In a Different Light

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IN A DIFFERENT LIGHT is a cohesive unit of six lessons for grades 6-12 that develops the understanding that visible light is composed of a full range (spectrum) of colors of light from red to violet, that extends the concept of a spectrum to include non-visible light (infrared and ultraviolet) through discovery, and that develops tools and strategies for student inquiry.

How to Use the Teacher Resources

The Introduction gives information on the entire unit, IN A DIFFERENT LIGHT. Here you will be able to find Grade Levels, the Purpose for the Unit, the Overview of Lessons, national educational standards applicable to these lessons, a discussion of teaching methods, and materials lists for each lesson. The Introduction should help you to understand the What and How and Whys of this unit and its structure.

In addition, the Introduction provides resources for you for each lesson. The Teacher Resource for each lesson provides information specific to that lesson: Purpose, national standards, Background, Overview of Student Assignments, Materials, and Preparation and Procedures. The Background and the Preparation and Procedures sections, in particular, should be read carefully with the Student Assignments (contained in Student Assignment packet) for that lesson in hand. The Background provides information on the content of that lesson. Web resources are identified that will support your learning. In addition, the Background discusses the preconceptions your students might have as they begin the exploration.

An Appendix contains a variety of resources you will need for this unit. Some of these are assignments that are used in several different lessons. Many of these student assignments, such as Report/Presentation formats and rubrics, Prediction Reflections, and Peer Review Guidelines, can be used in other units you teach. The Appendix also contains a short list of vendors for supplies. This is for your convenience and should not be considered an endorsement of any vendor.

For Whom Is This Unit Designed? Grade Levels

IN A DIFFERENT LIGHT is for grades 6-12 and can be used in any physical science class that includes the introduction of light and the electromagnetic spectrum. These topics may arise in a Physical Science curriculum, Astronomy, Earth and Space Science, Physics and Chemistry. While these lessons can be used in a wide range of grade levels, you may need to make some modifications. For example, in **Lesson 3 – Exploring Spectra** the activity **Analysis of Stars** may be more appropriate for grades 10 –12 and courses such as Chemistry and Physics. This one activity can be omitted or conducted as an in-class activity with teacher support in grades eight or nine. Lesson 1 and Lesson 2 may be more appropriate for grades 6-8, however, older students would benefit from beginning with these lessons if they have little experience with these topics.

The unit is designed to develop inquiry skills. It begins with much structure in the inquiry process and gradually places more control of inquiry with your students. The final lesson requires your students to develop a question and design and conduct the inquiry. You may wish to modify early lessons to be less structured. However, remember that all students need some degree of support and guidance in the inquiry process. If your students are struggling with independent inquiry, you may wish to provide more structure in the final lessons. However, remember that students will never learn to pose and answer questions independently if they are not asked to do so. It is better to provide the challenge and then provide coaching as needed.

Purpose of Unit

There are three specific goals for IN A DIFFERENT LIGHT. The first goal is to develop the understanding that visible light is composed of a full range (spectrum) of colors of light from red to violet. This is an essential understanding that should be developed before studying of the entire electromagnetic spectrum ranging from radio to gamma rays. In the process you need to confront the preconceptions that many students have (see Background for MIX IT UP and GETTING HOTTER?).

The second goal is to extend the concept of a spectrum to include non-visible light (infrared and ultraviolet) through discovery. Lessons 4 and 5 guide the student to a discovery of infrared and ultraviolet light, respectively. A reading that shows them how scientists use infrared light and ultraviolet light to study phenomena not accessible to visual inspection follows each discovery.

The third goal is to develop tools and strategies for student inquiry.

Overview of Lesson and Student Assignments

LESSON 1 – MIX IT UP

Students will develop an understanding that the color we see is a particular color of light reflected from an object. This activity will also introduce the concept that white light is a combination of other colors. Student assignments are:

1. **Colors and Light** is a journal assignment to start your students thinking about light. It will also reveal your students' ideas about light.
2. **Exploration with Colored Light and Colored Paper: Predictions** Students make predictions about different experiments with colored light and colored paper based upon the ideas they hold before they begin their explorations.
3. **Exploration with Colored Light and Colored Paper: Data** The students use the Data sheet to record the results of the experiments with colored light and colored paper.
4. **Making Conclusions** Students answer questions that lead them to make conclusions about light and color.

