Module Overview

Students of all ages, but particularly those in middle school, have innate curiosity about the world around them and its ever-changing natural processes. *Catastrophic Events* taps this curiosity by helping students clarify what they already know about the earth's natural catastrophic events and giving them an opportunity to perform a series of engaging hands-on activities through which they extend and enrich this knowledge.

Each lesson in this module builds on skills and concepts presented in previous lessons. 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 should not be used as a sourcebook of occasional experiments.

Catastrophic Events is divided into three parts: Storms, Earthquakes, and Volcanoes. A conceptual sequence chart for the module appears on page xxix.

PART 1 STORMS

Lesson 1 is a preassessment for the module. Using a concept map as a visual organizer, students share what they already know about natural catastrophic events and list questions they have about them. Students then use a globe and a world map to locate places on the earth where they think storms, earthquakes, volcanoes, and other natural catastrophic events are most likely to occur. They also discuss why they think these events occur in such places.

Lesson 2 is an introduction to storms. Students begin by focusing on what they know and want to know about the causes and effects of storms. They use cylinders of water to simulate the vortex of a storm and discuss possible causes of this circular movement. Finally, they view a short video showing hurricanes and tornadoes.

In Lessons 3 and 4, students begin their investigations of heat and the natural processes that underlie storms. To examine what causes the vortex of a storm, students in Lesson 3 investigate, graph, and analyze the uneven heating and cooling rates of soil and water. In Lesson 4, they manipulate the temperature inside a clear cylinder to investigate the effect that surface temperature has on the temperature of air above it. Using smoke as a flow indicator, students also investigate the effect that surface temperature has on airflow. In Lesson 5, having observed stable and unstable air masses in individual cylinders, students connect two cylinders and observe the formation of convection currents. Then they relate their observations of air movement in the lab to weather fronts and the formation of winds.

In Lessons 6 and 7, students move from observing local convection currents to examining the formation of storms on a global scale. In Lesson 6, they use sealed bottles of water to investigate the conditions under which water evaporates and condenses. They manipulate the air pressure in these closed systems to determine the effect of high- and low-pressure systems on cloud formation. Then they apply their observations to weather maps and draw conclusions about the conditions under which clouds and storms form and move. In Lesson 7, students apply their understanding of heat and convection to the conditions under which oceans gain heat energy and form currents. After exploring the effects of water temperature and winds on the movement of water, they plot major ocean currents to determine their influence on global weather patterns.

Lesson 8 is the first of three formal assessments in this module. The assessment has two parts. The first part is a performance-based

assessment in which students observe the movement of a paper helix over a hot lamp and relate their observations of the moving helix to the concepts they explored in Lessons 2 through 7. In the second part of the assessment, students complete a series of selected- and constructed-response questions. Many of these questions challenge students to analyze illustrations of processes or concepts introduced in Storms. Students also update and revise their concept maps at this time.

THE ANCHOR ACTIVITY

Lesson 9 introduces students to the *Catastrophic Events* Anchor Activity, which focuses on the risks associated with catastrophic events and challenges students to think about catastrophic events from social and personal perspectives. The Anchor Activity is a research project during which students work in groups to gather information about a particular catastrophic event, organize their findings, and present them to the class at the close of the module. Groups examine the cause of the event they have chosen to research, its impact on society and on individuals, and the lessons that people have learned from the event that can help reduce the risks associated with similar events in the future. Students are encouraged to use a variety of print, audiovisual, and on-line resources in their research.

PART 2 EARTHQUAKES

As Part 2: Earthquakes begins, students use their concept maps and world maps as the basis for a review of what they know and want to know about the causes, effects, and locations of earthquakes. Students then watch a video that shows actual earthquakes and discuss the kinds of destruction earthquakes can cause.

Lessons 11 and 12 focus on earthquake waves. Using a large metal spring, students model waves in Lesson 11. They examine the ways in which energy from an earthquake travels and anayze how earthquake waves affect ground motion. Students then design and build model structures resistant to shaking in order to demonstrate the importance of reducing the risks associated with earthquakes. In Lesson 12, students use a model seismograph to examine how the energy from earthquake waves is recorded. They then work with a replica seismogram recorded during a major earthquake that took place in Alaska in 1964 and investigate the methods scientists use to record earthquake waves. Using earthquake wave data recorded from three seismograph stations, students model the mathematical processes seismologists use to pinpoint the location of an earthquake epicenter.

