! Whatever they say, you should reply: "That's a good idea," "They might do that," etc. After brainstorming, proceed with the experiments, then finish the story.)

And we're going to leave this "To be continued . . ."

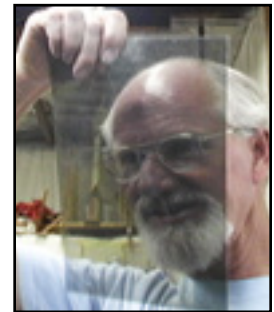
## Demo:

Here we have a thing *[holds up a frame with a gray screen mounted on it diagonally, so part of the background is transparent.]* *[To camera operator]* What do you see through your lens, by the way? *[Camera operator: I can see my reflection in the dark part, and I can see through the light part.]* Okay, good. Now, I'm going to show you this, and you tell me what you see *[walks around the table so each student can get a close look. Some students think there's a picture but can't describe it accurately.]* Now on the other side, what do you see? *[Flips over the frame, showing the back of the grey frame. Students don't see anything.]*



Grey screen in a frame.

Now we're going to take some stuff, magical stuff. *[Instructor pulls out a polarizing filter and holds it in front of his face.]* Here's some sunglass material. When you look through this, what do you see? *[Students: You.]* Okay. *[Rotates filter 90 degrees.]* Do you still see me? *[Students: Yes.]* *[Flips filter over.]* Do you see me now? *[Students: Yes.]* Okay,



Sunglass material.



Image in frame with Polarizing Filter in front.

I'm going to hold this *[filter]* in front of this *[framed screen]*, and then you tell me if you see the picture or not. *[Instructor walks around with the filter in front of the screen so students can see it close up, and they all see the picture of a female crossing guard with some children. As he goes, he also moves filter up and down to show the framed screen with and without the filter on it.]*

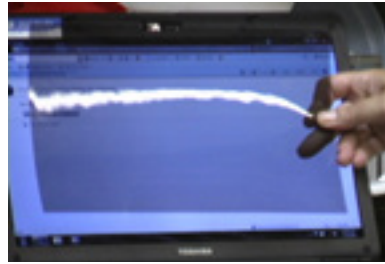
Now, what color was the dress that the lady was wearing? *[Students: Black.]* Would you bet your parents' car on that? *[Students: No.]* You're supposed to say yes. You guys were right there. You witnessed this picture right in front of your very face, you're eyewitnesses to the crime. A lady in the crosswalk was throwing children in front of passing buses. Was she wearing a black dress? *[Student: She was not.]* How do you know? *[Student: She was holding a stop sign so the children could cross at the crosswalk.]* I'm going to come by again quickly. What color is her dress? Is it green? Is it purple? Is it orange? Eyewitnesses, some people say it's white, some people say it's black.

Now, I'm the judge, I'm the jury, and I'm the executioner. I say she was wearing a white dress, and you're all wrong. Ha, ha, ha! And I can prove it to you -- there! *[Puts the filter in front of the picture again, but turned sideways, and walks around with it.]* See? It's a white dress. *[Student: You switched it!]* It turns out you were right. And somebody else observed that I turned this material. Okay, so this one *[the picture in the frame]* stayed the same, *[and other one changed.]*



Rotate the filter and the dress looks white.

*[Instructor holds a polarizing filter in front of a laptop computer to show how the computer screen becomes invisible and then visible again as the filter is rotated.]*



Left: Filter in front of computer screen. Right: Filter rotated.

*[Instructor takes out another filter and holds it in front of his face.]* Okay, can you see me? *[Students: Yes.]* Can everybody see my face? *[Takes out another filter.]* If I put this one up in front of my face, will you still be able to see me? *[Students: Yes.]* Okay. Puts second filter in front of the first one. Do you still see me? *[Students: Yes.]* Okay, now are you ready? *[Rotates the second filter 90 degrees, which blocks out his face, then rotates it back again, making him visible.]* Okay, so I can turn myself on and off.



Using two filters to block out face.

