Module Overview

Students of all ages, but particularly those in middle school, have an innate curiosity about our nearest neighbors—the Sun and Moon—and about the nine planets, their moons, and asteroids, comets, and meteoroids within our solar system. *Earth in Space* taps this curiosity by helping students clarify what they already know about the solar system and Earth as a planet and giving them the 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 increasing responsibility for their own learning. Eventually students plan and conduct their own procedures, devise their own data tables, and analyze the results they obtain. Therefore, the module should be taught as a complete unit. It should not be used as a sourcebook for occasional experiments.

Earth in Space is divided into three parts: Sun-Earth-Moon System, Solar System, and Earth's History as a Planet. A conceptual sequence chart for the module follows.

PART 1 SUN-EARTH-MOON SYSTEM

Lesson 1 is a premodule assessment. Students share what they already know about Earth in space and the solar system and then list any questions they have about them. Students then use a series of 10 questions and photographs to generate a discussion about their understanding of the solar system, allowing them to examine their own preconceptions about the solar system and Earth as a planet, and give them an opportunity to revisit their ideas throughout the module.

Lesson 2 serves as an introduction to the Sun-Earth-Moon system. Students begin by focusing on what they know and want to know about the Sun, Earth, and Moon as a system. They use spheres to represent the relative sizes of the Sun, Earth, and Moon and demonstrate to the class four things that they know about each of these solar system bodies. Students revisit this activity in Lesson 9 to gauge their growth in understanding.

In Lessons 3 and 4, students investigate motion with the Sun-Earth system. They track shadows and analyze patterns in shadow data to draw conclusions about the Sun's apparent motion in the sky. Students also compare and model shadows in winter and summer. They draw relationships between the rotation of Earth and the apparent path of the Sun. In Lesson 4, students examine how the revolution of Earth on its tilted axis affects Sun angle at various latitudes and, ultimately, determines seasons throughout the world.

In Lessons 5 and 6, students focus on motion within the Earth-Moon system and its effect on lunar phases and eclipses. Students determine how much of the Moon is illuminated by the Sun at various points in its orbit around Earth and model lunar phases as visible from Earth. The lesson ends with an embedded assessment in which students identify each phase by name and analyze the time of day in which each phase is visible from Earth. In Lesson 6, students investigate eclipses and their relationship to lunar phases.

During Lessons 7 and 8, students focus on the Sun as an energy source. They conduct an investigation to measure the effects of distance on the amount of energy received from a light source. Students design their own investigation, manipulate variables, and apply their results to their observations about the Sun. In Lesson 8, students track sunspots and analyze how changes in the Sun's energy output—and its impact on space weather—affect Earth.

Lesson 9 is the first of two summative assessments in this module. The assessment has three parts. The first part is a performance-based assessment in which students investigate the effects of distance on temperature and apply their results to the concepts and skills they explored in Lessons 2 through 8. 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 Part 1. Students also update and revise their answers to the 10 questions asked during Lesson 1.

The Anchor Activity

Lesson 10 introduces students to the *Earth in Space* Anchor Activity, which focuses on space technology. This activity challenges students to think about space science from both historical and technological perspectives. The Anchor Activity is a research project during which students work individually to gather information about a particular planet, organize their findings into a brochure, and present them to the class at the close of the module. Students also work in teams to develop a planetary mission design using the data that they have learned about their chosen planet. This lesson also introduces students to the Missions series, a collection of reading selections in which they will read about space exploration throughout Part 2: The Solar System.

The Mission series provides students with specific information about missions to each of the nine planets. Each reading selection in the series outlines information about the planet and provides images collected from its missions. Each reading selection ends with a graphically organized planetary facts page that details information on the planet's relative size compared to Earth, relative distance from the Sun, composition of the atmosphere, internal structure, and overall characteristics—including, for example, average surface temperature, mass, length of day and year, and number of moons. Students record information about each planet in an ongoing student sheet throughout Part 2. They use this information to prepare their Anchor Activity. During Lesson 19, they analyze and compare planetary data to determine patterns.