In Lesson 13, students move on to the logical next step, which is to explore the relationship between the location of earthquake epicenters and the structure of the earth's surface. Using a data set that displays information on earthquakes that occurred worldwide over a 10-year period, they plot earthquake epicenters on a world map. As students analyze patterns in earthquake locations, they see the outlines of the earth's plates emerging on their maps. They then consider reasons why earthquakes occur along plate boundaries. These activities prepare students for Lessons 14 and 15, in which they use computer simulations to examine the earth's internal structure and investigate the interactions between plates and the movement along faults as a cause of earthquakes. At the end of Lesson 15, students analyze a relief globe to discover that landforms—mid-ocean ridges, mountains, and trenches—are among the constructive results of plate interactions.

With their new knowledge that plate movement causes most earthquakes, students begin Lesson 16 by addressing the question of why plates move. After considering possible causes, groups return to the concept of convection and use a flow indicator and a small candle to investigate the conditions under which opposing convection cells form. Students compare what they observe happening in the convective substance with computer images of the earth's mantle.

Part 2: Earthquakes ends with Lesson 17, which is the second formal assessment in the module. In the performance-based assessment, students design an experiment to investigate the difference between the way in which a model structure erected on loose soil and a structure built on packed soil will respond to shaking. Students then apply their observations to real-world situations. In the written assessment, students use knowledge and data-interpretation skills gained in the module to answer questions on such topics as plate movement, the earth's interior, earthquake locations, seismograms, and mountain building.

PART 3 VOLCANOES

Lesson 18, the first lesson in Part 3: Volcanoes, serves as an assessment of students' current knowledge about volcanoes and the relationships between volcanoes and other catastrophic events. Students watch two short videos, analyze the destructive and constructive effects of volcanoes, and learn how scientists work to reduce the risks associated with volcanic eruptions. Students then return to their concept maps and compare what they learned in the two videos with the ideas about volcanoes they recorded earlier. A homework assignment provides students with an overview of seven different catastrophic events and helps them explore the causes, effects, locations, and interrelationships of these events.

In Lessons 19 and 20, students use two different substances to simulate magma and lava flow and consider the constructive influences of volcanic materials on land formation. Students then use their experiences in the lab to create working definitions of the words "magma" and "lava." During Lesson 20, students classify photographs of nine volcanoes by type and analyze why the volcanoes are not all the same shape and size. Groups then work as a class to test the viscosity of several liquids and to analyze how adding a solid to a liquid or increasing the temperature of a liquid can change its viscosity. Students then examine how the viscosity of lava affects the formation of volcanoes.

In previous lessons, students investigated how the cooling of lava helps build volcanoes. In Lessons 21 and 22, students examine igneous rocks, which form when cooling molten rock crystallizes under or on the earth's surface. During Lesson 21, students use a magnifier to examine the properties of five igneous rock samples and classify the samples on the basis of color, mineral composition, and texture. During Lesson 22, students explore rates of crystallization and hypothesize, by analyzing crystalline texture, how three of the rocks investigated in Lesson 21 may have formed. Lesson 22 ends as students read to learn more about the rock cycle.

