

EDUCATIONAL OUTREACH PRESENTATION GUIDE

OPTICS SUITCASE



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The Electro-Optics Center
A Manufacturing Technology Center of Excellence



Optical Society of America
Rochester Section



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I. LIST OF EQUIPMENT AND SUPPLIES

Your *Optics Suitcase* contains two types of supplies:
reusable and **giveaway**.

Reusable Supplies

Quantity	Item
1	Black suitcase with room for other items that you may add to customize your presentation
1	Prism portable heat-therapy pad
1	Set of Arbor Scientific “Happy and Unhappy” balls and fact sheet
1	Slinky
1	100-mm-diameter silicon wafer, one side polished to a “mirror” finish
1	Silica glass lens
2	8" × 8" pieces of high-quality sheet polarizer in protective transparency holders
6	Transparent plastic cups
1	Set of transparent plastic tableware: fork, spoon, knife
1	9" × 12" sheet of temperature-sensitive microencapsulated liquid crystal rolled in a protective tube
8	Transparencies to help with the presentation
1	Sample of a color flyer

Purchasing an ACE Brand “Cold Compress” instant ice pack is suggested for use with the liquid crystal demonstration.

Giveaway Supplies

Quantity	Item
Take-Home Theme Packets:	
75	Rainbow Peephole:™ Color by Redirecting (Diffraction)
75	Magic Stripes: Color by Polarized Transmission (Polariscope)
75	Magic Patch: Color by Selective Reflection (Liquid Crystals)
75	Periodic Table of Elements from the American Ceramic Society Color flyers (though not included, a sample is provided as a model)



Figure 1. Contents of the Optics Suitcase. Manufacturing details for the giveaway supplies and a template for making a flyer may be found on the COM Web site at:

<http://www.opticsexcellence.org>

2. INTRODUCTION AND OBJECTIVE

The *Optics Suitcase* is designed to make it easy to go into a classroom and get young people excited about careers in technology (Fig. 1). Kids enjoy the theme packets that may be taken home and shared with others. Every student takes home a flyer that serves as a prompt to aid the young person in describing you, the purpose of your visit, and your demonstrations.

You will want to customize your classroom visit with items and observations based upon your job and work environment. You must decide when and how to insert this information into the presentation. Expect to be asked questions about how much money you make, how long you went to school to prepare for your line of work, and what you like (and dislike) most about your job. Interaction with your audience can be exhilarating if you come prepared.

The objective is to convey a sense of excitement about technology in a short period of time. To achieve this, we have designed a “typical” classroom presentation with some initial demonstrations that should quickly capture the students’ attention. You should then be able to zoom through three activities that illustrate the overall theme of “colors in white light.”

After giving dozens of presentations, members of the Rochester Section of the OSA have learned quite a few lessons. The following summarizes a few general observations and suggestions:

- Make arrangements with the teacher ahead of time to have an overhead projector, screen, and table at the front of the room. The table will ensure that you have enough room to spread out.
- We have found that the presentation is most successful when given to the 6th through 10th grades. Younger children are excited by the gifts you bring, but the message seems to get lost.
- Ask the teacher for help in handing out the theme packets and flyers and for operating the room lights (more on this later).
- It takes a minimum of 40 minutes to do the presentation as described in this guide. With more time, you can slow the pace, add more personal information, and entertain more questions. With less time, you may want to cover only two activities.
- Adjusting the flow of your presentation is important. Read your audience and move on if their attention seems to be wandering. You have plenty of material.

3. PREPARING FOR A VISIT TO THE CLASSROOM

1 to 2 weeks before a visit

Obtain the following information from the classroom teacher to prepare your suitcase and make a take-home flyer:

- School name, school address, teacher's name, classroom location
- Ages of students
- Number of students
 - Take four extra sets of theme packets and flyers (one for the teacher, one for you, and two spares)
- Length of presentation
- Number of presentations
 - Will you speak to one or two classes?
- The setting and teacher's expectations
 - Is your visit part of a career day at school where others are coming in to describe their occupations as well?
 - Is your visit being used to emphasize experiments that demonstrate fun with science?
 - Is your visit being used as part of a science unit on the topic of physics?
- Protocol for entering the school
 - You will probably report to the school office for a badge.
- Appropriate arrival time
 - 20 minutes before the target class time?
 - Will there be time available to setup in the classroom?
- Would the teacher like a short biography to introduce you to the class?