PART 2 SOLAR SYSTEM

As Part 2: Solar System begins in Lesson 11, students use a set of objects to demonstrate what they know and want to know about the order, size of, and relative distance between each of the nine planets. Lessons 12 and 13 focus on the surface features of the terrestrial planets. Students examine photographs of Earth and are asked to analyze whether the landforms visible on Earth exist on other planets. Lesson 12 focuses on impact craters; students investigate the variables that affect impact cratering and model impact cratering. In Lesson 13, students use the jigsaw method to investigate four different planetary processes—wind erosion, water erosion, tectonics, and volcanism—and their effects on Earth, as well as on a variety of terrerestrial planets and moons.

During Lessons 14 and 15, students focus on gravity and its effect on orbital motion. In Lesson 14 students make general observations about a model that simulates the weight of an object on the surface of each of the nine planets. Students analyze planetary data to consider why weight at the surface varies from planet to planet and draw conclusions about the relationship between planetary mass and size and the weight of an object at its surface. They use a spring scale to investigate the effects of gravity on various objects and examine how the mass of an object determines its ability to attract another object. In Lesson 15, students investigate the effects of gravity on orbital motion.

Lesson 16 brings together Parts 1 and 2 of the module by asking students to apply what they now know about gravity to the Sun-Earth-Moon system and to the occurrence of tides on Earth. Students consider how the relative position of the Sun, Earth, and Moon causes ocean tides. Students analyze data about high and low tides and compare these data to moonrise and moonset times and phases to determine patterns. The lesson ends as students read to learn more about tidal processes on Earth, the Moon, and other bodies within the solar systems.

PART 3 EARTH'S HISTORY AS A PLANET

Lesson 17, the first lesson in Part 3, serves as an assessment of students' current knowledge about the history of Earth as a planet. Based on their knowledge of the solar system, students now look at ways in which asteroids, comets, and meteoroids have contributed to changes in Earth's history as a planet.

In Lesson 18, students explore how fossils reveal the history of possible asteroid and comet impact on Earth. They examine samples of fossiliferous limestone and brainstorm about fossils, watch a short video about dinosaur extinction, and discuss how an asteroid impact may have caused the demise of the dinosaurs. Students complete three inquiries to investigate the excavation, identification, and formation of fossils.