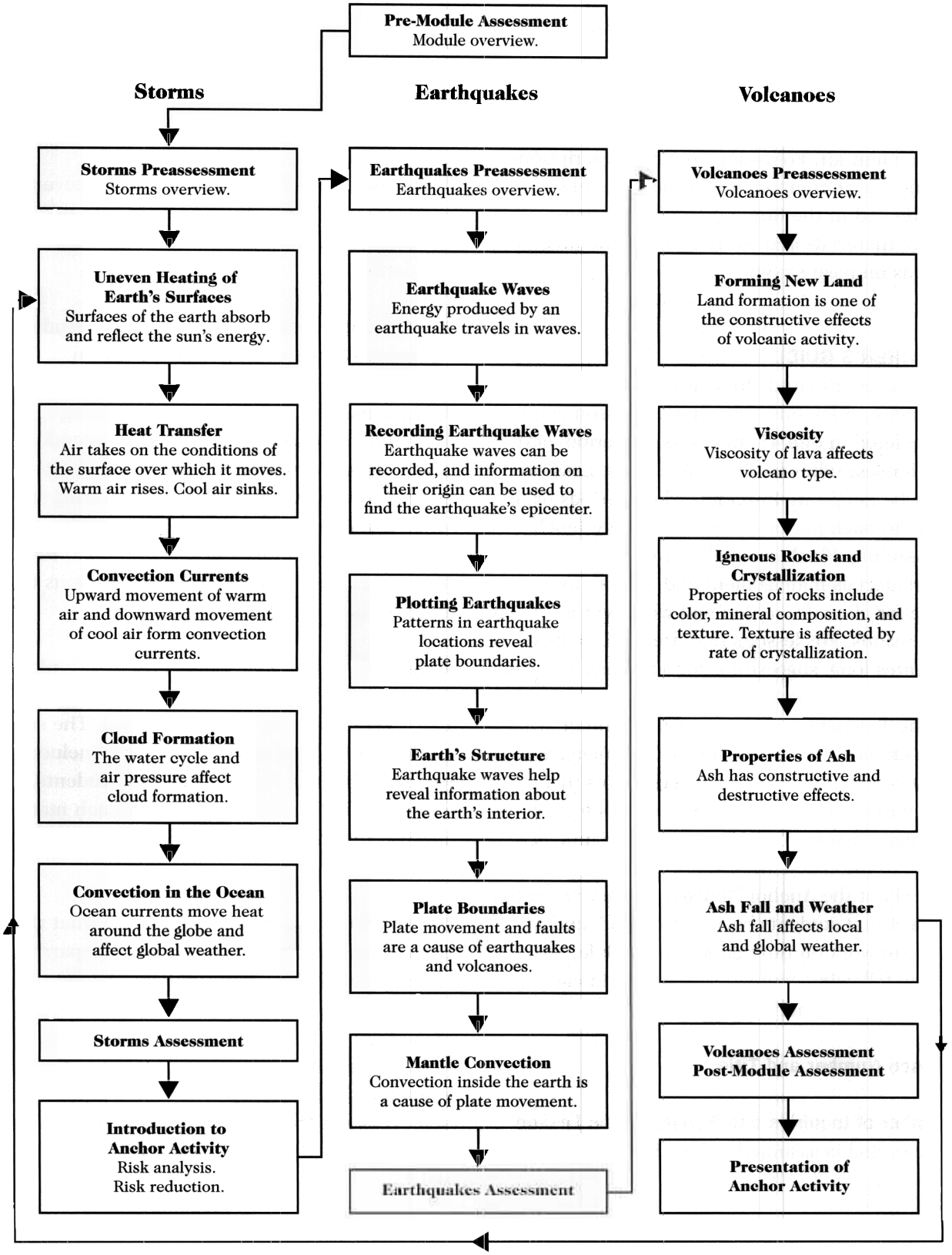
The next sequence of investigations focuses on the properties of rock fragments and the effects of ash fall. Lesson 23 begins as students brainstorm what they know and want to learn about ash. They then collect data on the properties of ash, including its hardness, settling rate, magnetism, texture, and appearance. In Lesson 24, students design their own experiments to simulate the eruption of pyroclastic ash. The concepts in the module come full circle as students collect data on ash fall and draw

conclusions about the effects of weather on ash fall and examine the constructive and destructive effects of ash fall on humans, the environment, and global weather.

The module ends with a comprehensive, three-part assessment in Lesson 25. In the first part of the assessment, students design and carry out an investigation in which they explore the effects of ash fall on the temperature of the earth's surface. Students must control variables, set up a data table to collect temperature and time data, record observations, graph data, and draw conclusions that relate to concepts and skills addressed throughout the module. In the second part of the assessment, students complete a series of higher-level thinking questions that address the concepts covered in Part 3: Volcanoes. Students then complete a post-module assessment that matches the pre-module assessment in Lesson 1. By comparing students' post-module thinking with their ideas from Lesson 1, teachers can assess each student's growth in understanding natural catastrophic events.

Catastrophic Events is a rigorous, engaging earth science module appropriate for students of middle school age. It addresses the skills and concepts deemed appropriate for grades 5 through 8 by the National Science Education Standards (see Appendix B). It allows students to experience phenomena that they find fascinating and exciting and that often make headline news: natural catastrophic events. By completing this module, students and teachers alike will develop a better understanding of the causes and effects of natural events and how these events help shape our world.

Conceptual Sequence for *Catastrophic Events*



Module Structure

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

TEACHER'S GUIDE

The Teacher's Guide for *Catastrophic Events* includes 25 lessons. The shortest lesson can be completed in one 45-minute class period, and the longest takes four to five periods. Lessons may be taught in 45-minute class periods 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 work on the extensions. For lessons that are more than 45 minutes long, suggestions for appropriate breaking points are made.

The Teacher's Guide contains general information on teaching the module. It also includes information about the science concepts that apply to each lesson, materials and their management, assessments, homework assignments, and extension activities. It also contains information about the Anchor Activity, a major research project that students begin in Lesson 9 and continue to work on throughout the module.

The following components appear in each lesson of the Teacher's Guide:

Lesson Number and Title

Number of Inquiries and Periods in the Lesson

One period is assumed to be 45 minutes.

Overview A brief introduction that puts the lesson in context. It provides a link between the current lesson and those that precede and follow it and outlines what students do in the lesson.

Concepts A list of the major concepts covered by the lesson. Many of the concepts are based on those in the National Science Education Standards.

Student Objectives A list of the things students are expected to accomplish in the lesson.

Background Detailed information relating to the content of the lesson. This section is intended to provide teachers who are unfamiliar with the lesson's content a foundation for answering student questions and facilitating inquiry. The Background section may also contain information about common student misconceptions that relate to the content of the lesson.