The day before your visit

Check the contents of your suitcase. Make sure that the heating pad demo is in its liquid phase (*see section 4*). Print out the flyers and a transparency of the flyer to use on the overhead projector and take some time to practice, even if you simply run through the presentation in your mind. If you have a laser pointer, you might bring it along, **but be careful not to share it with anyone or leave it where it can be “borrowed.”**

4. GETTING STARTED (BREAKING THE ICE)

 After the teacher or one of the students has introduced you, try the following:

Heating Pad Demo

- Thank the teacher for inviting you to school, restate who you are, where you work, what you do, and the types of people with whom you work.
- Pick someone out and ask them to come forward to help you.
- Take the portable heat therapy pad out of its box (do not indicate what it is yet), place it in the student's hands, and ask her (him) to gently handle the pad and describe how it looks and feels (squishy, clear, slightly yellow, liquid, cool to the touch). (*You may have to gently prompt the student to get these answers.*)
- Ask the student to hold the heating pad up so everyone can see it and so that the metal disk falls down to a corner of the pad. Ask your helper to snap the metal disk inside the pad. (*Crystallization is initiated at the disk and spreads throughout the pad in ~30 seconds, accompanied by heat. The pad turns opaque.*)
- Tell everyone that this is a reusable heating pad for alleviating aches and pains. It is an example of how technology can be used to make life better for us. Someone has to be willing to study math and science to invent such things.
- Pass the heating pad around so everyone can feel the heat.
- Put the demo away.

Happy and Unhappy Balls (if time permits)

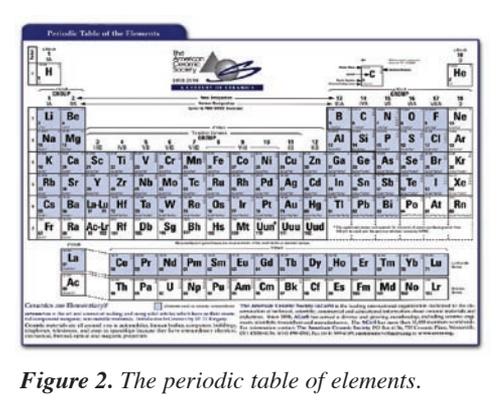
- Select another student to come forward.
- Hand her (him) the two black spheres and ask the student to drop both onto the table. (*As explained in the note from Arbor Scientific included in your suitcase, the rubber in one ball is fully vulcanized, retains its shape, and bounces well. The rubber in the second ball is much more easily deformed and does not bounce.*)
- As your helper continues to bounce the unhappy ball, ask which kind of rubber would be best suited for the tires of a racing car or the bottoms of a pair of sneakers. (*Answer: a blend of both, for improved friction or gripping power and to absorb shocks, but not too “energy absorbing,” because this is accompanied by high heat from friction and excessive wear.*)
The best rubber for a handball is ???
- Again, you might point out that technology and invention are the keys to improving our lives.
- Put the demo away.

5. INTRODUCTION TO OPTICAL ENGINEERING

 Now that you have their attention, you are ready to introduce a field of technology called “optical engineering.”

- Hold up the **silicon wafer** (shiny side out) and the **large silica lens**. Ask if anyone can identify them. (*The lens is usually easy. The students will likely refer to the wafer as a mirror.*)
- Identify the wafer as single-crystal silicon, a pure elemental substance and the basis for all computers (the chips and microcircuits). Show them the reverse side of the wafer, which is dull, and explain that this side is ground and the other is polished to a mirror surface. Some optical engineers develop the technologies for turning rough silicon wafers into integrated circuits for making computer chips. (*You may want to elaborate on this.*)
- Hand out copies of the periodic table of elements [*useful for 8th and 9th grades and higher (Fig. 2)*] and use the transparency to help the students locate silicon (#14) and oxygen (#8).