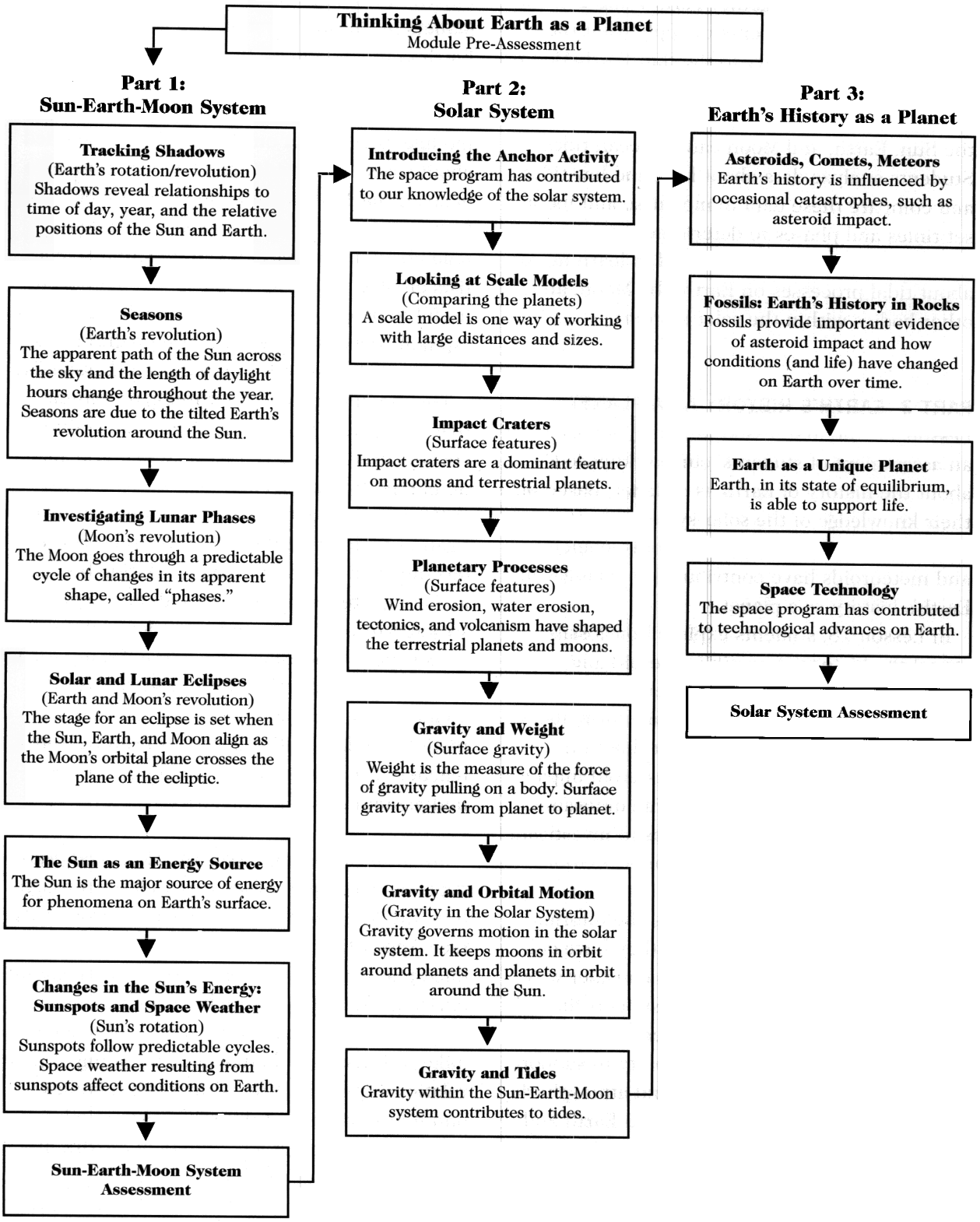
During Lesson 19, students use the information about the nine planets that they have collected from the Mission series to consider why planet Earth is uniquely able to support life. They also consider how the delicate balance of a planet's condition affects its ability to support life by exploring the geological and atmospheric similarities and differences between Earth and the other planets. Students use their planetary brochures and mission designs from the Anchor Activity project to compare Earth to the other planets in the solar system and examine how Earth's climate and other characteristics may support life.

As students complete the final part of the module, they reflect on what they have learned about space by considering how our knowledge of space has lead to improvements in technology for life on Earth. During Lesson 20, students read about a number of inventions that scientists created for the space program that became useful to people on Earth. They each research a "spinoff" developed by the space program and present their research to the class in Lesson 21.

The module ends with a three-part summative assessment in Lesson 22. This assessment covers Parts 2 and 3 of the module and is made up of a performance-based assessment and a written assessment. Students conduct an investigation to describe the relationship between distance and orbital period on orbiting bodies, and complete a series of selected- and constructed-responce questions. Students also revisit the 10 questions they answered in Lesson 1 to see how much they have learned over the course of the module. By comparing their post-module thinking with their ideas from Lesson 1, teachers can assess each student's growth in understanding of Earth in space.

Earth in Space 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. By completing this module, students and teachers alike will develop a better understanding of the relationships among the solar system bodies and how our study of the solar system helps improve our own understanding of Earth's history and future as a planet.

Conceptual Sequence for *Earth in Space*



Module Structure

Earth in Space 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 xxxix.

TEACHER'S GUIDE

The Teacher's Guide for *Earth in Space* includes 22 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 are made for appropriate breaking points.

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 10 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, they first brainstorm what they already know about the topic. This encourages students to begin thinking

about the topic of the lesson and allows the teacher to assess their pre-existing ideas.

Number and Title of Inquiry 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 data, to graph their results, 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 may contain questions that students discuss in their groups.

Reflecting on What You've Done A closing section that provides students an opportunity to think and write about 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.