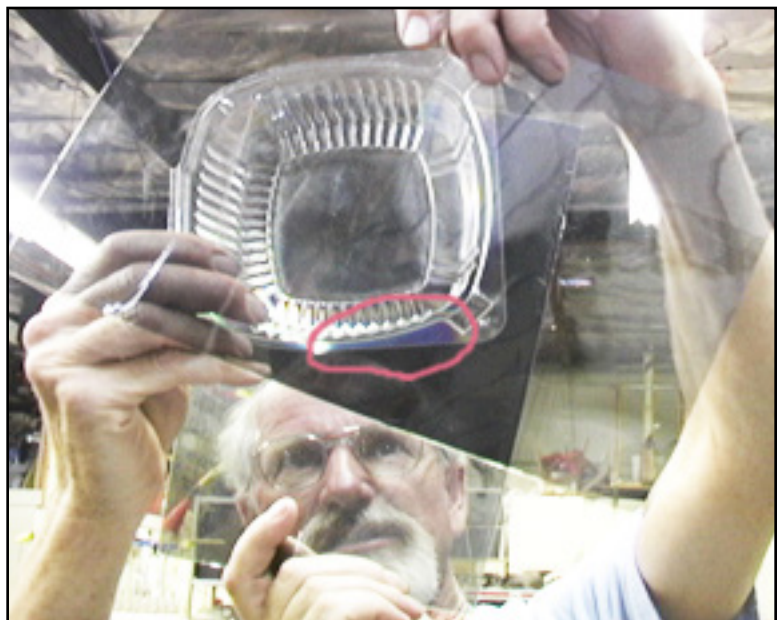


With a third filter between, he reappears.

Now, I'm going to turn myself off *[holds first filter close to his face and the second one about a foot in front, rotated 90 degrees]*. You can see I'm off here. Now my assistant is going to put another one in between my two and see if he can make me reappear again. *[Assistant places a filter between the other two, at a 45-degree angle, and instructor's face is visible again.]* There I am, *[assistant removes third filter]* and there I go away again.

So you can make things appear and disappear with pieces of plastic. And you can make them change from black to white or white to black, if you do it carefully. You can do it on computer screens. It also does something else. *[Picks up a clear plastic food container and holds it above a student's head so he can look through it to the lights in the ceiling.]* What do you see? *[Student: Lights.]* Do you see any heavy?

Now I'm going to hold up this -- it's called a polarizing filter. I'm going to hold up a polarizing filter *[holds filter just beneath*



With one filter above the plastic container and one underneath, you begin to see rainbows in the plastic (see red circle).

*the plastic container and passes them above the students' heads]. There -- what do you see? [Students: Light.]*

Okay, now we're going to use two of these. We're going to bring the same thing by. My assistant's going to hold his perpendicular to mine, and we're going to walk around and see what we see when we come over your head. *[Assistant holds one filter below the container; Instructor holds another one above it and rotates the filter back and forth while holding it over each student's head.]* Do you see anything when we do this? *[Student: Yes.]* Don't tell, it's a secret. No one must know.

## Experiment: "Polarized Light"

*[Note: Part of the video is missing here, where the Instructor describes how to build a device that will allow students to manipulate polarizing filters. The video picks up with the students gluing two plastic clips to either end of a stick of wood.]*

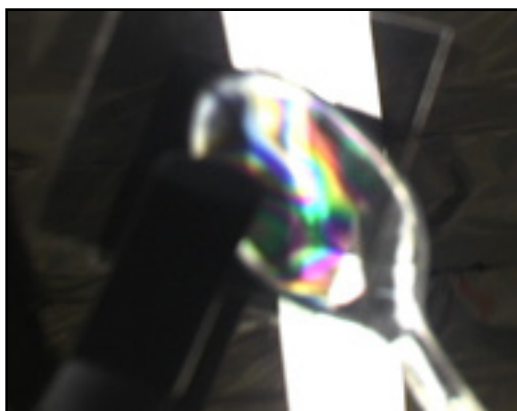


Gluing the plastic clips onto the stick of wood.

When your glue is hard and when you're sitting there more or less quietly, we'll give you two of these polarizing filters. *[Each student receives two 2"x2" filters and puts one in each clip.]* After you get your pieces and figured out how to make it look dark, then look at the lights up above and see what color those are. *[Students: Purple.]* Are they maple-surple-purple or plain purple? Do you see any rainbows anywhere? *[Most students say: No. One student says: On that plastic ball.]* Ah! That's what I was hoping somebody would say. Somebody else noticed there were rainbows in the plastic ball.



Manipulating the filters.



Rainbows in the plastic spoon.

