Module Overview

The concepts covered in *Light* closely correspond to those in the National Science Education Standards for grades 5–8. The focus of this module is the nature of light and how light interacts with matter. Throughout the module, students engage in a series of inquiries carefully designed to develop their understanding of the nature of light, the science of optics, and how knowledge of these is applied to the development of optical devices.

Student knowledge is built up through a carefully planned sequence in which one concept and experience builds on another. As students progress through the module, they take greater responsibility for their own learning, eventually planning and conducting their own procedures, devising their own data tables, and analyzing the results they obtain. Therefore, the module should be taught as a complete unit. It is not intended for use as a sourcebook of occasional experiments.

The module is divided into three parts: The Nature of Light, Reflection and Refraction, and Using Light. The concepts taught in this module are summarized in the Conceptual Sequence flow chart for *Light* (page xxx).

PART 1 THE NATURE OF LIGHT

In Lesson 1, students briefly explore some aspects of the nature of light by conducting a series of short, simple inquiries. These inquiries provide both students and teacher with the opportunity to discuss some of students' existing ideas about light. Lesson 1 also acts as an informal preassessment to the module. Students draw up a list of questions based on this lesson that they refer back to and attempt to answer as they proceed through the module. This process gives them ownership of their learning and acts as a useful formative assessment process.

In Lesson 2, students investigate light sources and the production of light through a variety of energy transformations. In Lessons 3, 4, and 5, students investigate the way light travels in air and water, how light spreads out as it moves from a light source, and how these aspects of the nature of light relate to the nature and size of shadows produced when opaque objects block light. The problems encountered measuring the speed of light are discussed in some detail.

Students construct a pinhole camera in Lesson 6 and use their knowledge of the way light travels and simple ray optics to explain how the pinhole camera works.

Lesson 7 introduces students to the concept of a scientific model using two possible models for light—a particle (photon) model and a wave model. Students use ball bearings and water waves (in a simple ripple tank) to model the transfer of energy by light—including the rectilinear propagation of light, light spreading out from a source, and the formation of shadows.

In Lessons 8–12, students investigate the phenomenon of color. They split white light into its component colors, first by using a prism and then a diffraction grating. They relate their observations to the wave model for light. Students discuss the wider electromagnetic spectrum and investigate the behavior of infrared. Students construct a spectroscope to examine spectra from a variety of light sources and discuss how emission and absorption spectra are used in the science of spectroscopy. They also examine how color filters alter the spectrum of white light and investigate additive and subtractive color mixing.

Lesson 13 is an assessment for the first part of the module. It consists of both a performance and a written assessment. In the performance assessment, students measure the size of a

shadow produced on a white screen by a square of paper. After collating their data in a table of their own design, they use diagrams and words to explain their results. Most of the written part of this assessment requires students to apply their skills and knowledge to interpret diagrams and data.

PART 2 REFLECTION AND REFRACTION

In Lessons 14, 15, and 16, students investigate reflection from mirrored surfaces. In Lesson 14, they make general observations about reflections in plane mirrors and then investigate the position and nature of an image in a plane mirror. In Lesson 15, students investigate the reflection of a ray from the surface of a plane mirror and collect data, from which they formulate their own law of reflection. They use their law of reflection to manipulate reflection of a ray from a number of mirrors, build a periscope, and understand the formation of a virtual image. In Lesson 16, students use a flexible mirror to observe reflection from concave and convex mirrored surfaces. Students then investigate the reflection of multiple rays from these surfaces and discuss the nature of the images formed by them.

In Lesson 17, students commence their inquiries into refraction by making observations through a transparent block and then investigate (and make measurements of) the behavior of a ray as it enters and leaves the same block when the ray enters the block at different angles of incidence.

Lesson 18 focuses on convex and concave lenses. Students describe the nature and position of images they produce using convex lenses of differing focal lengths and then investigate the behavior of rays as they pass through these lenses. Students then devise their own investigation of a concave lens. Students are offered simple explanations of the formation of images by these lenses.

In Lesson 19, students return to the particle and wave models they used in Lesson 7. After reviewing the models, they use them to model reflection and refraction. Students evaluate the models (comparing them with the behavior of light) and discuss their usefulness and the historical development of the two models.