- State that the periodic table is a visual means for displaying all of the elements known to man—every bit of matter in the universe is composed of one or more of these elements. Ceramic engineers, chemists, materials scientists, geologists, and optical engineers work with many of these elements and the compounds they form.



The image shows a standard periodic table of elements. It is titled "Periodic Table of the Elements" and includes the logo of the Royal Society of Chemistry. The table is organized into groups and periods, with element symbols and names. Silicon (Si) is located in group 14, period 3, and oxygen (O) is in group 16, period 2. The table also includes the lanthanide and actinide series at the bottom.

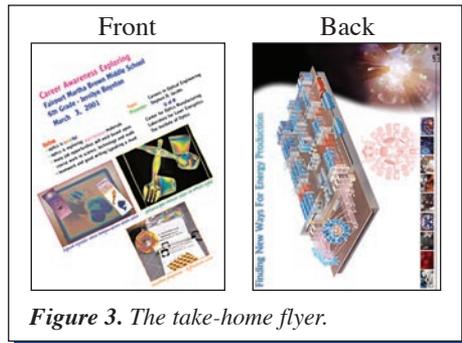
Figure 2. The periodic table of elements.

- Explain that the only difference between the silicon wafer and the silica lens is oxygen. Point out how a little oxygen turns a visibly opaque material into a visibly clear one. Suggest that if we were aliens whose vision was in the infrared, the silica lens would look opaque and the silicon wafer would look transparent! Mention that optical engineers build lenses into systems that image light such as the Hubble Space Telescope, the Chandra X-Ray Telescope, or the digital cameras that record images on silicon.

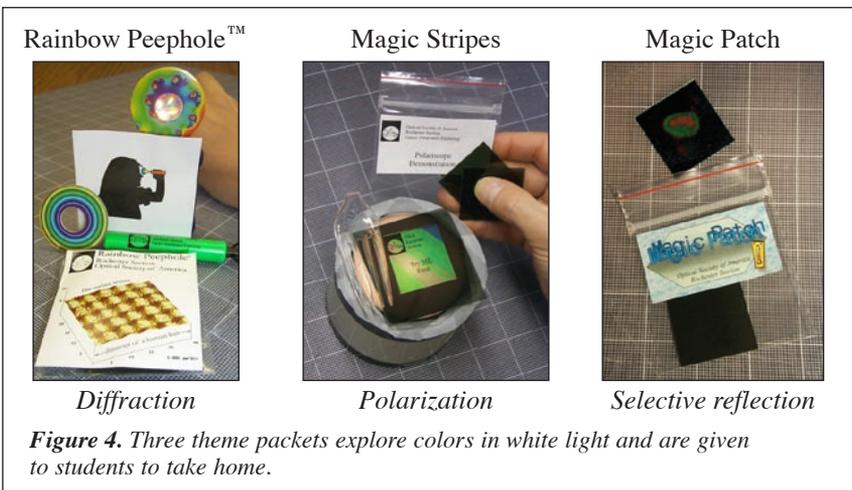
6. COLORS IN WHITE LIGHT

 You are now ready to do some experiments with the class that illustrate what optical engineering is all about.

- State that these experiments explore several ways to “see” the colors in white light. You are prepared to reveal certain “secrets” that might not be obvious to others when doing these experiments. (*The “trick” aspect to these demos works well with 6th graders!*)
- Put up the overhead of your take-home flyer and walk the students through the salient features that describe optics and what it takes to be successful in this career. [*The flyer may be handed out now or at the end of the class (Fig. 3).*]
- On the other side of our flyer is a schematic of the OMEGA laser at the University of Rochester. With your transparency, you might want to point out the size of this laser system (equal to the length of a football field).