5. **Prediction Reflection** (Appendix) After the exploration is completed and you have discussed the data and conclusions, assign the Prediction Reflection. This will help them to be more aware of their thought process.
6. **Inquiry Reflection – Mix It Up** This reflection is designed to focus the attention of your students on the process and elements of inquiry.

LESSON 2 – PRISMS AND RAINBOWS

In this lesson students will develop the understanding that "white" light from the Sun and "white" light from an artificial light source is a full range of colors from red to violet. Students will also learn how droplets of water function as prisms to separate this full range of colors into rainbows. Student assignments are:

1. **Rainbows** is a journal assignment to be done in class. The purpose of the assignment is to explore the student's previous knowledge about spectra and rainbows and to engage them in the exploration.
2. **Exploration with Prism and Light** is a two-part lab investigation. Part 1 investigates the light from a light bulb and Part 2 uses light directly from the Sun.
3. **Making Conclusions** should be completed immediately after the students complete **Exploration with Prism and Light.** The students can be working on this short-essay format conclusion outside of class while they are proceeding to the next exploration.
4. **Exploring Rainbows** is a computer-based activity that develops an understanding of rainbows and how they are formed. If students do not have access to computers, you can conduct a lecture/demonstration using materials from the web site.
5. **Rainbows-Revisited** is a journal assignment that asks the same questions as **Rainbows,** the opening journal assignment of this lesson. You can treat these as pre and post assessment tools.
6. **Prediction Reflection** (Appendix) to compare their predictions from **Rainbows** with their answers to the same questions from **Rainbows-Revisited** or they might choose the prediction from the **Exploration with Prism and Light**.
7. **Inquiry Reflection - Prisms and Rainbows** This reflection is designed to focus the attention of your students on the process and elements of inquiry.

LESSON 3 – EXPLORING SPECTRA

Students will develop the understanding that elements emit light in a distinct spectrum that can be used to identify the elements and that this information can be used to identify the composition of complex light sources like stars. Students will expand on their understanding of the visible light spectrum. Student assignments are:

1. **Student Lab Investigation** investigates the properties of spectroscopes and uses spectroscopes to investigate a variety of light sources. Students will need the **Spectra Data Sheet** to record data.
2. **Making Conclusions – Spectra** asks students to interpret the data obtained in the investigation.
3. **Analysis of Stars** is an application and extension of the knowledge gained in the investigation.

LESSON 4 – GETTING HOTTER?

Students will discover the existence of non-visible light, infrared light, outside of the visible light spectrum and the use of infrared light in science. Students will also develop experimental techniques useful for further exploration of the light spectrum. Student assignments are:

1. **How Are Parts of the Spectrum Different?** is a journal assignment to engage your students in thinking about characteristics of the spectrum. Their ideas will be used in Lesson 6 to develop an inquiry of their choosing.
2. **Laboratory Investigation** is a formal lab to determine whether different colors in the light spectrum heat objects differently.
3. **Data Sheet** is used to record data.
4. **Conclusions** requires the student to write a thoughtful, short essay that answers the central question of the lab.
5. **Prediction Reflection** (Appendix) will allow the students to reflect upon the prediction they made at the beginning of the Laboratory Investigation.
6. Reading Assignment "Seeing Our World in a Different Light" at http://sirtf.caltech.edu/Education/IRapp/intro.html.
7. **Inquiry Reflection – Getting Hotter** This reflection is designed to focus the attention of your students on the process and elements of inquiry.