Lesson 20 is the assessment for Part 2 of the module. Students conduct a performance assessment in which they investigate the nature and focal lengths of the lenses in a simple magnifier. The written assessment consists of objective test items. Together these assessments test the knowledge, concepts, and skills developed in Parts 1 and 2 of the module.

PART 3 USING LIGHT

In this final part of the module, students use the knowledge and skills they have acquired in Parts 1 and 2 to investigate a variety of optical devices—from a telescope to the human eye.

Lesson 21 is an introduction to the Anchor Activity. The Anchor Activity requires students to investigate the function, construction, and history of an optical device—such as a microscope or fax machine. Students combine the knowledge they have gained during the course of the module with information collected from their own observations of the device, the library, and the Internet to produce a visual aid—poster, web presentation, or PowerPoint™ presentation—and make an oral presentation (at the end of the module).

In Lesson 22, students are challenged to construct a telescope from lenses and other materials. Students test, compare, and explain their telescope designs. In Lesson 23, students

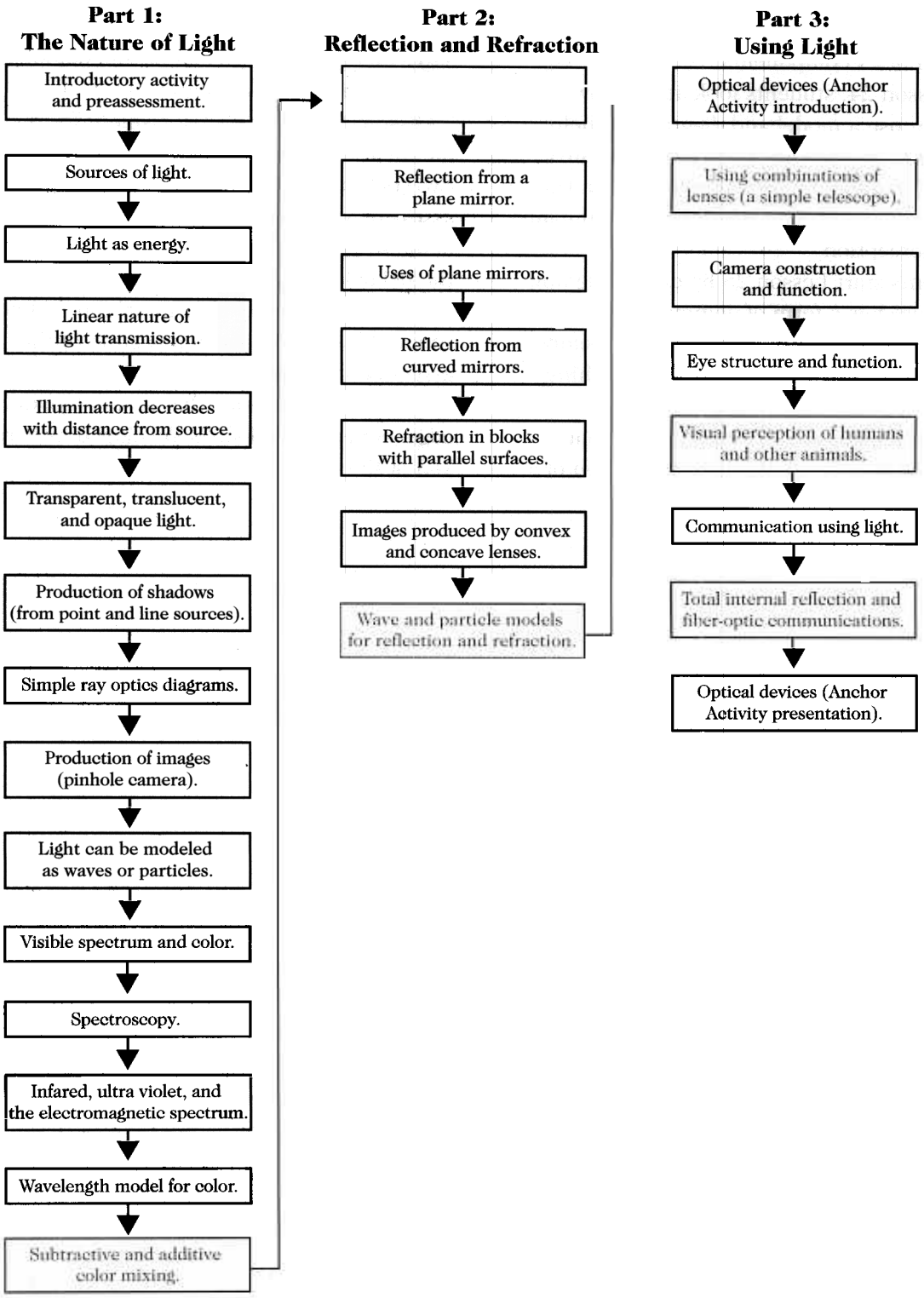
dissect a disposable camera and use their knowledge of optics to describe and explain the function of its components.