- Mention that 250 people with technical degrees in optical engineering, photonics, physics, electronics, computer engineering and mechanical engineering work on this giant experiment to generate energy from sea water.



7. RAINBOW PEEPHOLE™ COLOR BY REDIRECTING (DIFFRACTION)

Have the teacher pass out the **Rainbow Peephole™ Theme Packets** [Fig. 4(a)], but ask the students **not to open them yet**. When everyone has their own packet, proceed as follows:

- Remove the flashlight and the peephole from your packet, hold them up, and identify them. Ask the students to remove theirs. Hold the peephole up and look at the flashlight through it. Have the students copy you.
- During the “oohs” and “ahs,” ask the group, “Where does the color come from?” (*Many children will answer that the colors comes from the peephole. Tell them that the color comes from the white light in the flashlight.*)
- You can ask any or all of the following questions:
 - Do you see a regular pattern? Describe it.
 - Identify all of the colors. Are they the same in each spot?
 - Does the pattern change if the flashlight is close or far away? Do you see colors from other people's flashlights, even those far away from you? Do you see colors from the room lights?
- Hold up the packet and show the picture on the front. Describe this as a highly magnified photograph of the surface of one side of the clear plastic in the peephole. It is taken with an instrument called an atomic force microscope. (*Optical engineers develop instruments like this.*)
- Note that the scale is in microns, that a human hair is 30 to 80 microns wide, and that the plastic has a regular array of small bumps across it that are only 2 microns high—too small to be seen or felt.
- The bumps are packed so closely together that about fifty could fit inside a human hair. These bumps are responsible for breaking up the light coming into the peephole, depending on its color. This is called “diffraction.” It occurs when light travels through small apertures (e.g., holes or slits). Point out the similarity between the regular array of bumps and the pattern seen through the peephole.
- Ask for a show of hands by everyone who wants a cell phone. With the transparency (Fig. 5) explain how telecommunications uses fibers and lasers to divide light from one beam into many, each with a different color. This is the key to unlimited numbers of conversations all over the world at the same time. (*Optical engineers do this stuff.*)

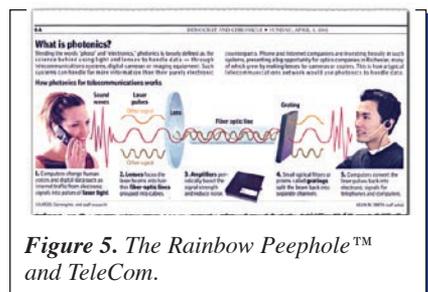


Figure 5. The Rainbow Peephole™ and TeleCom.

- Ask everyone to seal the flashlights and peepholes back into the packets. Tell them the packets are theirs to keep. Suggest that they can reveal to family members the secret of seeing colors in white light through diffraction.

8. MAGIC STRIPES: COLOR BY POLARIZED TRANSMISSION (POLARISCOPE)

Remove the **slinky** from the suitcase and choose a volunteer to come up front.

- Give the student one end of the slinky and ask her (him) to hold this end steady at midchest level. Stand 4 feet away and begin to vibrate your end up and down and in a circle. You should be able to create a standing wave with a few nodes, but the plane of vibration should not be well defined.
- State that, in addition to color, light has a wave nature. The slinky represents a light wave. This motion represents unpolarized light—light without a preferred vibration direction. (*For simplicity, we ignore circularly polarized light.*)
- Stop the circular motion and vibrate only vertically. State that light is “polarized” when it vibrates in one direction—vertical or (switch hand motion) horizontal. (*Horizontal motion is a bit harder to maintain while speaking and you might want to go back to the vertical motion.*)
- Define linearly polarized light as light whose vibration direction is in a plane. [*Here you might use the **overhead transparency from NASA (Fig. 6)** that shows the spectrum from radio to gamma rays with low frequency, long-wavelength and high-frequency, short-wavelength radiation. The photos at the bottom of the transparency show what the Milky Way looks like through different telescopes that “look” at different frequencies or wavelengths of optical radiation.*]
- Put the slinky away.