LESSON 5 - MYSTERY LIGHT

Students will develop research techniques useful for further exploration, using models developed in previous lessons. Students will design their own experiment to explore the conditions under which special beads change color. Since these beads actually change in the presence of UV light, this lesson will allow them to discover the existence of another non-visible light, ultraviolet light, outside of the visible light spectrum. Students will also learn how ultraviolet light is used in science. Peer Review is introduced as a tool to aid in experimental design. Student assignments are:

1. **Students Investigation Procedure and Guide Questions** is a laboratory investigation that provides the problem to be solved by the investigation and leaves the design of the investigation to the student.
2. **Peer Review in the Science Classroom** (Appendix) provides a process to aid the students in the development of more effective designs for inquiry.
3. **Lab Report Format**, **Journal Article Format**, and **PowerPoint/Webpage/Poster Presentation** (Appendix) are three different formats students can use to present the results of their investigation.
4. **Prediction Reflection** (Appendix) asks your students to reflect upon their process, their thinking, what went right, and what they would improve.
5. **Reading Assignment** "Electromagnetic Spectrum" and "How Astronomers Use the Electromagnetic Spectrum" on the *STP Education* website at http://stp.gsfc.nasa.gov.

LESSON 6 – INDEPENDENT INVESTIGATION

Students will develop a question about light spectra and design their own experiment to answer the question. Peer Review is used as a tool to aid in experimental design. Student assignments are:

1. **Independent Investigation** is a laboratory investigation in which the students provide the problem to be solved by the investigation, design the investigation, use Peer Review to refine the design, conduct the investigation, and communicate their results.
2. **Peer Review in the Science Classroom** (Appendix) provides a process that aids the students in the development of more effective designs for inquiry.

3. **Lab Report Format**, **Journal Article Format**, and **PowerPoint/Webpage/Poster Presentation** (Appendix) are three different formats from which you can choose for students to communicate the results of their investigation.
4. **Prediction Reflection** (Appendix) asks your students to reflect upon their process, their thinking, what went right, and what they would improve.

APPENDIX

The Appendix contains supporting resources, including sources for materials and a bibliography.

1. **Exploring Spectra – Constructing a Spectroscope** provides directions for making your own spectroscope from a shoebox or paper tube.
2. **A Modified Ritter Experiment: Discovering Ultraviolet Light** is an alternative activity for Lesson 5 and a resource for you to see an "ideal" investigation for the discovery of UV light.
3. **Prediction Reflection** is an activity to help students think about how they solve problems.
4. **Lab Report Format** provides a structure and rubric for a traditional lab report.
5. **Journal Article** provides a format and rubric for a journal article presentation
6. **PowerPoint©/Webpage/Poster Presentation** provides a structure and scoring for a third type of student presentation of results.
7. **Peer Review in the Science Classroom** gives the guidelines and rationale for using peer review in inquiry science.
8. **Independent Investigation** provides a structure and timeline for independent inquiry
9. **5Es** is a useful chart showing the 5Es of Constructivism (Engage, Explore, Explain, Extend, and Evaluate) and the types of activities representative of each E.
10. **Supplies and Vendors**
11. **Bibliography**

Benchmarks for Science Literacy (Bold print indicates essential Benchmarks or part of Benchmark)

Chapter 1, The Nature of Science

B. Scientific Inquiry

Grades 6-8

- **Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.** 1B/1 (6-8)
- If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables. It may not always be possible to prevent outside variables from influencing the outcome of an investigation (or even to identify all of the variables), but collaboration among investigators can often lead to research designs that are able to deal with such situations. 1B/2 (6-8)

Grades 9-12

- Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories. 1B/1 (9-12)
- **Sometimes scientists can control conditions in order to focus on the effect of a single variable.** When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns. 1B/3 (9-12)

Chapter 3, The Nature of Technology

A. Technology and Science

Grades 6-8

- **Technology is essential to science for such purposes as access to outer space and other remote locations**, sample collection and treatment, measurement, data collection and storage, computation and communication of information. 3A/2 (6-8)