In Lesson 24, students look at their own eyes and then use a model and diagrams to help them explain how the eye works. They investigate and discuss depth perception and a variety of optical illusions and relate these to human visual perception.

Students start Lesson 25 by discussing how light is used as a form of communication. They discuss and investigate its limitations before observing what happens when light is shined along an optical fiber. Students investigate how light travels along the fiber and observe a demonstration of total internal reflection of a very low-powered laser in a light tube. They devise their own codes for transmitting messages along a fiber-optic cable and demonstrate these to the rest of the class.

Lesson 26 is the final assessment for the module. Like the other assessments, it consists of two sections—a performance and written assessment. In the performance assessment students work in pairs to investigate and explain the behavior of light as it is reflected and transmitted out of a shiny aluminum can and down a spout of water. The written section of the assessment consists of objective test items and short-answer questions that assess the knowledge, concepts, and skills developed in Parts 1–3 of the module.

Conceptual Sequence for *Light*



Module Structure

Light includes a Teacher's Guide, a Student Guide, and a master Materials List. Following are brief descriptions of the major components in the Teacher's Guide and in the Student Guide. The master list of materials for the module begins on page xxxviii.

TEACHER'S GUIDE

The Teacher's Guide for *Light* includes 26 lessons. The shortest lesson can be completed in one 45-minute class period, and the longest takes three to four periods. Lessons may be taught in a 45-minute class period or in back-to-back periods to accommodate block scheduling. Block scheduling requires less time for materials management and allows more time for class discussion and extensions.

This module takes a hands-on, inquiry-based approach. Most of the lessons follow this general format:

- an introductory section called "Getting Started," which often involves a brainstorming session or short introductory inquiry
- one or more inquiries done by students
- a reflections section, which usually involves a class discussion and is designed to encourage students to reflect on the results of the inquiries and to help you determine whether students have grasped the concepts and skills addressed in the lesson

The Teacher's Guide contains general information on teaching the module. It also includes information on the science concepts that apply to each lesson, materials and their management, assessments, homework assignments, and extension activities.

Each lesson in the Teacher's Guide contains the following components:

Lesson Number and Title

Inquiries The number of inquiries in the lesson.

Periods The suggested duration of the lesson. (It is assumed that one class period is 45 minutes.) The duration suggested usually consists of a range of time (two to three periods, for example).

Overview This section is a brief introduction that gives the context for the lesson. It provides a thread between the previous lesson and upcoming lessons. It also briefly outlines what students will do in the lesson.

Concepts This section lists the major concepts covered by the lesson. Many of the concepts can be found in the National Science Education Standards.

Student Objectives This section lists what students are expected to accomplish in the lesson.

Background This section discusses science information that relates to the content of the lesson. It is intended to provide teachers who are unfamiliar with the subject covered by the lesson the necessary background for answering student questions and facilitating inquiries. It also contains information about common student misconceptions.

Reading Selections This section provides a short summary of the reading selections provided within the lesson. Reading selections take two forms. Those that relate directly to concepts central to the lesson are printed in the

Student Guide in blue and occur within or between the text of the inquiries. Additional readers are provided at the end of most lessons. These cover supplemental information that support the inquiries, meet standards not addressed through inquiry, and provide links to other subjects. Many of these readers are used as homework and extension suggestions.