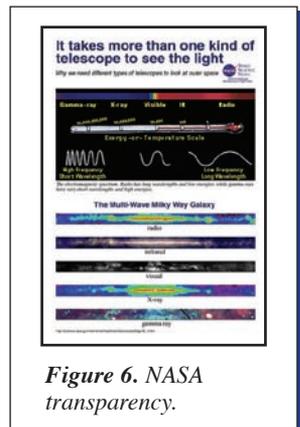


Figure 6. NASA transparency.

Have the teacher hand out the **Magic Stripes Theme Packet** [Fig. 4(b)], but ask the students **not to open them yet**. When everyone has their own packet, proceed as follows:

- Ask the students to remove everything from the packet and place the 5 items on their workspace (Fig. 7). Have them check that they have two dark pieces of plastic, one transparent piece of plastic with writing on it, a fork, and a plastic vial.
- Take your **two large pieces of linear sheet polarizer** and hold them up, one in each hand. Combine them about one foot in front of your face with the transmission axes parallel. You should be able to see the students, and they should be able to see you. Ask them to make a sandwich in the same way with their dark pieces of plastic. Show them what happens when you rotate one polarizer relative to the other.

- During the “oohs” and “ahs,” reveal that each piece of dark plastic has a secret code on its surface in the form of small lines. Combining the plastics so that the lines are parallel makes it possible to see through them. Combining them with lines that are perpendicular, or “crossed,” blocks the light. Identify the plastics as **linear polarizers**. One piece of plastic held up to the room lights causes the unpolarized white light to become linearly polarized. Once the light is linearly polarized, it vibrates in one plane, and it is either transmitted or absorbed by the second plastic polarizer. Polarized sunglasses are made of this plastic.



Figure 7. Contents of the Magic Stripes Theme Packet, including supplies for making a polariscope.

- Have the teacher turn off the lights. Place the large polarizers on the overhead projector and demonstrate how they polarize and extinguish the white light. Separate the crossed polarizers at four corners with the **plastic cups** to make a **polariscope**, place the **plasticware** inside, and enjoy the excitement.
- Ask where the color comes from. (*You might get some correct answers.*)
- Explain that stresses inside transparent materials degrade the quality of linearly polarized light coming through the polariscope, causing various colors to show up. With a polariscope, geologists identify certain crystals and mineral structures. Civil engineers examine stresses inside structures made out of transparent plastic to understand how to build them better. Photonics technicians evaluate the quality of laser glasses and laser crystals with polariscopes.
- Have the room lights turned back on. With the items from your packet, show the students how to make a polariscope in one hand. Ask them to find the colored stripes in the clear sheet of plastic from their packet. (*While looking through the crossed polarizer sandwich at the overhead lights, they must insert the clear plastic between the polarizers.*)

- Ask the students to evaluate the internal stresses in the plastic vial and the fork. By squeezing the tines of the fork, the students may be able to induce and visualize additional stresses. (*See Fig. 8*)

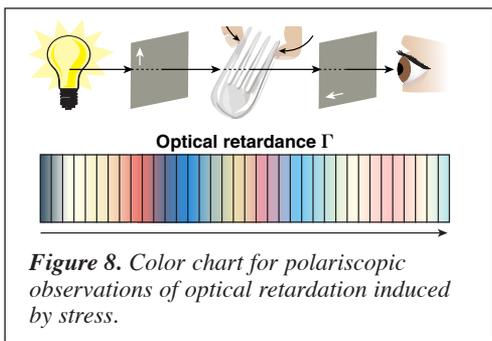


Figure 8. Color chart for polariscopic observations of optical retardation induced by stress.

- Have everyone put all items back in the packets. Suggest that the students demonstrate the Magic Stripes trick to their families, since they know the secret polarizer code and how to construct a polariscope.