Chapter 4, The Physical Setting

A. The Universe

Grades 9-12

- **The stars differ from each other in size, temperature, and age, but they appear to be made up of the same elements that are found on the Earth and to behave according to the same physical principles**. Unlike the Sun, most stars are in systems of two or more stars orbiting around one another.
- **Increasingly sophisticated technology is used to learn about the universe. Visual, radio, and x-ray telescopes collect information from across the entire spectrum of electromagnetic waves**; computers handle an avalanche of data and increasingly complicated computations to interpret them; space probes send back data and materials from the remote parts of the solar system; and accelerators give subatomic particles energies that simulate conditions in the stars and in the early history of the universe before stars formed. 4A/3(9-12)

E. Energy Transformation

Grades 9-12

- When energy of an isolated atom or molecule changes, it does so in a definite jump from one value to another, with no possible values in between. The change in energy occurs when radiation is absorbed or emitted, so the radiation also has distinct energy values. As a result, **the light emitted or absorbed by separate atoms or molecules (as in a gas) can be used to identify what the substance is.** 4E/5 (9-12)

F. Motion

Grades 6-8

- **Light** from the sun **is made up of a mixture of many different colors of light, even though to the eye the light looks almost white.** Other things that give off or reflect light have a different mix of colors. 4F/1 (6-8)

- **Something can be "seen" when light waves emitted or reflected by it enter the eye**—just as something can be "heard" when sound waves from it enter the ear. 4F/2 (6-8)
- **Human eyes respond to only a narrow range of wavelengths of electromagnetic radiation—visible light. Differences of wavelength within that range are perceived as differences in color.** 4F/5 (6-8)

Grades 9-12

- Accelerating electric charges produce electromagnetic waves around them. **A great variety of radiations are electromagnetic waves: radio waves, microwaves, radiant heat, visible light, ultraviolet radiation, x rays, and gamma rays.** These wavelengths vary from radio waves, the longest, to gamma rays, the shortest. In empty space, all electromagnetic waves move at the same speed—the "speed of light." 4F/3 (9-12)

National Science Education Standards- Content:
(Bold print indicates essential Standard or part of Standard)

Grades 5-8
Science As Inquiry-Understanding About Scientific Inquiry

- **Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.**
- **Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories.** The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.
- **Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.**

Physical Science – Transfer of Energy

- **Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object--emitted by or scattered from it--must enter the eye.**
- The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. **The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.**

History and Nature of Science – Science as a Human Endeavor

- Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity--as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

History and Nature of Science – Nature of Science

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.

History and Nature of Science – History of Science

- Many individuals have contributed to the traditions of science. Studying some of these individuals provides further understanding of scientific inquiry, science as a human endeavor, the nature of science, and the relationships between science and society.

Grades 9-12

Science as Inquiry – Abilities Necessary to do Scientific Inquiry

- COMMUNICATE AND DEFEND A SCIENTIFIC ARGUMENT. **Students in school science programs should develop the abilities associated with accurate and effective communication. These include writing and following procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments.**

Physical Science- Interactions of Energy and Matter

- Electromagnetic waves result when a charged object is accelerated or decelerated. **Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays.** The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.

- **Each kind of atom or molecule can** gain or **lose energy only in particular discrete amounts and thus can** absorb and **emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.**

Teaching Methodology

Philosophy

It is constructive to begin with the basic assumption about our students that they are innately curious- that they want to learn, discover, and create. This doesn't mean that they are curious about chapter one of a science book, but that learning normally originates from a desire to know as much as a need to know. Recognizing that people learn through a variety of modes (aural, oral, visual and kinesthetic), we attempt to engage their problem solving in as rich an experiential matrix as possible. Learning can be described as the interaction between the self and an experience that brings about a change. There must be an experience, and, while this could include a lecture or a reading, the greatest interaction occurs when an individual is engaging more of the learning modes. It also helps if the person desires and needs to know. The richer the experience is, the richer the interaction will be, and the more substantial the change will be. With this approach our language of teaching changes from controlling, molding, giving, ... to enhancing, opening, challenging, nourishing, guiding, ... (See Science Teaching Standards-Changing Emphasis, p52 NSES)