Student Misconceptions This section provides a list of common student misconceptions. Its purpose is to alert the teacher to common misconceptions students may have about topics or concepts central to the lesson.

Materials This section lists the materials needed for the lesson.

Preparation This section lists preliminary steps to be taken before beginning the lesson. Preparation may include photocopying student sheets, preparing transparencies or newsprint, collecting additional items of equipment not included in the kit, preparing solutions, or setting out and testing equipment. It is assumed that the teacher will replace consumables when necessary.

Getting Started This section introduces the lesson to students. It encourages students to begin thinking about the topic of the lesson and allows the teacher to assess students' preexisting ideas about the topic.

Inquiry Title Most lessons contain more than one inquiry. Each inquiry has its own procedure.

Procedure This section gives step-by-step directions for doing the inquiries.

Reflections In this section, students reflect on their inquiry results and discuss how the concepts encountered in the lesson can be applied to situations outside the classroom. Extensions listed after each lesson have students relate what they have learned to different fields of study.

Homework This section lists homework assignments that relate to either the current or the next lesson. Many of the homework assignments are tied to the reading selections provided in the Student Guide.

Extensions This section outlines activities designed to extend students' experience of the lesson topic not only into other fields of science but also into other curriculum content areas. They provide an opportunity for you to work cooperatively with teachers from other content areas to construct a more integrated curriculum.

Assessment This section lists methods for assessing students for each lesson. Teachers may assign point values in keeping with their regular grading schemes. When the lesson itself is designed as an assessment, scoring rubrics are provided.

Preparation (for later lessons) This section gives teachers information about preparing for subsequent lessons. It appears only when teachers need to prepare items more than one day in advance. Teachers should check materials requirements more than one day before the lesson is to be taught.

Inquiry Masters Inquiry masters are reproducible sheets (for example, the Protractor Paper used in Lessons 15, 17, and 19) that are not student sheets. They may be used by groups of students, or the teacher, during the course of the module.

Student Sheets Student sheets are an essential part of the module. Students use them to record data, write their interpretations of results, and answer questions about the concepts covered in the inquiries. It is assumed that teachers will make copies of the master student sheets before each lesson. Some student sheets are homework assignments, reviews, and assessments.

STUDENT GUIDE

The Student Guide and the Teacher's Guide closely complement each other. Because the Student Guide is intended to be used in conjunction with the Teacher's Guide, it does not work as a stand-alone textbook. It provides instructions and guiding questions for each lesson. It also includes reading selections that relate to the topic of the lesson. Instructions for assessment lessons are included.

The lessons in the Student Guide correspond with those in the Teacher's Guide and include the following components:

Lesson Number and Title

Introduction This section places the concepts addressed in the lesson in context with concepts from previous lessons. It also provides a brief preview of the lesson. Some introductions include background information to draw students into the topic to be investigated.

Objectives for This Lesson This section lists what students are expected to accomplish by the end of the lesson. To maintain a constructivist approach, the objectives in the Student Guide are worded differently than those in the Teacher's Guide.

Materials This section specifies the size of the group in which students will be working as well as the materials required.

Getting Started This section encourages students to focus on the concept being introduced in the lesson. It may include a group or class brainstorming session on what they already know about the topic or a series of questions that form the basis for a short group or class discussion.

Inquiry Title The inquiry title tells students what they will be exploring. Many lessons contain more than one inquiry.

Procedure This section includes step-by-step instructions that students follow to complete the inquiry and to explore the concepts of the lesson more fully.

Reflecting on What You've Done In this section, students reflect on the results of the inquiries as well as revisit and modify the ideas they expressed in "Getting Started." They may also apply what they have learned to new situations.

Readers Most lessons have one or more readers. Some readers provide background information that further explains or develops the concepts covered in the lesson. They are printed in blue. Others address these and additional concepts listed in the National Science Education Standards. Most readers develop these concepts in the context of the world outside the laboratory. They are designed to increase student awareness of the application of scientific principles by providing a wider historical and cultural perspective for their use in technology.