9. MAGIC PATCH: COLOR BY SELECTIVE REFLECTION (LIQUID CRYSTALS)

Remind the students that you have demonstrated how to see the colors in white light through diffraction and polarized transmission. Making sure that everyone is looking at you, take the **large sheet of microencapsulated liquid crystal** and place it against your face, shiny side out. (*If you wear glasses, remove them first.*)

- Wait a bit for the “oohs” and “ahs” to die out, then ask, “Where do the colors come from?” (*If some students say the heat from your face, answer no.*)
- Explain that the colors come from the white room lights reflecting off the black “paper.”
- As the teacher passes out the Magic Patch Theme Packets [Fig. 4(c)], explain that the paper has liquid crystal fluid trapped, or encapsulated, against the shiny side. (*Note: The patch material goes through a complete color change with a temperature change of 77°F to 86°F. If the room is warm, you may have to open the ice pack to enable students to cool their patches down. Ice cubes also work well.*)
- Suggest that each student determine if she (he) is a vampire by placing the magic patch on the inside of her (his) wrist. (*Vampires are the living dead and give off no heat.*)
- Ask if anyone can “see a vein.” (*This would be characterized by a blue line.*) To explain selective reflection in liquid crystals and “mood rings,” you may use the set of transparencies included as follows:

“Liquid Crystals in Education” transparency

- Students are laying on the grass, disguised as liquid crystal molecules. In liquid crystals, the molecules show a high degree of organization and alignment in some regular order (Fig. 9).

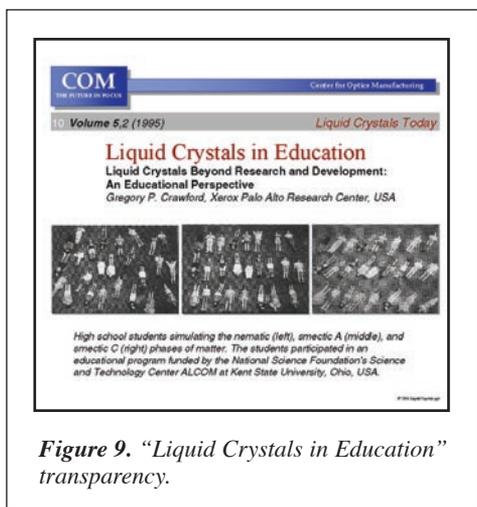


Figure 9. “Liquid Crystals in Education” transparency.

“Selective Reflection in Cholesteric Liquid Crystals” transparency

- If we try to stack students (or liquid crystal molecules) in a series of layers on top of each other, they tend to twist as shown on the left in Figure 10. The heads of the students point in a spiral direction as we move up through the structure, like a spring.
- Think of the liquid crystals in the black sheet as springs. When they are cool, the springs are relaxed with a long pitch (or twist). (*Refer to the right side of Fig. 10.*)
- Most of the colors in white light pass right through the cool liquid crystal film and are absorbed in the black paper. The patch appears black.
- As body temperature heats up the patch, the liquid crystal “springs” get tighter and they “selectively” reflect the red light part of the white room lights. As the temperature climbs, yellow, then green, and finally blue light are reflected. This is as tight as this liquid crystal gets (*Fig. 10*).
- The effect is reversible. Students may put their patches on an ice cube or under a mug of hot cocoa to see the effect of selective reflection. Give a warning that the sheet should not be folded or marked with a sharp object like a pencil.

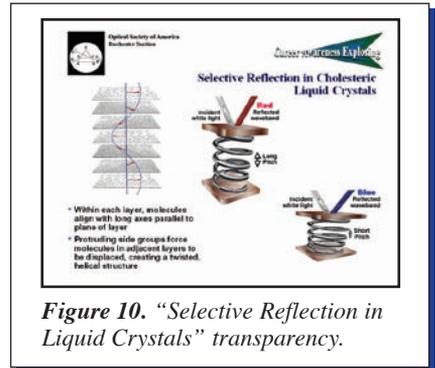


Figure 10. “Selective Reflection in Liquid Crystals” transparency.