Learning Environment

It is essential to create an environment in which our students are active participants in the learning process. In this environment the students are the essential workers in the educational process. They construct, discover, and develop central concepts. They create and solve problems. They read, write, talk, think, pose questions, and solve problems. They observe and manipulate aspects of their environment, and in the manipulation, confront problems about which they think, talk, write, and read. They take risks. Students exhibit the ability to learn how to learn. Students exhibit understanding of the central concepts and competence with the essential skills in a problem-solving environment. Students exhibit competence in individual and group problem solving. Students exhibit a willingness to accept different kinds of solutions to the same problem. They exhibit a willingness to work with other students outside of class.

Within this changing emphasis the teacher is committed to presenting learning experiences, not necessarily information, and to using open-ended questions whenever appropriate. Teachers guide the experience. Teachers define the problem field, and sometimes define the central question. This does not mean that teachers do not ever give information. The criterion, it seems, must be, "Is this information closing down investigation or enabling and enhancing investigation; is it giving the answer or providing the framework in which questions can be asked, problems posed and investigation begun?" Teachers respect the student's ability to solve problems. Whenever we give an answer, we run the *risk* of communicating that we believe the student is incapable of solving the problem. Teachers praise careful thought and process publicly and often, recognizing the risks taken. Teachers encourage different problem-solving techniques and the involvement of as many different learning modes as a student needs. Teachers also encourage students to develop problem-solving techniques that are weaker than their preferred style. For example we encourage intuitive problem-solvers to marry analysis to their intuition, and we encourage analytical problem-solvers to use intuition.

Inquiry

"Students … should be provided opportunities to engage in full and in partial inquiries. In a full inquiry students begin with a question, design an investigation, gather evidence, formulate an answer to the original question, and communicate the investigative process and results. In partial inquiries, they develop abilities and understanding of selected aspects of the inquiry process. Students might, for instance, describe how they would design an investigation, develop explanations based on scientific information and evidence provided through a classroom activity, or recognize and analyze several alternative explanations for a natural phenomenon presented in a teacher-led demonstration." (NSES, p143) This unit is designed to help students become more proficient within the inquiry process as well as to learn specific content. Make the structure of the unit explicit for your students; discuss the structure and the modeling of inquiry process as you progress through the unit. The first lesson involves the student in partial inquiry with a great deal of structure. The teacher manipulates the experimental tools, questions are provided for students, and the analysis of data is guided by questions that require short answers. In Lesson 2 students follow directions that require them to manipulate equipment themselves. Guide questions are provided in the Observation part of the investigation, but the student is required to provide more of the problem-solving structure in the Conclusion than they did in Lesson 1. Modeling of experimental technique and of problem-solving process is provided throughout the unit allowing the student to become more responsible for the inquiry process. In the final lesson the student provides the question, the design for the inquiry, the planning, the execution of the inquiry and the communication of results.

Unique Assignments to Promote Inquiry and Learning Strategies

Several types of assignments are used in this unit that may be unfamiliar to your students. Journals, Predictions, Prediction Reflections and Peer Review are powerful tools that can enhance the learning experience for your students in any inquiry.

Journals

Although there are journal assignments in this unit you are encouraged to make more assignments. The journal assignments in this unit are designed to engage your students in the problem presented by the lesson and to reveal your students' preconceptions about the concepts before instruction. In addition, in Lesson 2 the journal assignments can be used as pre-test/post-test evaluations of student understanding. You can assign intermediate journal entries to monitor student progress and to help your students organize their thoughts. Many teachers use journal reflections as a regular part of the daily schedule. Students enter the room, get their journal from a central location, and respond to a question the teacher has provided. The question is connected to the day's activity. Students begin work immediately, and the teacher completes administrative chores while the students are working.