Materials A list of materials, presented under appropriate subheadings depending on the nature of the inquiry to be performed. The subheadings for lists of student materials include For Each Student, For Each Pair of Students, and For Each Group of 4 Students. Each materials list may also include a subsection entitled For the Teacher.

Preparation A list of steps explaining what the teacher must do prior to the lesson. Preparation may include photocopying student sheets, preparing transparencies or newsprint, collecting additional items of equipment not included in the kit, preparing solutions, assembling lab equipment, or setting up audiovisual equipment. It is assumed that the teacher will refill containers of chemicals and replace other consumables when necessary.

Getting Started A brief exercise or activity that introduces students to or provides the context for the lesson. In some cases, students first brainstorm what they already know about the topic. This encourages them to begin thinking about the topic of the lesson and allows the teacher to assess their pre-existing ideas.

Inquiry Number and Title Lessons may contain more than one inquiry. Each inquiry has its own number, title, and procedure.

Procedure A step-by-step guide for facilitating the inquiry. This section provides a carefully planned route through the lesson and complements the Procedure in the Student Guide.

Reflections A list of steps presenting guidance on how to provide closure for the lesson. Students may be asked to reflect on their inquiry results and discuss how the concepts encountered in the lesson can be applied to situations outside the classroom.

Homework Homework assignments that relate to either the current or the next lesson. Many of the assignments involve the reading selections that appear in the Student Guide. Additional homework can be assigned from the extensions (see below).

Extensions Activities designed to extend students' experience of the topic into other fields of science and other content areas. These activities provide the opportunity for science teachers to collaborate with colleagues from other content areas to ensure a more integrated curriculum.

Assessment A section that suggests methods for assessing students for each lesson. Teachers may wish to assign point values in keeping with their customary grading schemes. When a lesson itself is designed as an assessment, scoring rubrics are provided.

Preparation for [a subsequent lesson] Brief mention of preparation and/or materials needed for an upcoming inquiry when they must be prepared by the teacher in advance. It is suggested that teachers check materials requirements before each lesson is to be taught.

Inquiry Masters Reproducible sheets that include keys to the types of answers students may give in response to questions posed in an inquiry, transparency masters, suggested data tables and graphs, and scoring rubrics. These are generally for teacher use only. (See Appendix A for a complete list of inquiry masters.)

Student Sheets Reproducible worksheets that students use to record their ideas and interpret their data and to answer questions about the concepts covered in the inquiries. Student sheets may also be used for homework assignments, reviews, and assessments. Most lessons have at least one student sheet; some have several. Masters for these sheets appear at the end of each lesson in the Teacher's Guide. Teachers must photocopy sufficient quantities of them before each lesson. (See Appendix A for a complete list of student sheets.)

STUDENT GUIDE

The Student Guide is intended to be used in conjunction with the Teacher's Guide. The components in the Student Guide complement those in the Teacher's Guide. For example, both guides contain lists of student objectives, but the wording may differ slightly between the two volumes, as appropriate for teachers and for students. The materials lists are less detailed in

the Student Guide than in the Teacher's Guide. Some sections are unique to each guide; for example, Homework and Extensions are not included in the Student Guide, while reading selections do not appear in the Teacher's Guide. The two volumes are designed to be complementary, and the teacher needs both guides to facilitate inquiry.

Each lesson in the Student Guide contains the following sections:

Lesson Number and Title

Introduction A brief section of text that places the concepts included in the lesson in context with those that have preceded it and with the students' own experiences. It may also provide a brief preview of the lesson. Some introductions include background information to draw students into the topic to be investigated.

Objectives for This Lesson A list that outlines what the students are expected to accomplish by the end of the lesson.

Materials A list that specifies the size of the group in which the students will be working as well as the materials they will require.

Getting Started A brief exercise or activity that introduces students to the topic of the lesson. It may include a brainstorming session on what students already know about the topic or a series of questions or experiences that form the basis for a brief group or class discussion.

Number and Title of Inquiry

Procedure Step-by-step instructions that students follow to complete an inquiry or to explore the concepts of a lesson more fully. This section often contains questions that students discuss in their groups.

Reflecting on What You've Done A closing section that provides students an opportunity to think about, record, and discuss what they have learned in the lesson and to begin to apply what they have learned to new situations.

Reading Selections Readers—frequently accompanied by photographs and illustrations—that pertain to the content of the module or, more specifically, to that of a lesson. Most lessons in this module have one or more reading selections. A reading selection may provide background information that helps apply the concepts addressed in the lesson or it may introduce additional concepts from other areas of the National Science Education Standards. Most reading selections develop these concepts in the context of the world outside the laboratory. They are also intended to increase students' awareness of the history of science and technology.