“A Subtle Message About Smoking” transparency

- Mention that doctors study circulation in the body with liquid crystals. On the left side of the picture, the blue color of the man's hand shows good blood circulation to the fingers. The picture on the right side shows that, after smoking one cigarette, the man's fingers reflect green because of reduced circulation. Nicotine constricts the blood vessels (*Fig. 11*).

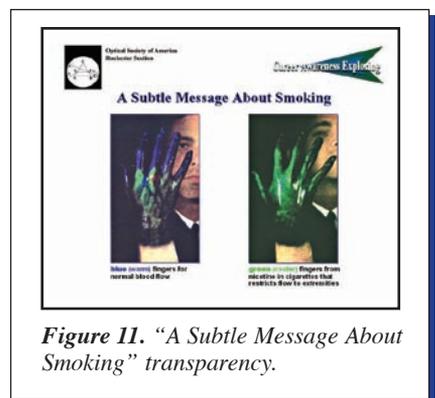


Figure 11. “A Subtle Message About Smoking” transparency.

- End by reminding the students that liquid crystals are found in every thing from cell phones to watches to laptop computers to video games. What would the information age be like without the engineers and scientists who developed liquid crystals?

10. TIPS ON ENDING (YOU ARE ALWAYS RUSHED)

While the teacher hands out the take-home flyer, thank the students for inviting you and ask if there are any more questions. Are there things that they want you to clarify or repeat?

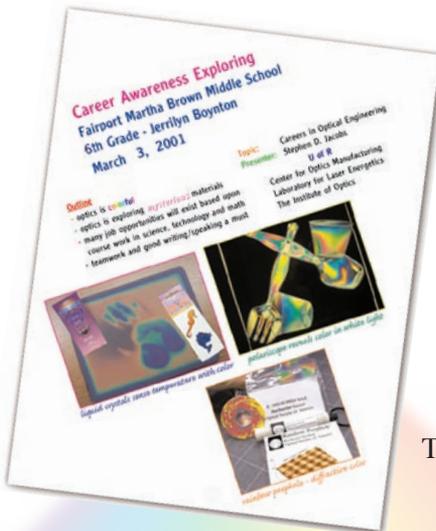
The teacher may have to start up with another class five minutes after this one leaves, so be prepared to throw all of your props into your *Optics Suitcase* and make a hasty retreat.

11. ACKNOWLEDGEMENTS

Much effort has been devoted to the development of the *Optics Suitcase*. Over 5000 theme packets and one page flyers have been distributed across the country. With Activity Grants awarded by OSA's Member & Education Services Council and additional financial support from the Rochester Section of OSA, SPIE, Laboratory for Laser Energetics (LLE) at the University of Rochester and the E-O Center/ARL, Penn State University, this effort will continue.

I (SJ) acknowledge many individuals for their contributions: Leslie Gregg (COM) for theme packet design and manufacture, packaging, and suitcase assembly; COM graphic designers Rebecca Coppens and Christine Andrews for the design and preparation of the flyers; Jennifer Hamson for modifications to this brochure and to our web site; U of R undergraduates Jessica DeGroote, Jennifer Hayes, Jacob Hesterman, Anne Marino, Terri Pfuntner, Jennifer Sternal, Rupal Varshneya, and John Wilson for cutting, pasting, and bagging packets; Mark Glasper and the American Ceramic Society for providing periodic tables; Wayne Knox (The Institute of Optics) for introducing me to the Rainbow Peephole;TM Eileen Korenic (University of Wisconsin, River Falls) for coining the term "theme packet;" OSA President Erich Ippen for suggesting the term "*Optics Suitcase*" in the March 2000 issue of OPN; Theresa Macon and Courtnee Young for opening up classrooms to us under the Rochester Otetiana Council Explorer Scout Career Awareness Exploring Program; and Kathleen Raniewicz and Eileen Hartmann for inviting us to test our presentations on teachers under the banner of the Rochester Area Career Education Collaborative.

Example of one thank you note received from a class of 6th graders presented with the “*Optics Suitcase.*”



Take-home flyer

For more information, visit our Web site at www.opticsexcellence.org