Journals are evaluated on the basis of careful thought. The emphasis should not be on the correctness of an answer. You want to know what your students are thinking, not what they think you want them to think. Because of the role of the journal assignments included in this unit, you need to read each student's entry. For other entries you can decide to read each, or read one from each team. In some cases teachers have asked each student to identify one for each week she/he wants the teacher to read. Teachers can then scan the others.

Predictions

Students may not have much experience making predictions formally. Ask them to think about what they know - what experiences they have had to guide them. Physics Education Research (PER) has shown that student performance and investment are enhanced when they make predictions. Stress to your students that their predictions will not be graded except for completion and the thoroughness of their answers. Do stress, however, that the predictions are important.

Prediction Reflections

Research also indicates that students can learn to learn more effectively if you ask them to reflect upon their predictions after they complete the activity. A Prediction Reflection assignment is provided in the Appendix that can be used after any exploration in which the students make predictions. Introduce the Prediction Reflection to students before they start the prediction, and tell them a Prediction Reflection will be an assignment later on. Ask them to be aware of their reasons for making each prediction in preparation for this assignment.

Peer Review

Many scientists, engineers, and businesspersons use peer review to improve the quality of their efforts. Some review is evaluative. One person or team presents and defends a business plan or the results of an investigation to peers who critique the work. Many groups use a more informal review to assist in the planning stages. It is this formative review that is used in this unit. The benefits to the presenter and to the reviewers are explained in the guidelines in the Appendix.

Materials

Lesson 1

- 5 pieces of large sized colored construction paper (one each of red, blue, green, white and black)
- Red, blue and green gels (gelatin filter), Wratten filters or cellophane (your theater department may help you obtain the gels, and they are available in art supply stores)
- An overhead projector, 3 slide projectors or powerful flashlights with the colored gels or cellophane fixed securely over the lens. You may also use red, blue, and green floodlights from a hardware store.
- A very large (3'x5') sheet of white paper, white wall, or a white board
- A dark room

(You may wish to run this exploration as a small group activity. In that case you will need 3 flashlights for each group and small size gels or cellophane for each group.)

Lesson 2 – Exploration with Prism and Light
- An equilateral glass prism per group (see Appendix for source)
- White paper per group
- Colored pencils or crayons per group
- Overhead projector, slide projector or strong flashlight per group
- A dark room for first part of activity
- Copier paper box per group

Lesson 2 – Exploring Rainbows
- Computer with Internet connection
- Water glass
- Flashlight, or other directed beam of light
- Round-bottomed flask, or some spherical glass container (a round fishbowl would work)
- Small piece of cardboard or poster board that fits over the head of the flashlight
- 10"x14" piece of white poster board

Lesson 3
- Spectroscopes for each group or spectroscope kits or materials for the shoebox spectroscope (see **Exploring Spectra – Constructing a Spectroscope:** Appendix)
- 1 CD per group- use old CDs such as promotional CDs
- 1 or 2 Spectrum tube power supplies (see Appendix for source)
- Spectrum tubes – at least hydrogen, helium, neon (see Appendix for source)
- Incandescent light bulb and lamp (60W)
- Fluorescent (mercury) light source
- 1 or 2 microscopes – low power or dissecting
- Periodic Table of the Elements (individual or large display)
- Crayons or colored pencils- full set per group
- A fairly dark room
- Spectrum glasses – optional (see Appendix for source)

Lesson 4

- Equilateral **glass** prism per group (see Appendix for source)
- Prism holder (optional) per group
- 3 alcohol thermometers per group (see Appendix for source)
- Tape per group
- Cardboard box per group (a photocopier paper box works very well)
- Black spray paint (black marker will work)
- White paper for bottom of box per group
- Scissors per group

Lesson 5

- 15 special (UV) beads per group (see Appendix for source)
- 5 dark film canisters per group
- Equilateral **glass** prism per group (see Appendix for source)
- Prism holder (optional) per group
- Tape per group
- Cardboard box per group (have available the copier paper boxes used in **Getting Hotter?**)
- Equipment to be determined by group

Lesson 6

- To be determined by groups