Have you noticed that when you least expect it, it starts to rain spoons? *[Tosses a bunch of clear plastic spoons onto the table.]* Grab a spoon and find the rainbow. Can you see rainbows in your spoon? *[Students: Yes.]* Rainbows all over the place. *[Student: If you look up at the light, you see more rainbows.]*

*[Instructor passes out permanent markers so students can write their name on their stick of wood. They get to take home the device, including the two filters.]*

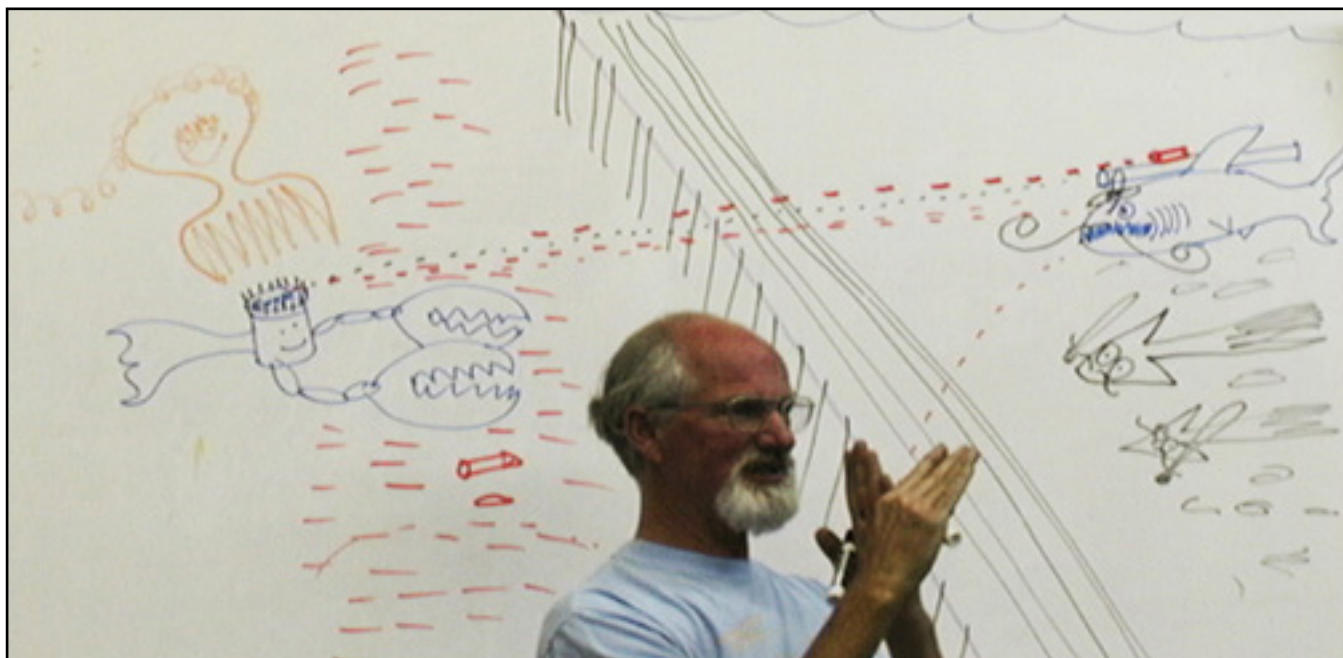
## End of Story

**\* DO NOT \* present this part of the lesson until after the experiments!**

*[Note: Part of the video is missing here. In the story, Jack and Jill have built an underwater fence made of vertical slats, and another one in front of it made of horizontal slats. The Evil Mister Fred shark and his minion squids can't get through it. When Evil Mister Fred tried to get through, he got stuck between the two fences.]*

The minion squids started going bang, bang, bang, bang, trying to break the fence. But they couldn't break the fence. And minions, they're not really skillful with their baseball bats. As they're banging around, trying to free Evil Mister Fred, one of them accidentally hit the firing trigger on his bazooka. And the bazooka went booozzzzhhh! And it shoots out underwater rockets. And the rockets follow the laser beam. The laser beam was pointed straight at Jack's grape jelly head. And it looked like this was going to be the end of Jack. And the thing went shooting forward at high speed, and Jack said, "Uh-oh!" He saw a bazooka thing hit him right between his eyes. He says, "No!" and he put his head down like this. The top of his jar had a mirror finish on it, and the laser beam bounced off -- ba-jinggg! -- and pointed right between Evil Mister Fred's eyes. And the bazooka thing said, "Where'd it go? Where'd it go?" It turned around and said, "Oh! There it is!" Ba-zhoom! Crash! And that was the end of Evil Mister Fred. Everybody lived happily ever after, except Evil Mister Fred.

*[Student asks a question off-camera about the fence and the filters.]* One of them was up and down. One of them was sideways. When you have them like this, you watch the light and it looks black. Only the tiny, tiny waves of ultraviolet can get through. When you put something in the middle, it helps them bend so then you can see the rainbow color.



**End of Lesson:** *If you have questions about this lesson, please ask them through the [online Teacher Support Forum](#) on our web site.*