Students read
and understand
grade-level
appropriate
material. They
describe and

Strategic Science Teaching

Grades K-12

A Sampler of Science Lessons Connecting Literature with the California Standards

perspectives of
the text by using
their knowledge
of text structure.
Connect and

Curriculum and Instruction Steering Committee
of the California County Superintendent
Educational Services Association

CISC Science Subcommittee

Table of Contents

Foreword

"At the daybreak of this new century and millennium, we are convinced that the future well-being of our nation and people depends not just on how well we educate our children generally, but on how well we educate them in mathematics and science specifically."

Before It's Too Late
Glenn Commission, 2000

As we begin the 21st century, we should be mindful of the wisdom of the ancient Greeks who thought of knowledge as holistic, recognizing that everything was related to everything else. While our content specific standards provide knowledge and skills that students need to know and be able to do, these same standards also provide cross-curricular themes for building student understanding, increasing student achievement, and providing a basis for a scientifically literate society.

Standards in English-Language Arts, Mathematics, History-Social Science, and Science ask students to process and organize information; to focus on the meaning and implication of a phenomenon, story or equation; to discover relationships and make connections; and to analyze and solve problems. By their very nature, these standards offer a unique opportunity to identify strategic intersections that intensify the learning experiences of students in grades K-12. Nowhere is this more apparent than in the integration of literacy and science.

Strategic Science Teaching Grades K-12: A Sampler of Science Lessons Connecting Literature with the California Standards was designed to provide examples of "standards-intersections" that build meaning for all students. *Strategic Science Teaching* uses a science instructional model to teach science concepts through active learning that incorporates hands-on science activities/experimentation, literature selections, and learning strategies. The result is a compilation of grade-level exemplars that assist educators in thinking strategically about science instruction and how it can support students' abilities to "read to learn" across the curriculum.

This document has a wide audience: K-12 teachers of science; reading teachers; special education teachers; English-Language Learner specialists; teachers of court and community schools; administrators and other instructional leaders; and curriculum specialists. These educators will find *Strategic Science Teaching* particularly useful in conjunction with the Science Standards/Framework and the Reading/Language Arts Framework as a basis for professional development. Parents, pre-service educators, students, tutors, school site councils, teacher trainers, and other members of the educational community will also find this document useful. Most importantly, students who receive the type of integrated instruction found in this document will grow in their depth of scientific understanding and their appreciation of the holistic nature of knowledge.

Tim McClure
2002 CISC Chair

Barbara Clarence
CISC Science Committee Facilitator

Preface

Life Science

Teachers have a responsibility to provide all students with the best possible opportunities to learn. On the surface, this assertion may seem simple enough; it involves developmentally appropriate activities aligned with standards. On further analysis, however, one may recognize more elusive ideas, such as incorporating engaging and interesting experiences that have meaningful connections for learners, and activities that encourage those who often do not study and achieve in science. It is imperative that science teachers heed the call to enriching science learning experiences for all learners.

I have often written that the development of science curriculum represents a series of constructed relationships among conceptual schemes, procedural strategies and contextual factors. This publication, *Strategic Science Teaching*, provides a template for and examples of science lessons that are dynamic and represent a systemic view of science curriculum. *Strategic Science Teaching* lessons include science content, the actions and behaviors of teachers and learners, and the various technologies of teaching – all essential to effective curriculum design. The specific examples provided for elementary, middle school and high school science classrooms promote standards-based learning from literature selections that provide a relevant context for science learning.

I am convinced that the ultimate reform of science education will only occur at the level of science classrooms. The instructional model recommended in this document touches at the heart of teaching – the most practical level at which educational reform occurs. The instructional model, commonly referred to as the 5 E's, is used extensively in *Strategic Science Teaching*. Each phase of this instructional model has a specific function and contributes to the teacher's coherent instruction and the students' constructing a better understanding of scientific and technological knowledge, attitudes, and skills. Identifying a place for readings from literature selections in the 5E's model is an exemplary accomplishment in this publication's lessons. I encourage California teachers using these lessons to internalize the model as it can also inform the many instantaneous decisions science teachers must make in classroom situations, and frame the sequence of, and organization of, programs and units of study.

Rodger W. Bybee

Rodger Bybee, a prolific author on scientific literacy, is Executive Director at the Biological Science Curriculum Study (BSCS). He served the National Research Council in Washington, D.C. as the Executive Director of the Center for Science, Mathematics, and Engineering Education. Dr. Bybee participated in the development of the National Science Education Standards and has a distinguished background as a university professor.

Acknowledgements

Strategic Science Teaching, Grades K-12: A Sampler of Lessons Connecting Literature with the California Standards was made possible by the leadership and support of the California County Superintendents Educational Services Association (CCSESA) and the curriculum and Instruction Steering committee (CISC). Members of CISC Science Subcommittee were invited to create and develop the document because of their leadership roles in the field of science education. Their expertise and knowledge of research-based instructional design played a key role in shaping content and design of the publication. they were asked to identify additional collaborators to field-test learning activities, peer review lesson design, and evaluate the scientific accuracy of a the work. The committee was convened under the direction of Barbara Clarence, Assistant Superintendent, Riverside County Office of Education.

The work of the entire project was chaired and coordinated by Nancy Taylor, Science Coordinator, San Diego County Office of Education who directed the editorial process and manuscript review for this publication with colleagues throughout California.

Design and Principal Writing Team

Members of the Design and Writing team convened to identify critical research and relevant literature that would be useful for the development of this document. The group created a set of design considerations and developed a design template that is utilized in each lesson in this book. Each member of the Design and Writing Team authored one or more grade specific lessons and participated in the peer review of one or more lessons included in this document.

Maureen Allen, *Orange County Department of Education*
Diane Carnahan, *San Joaquin County Office of Education*
Cathy Dickerson, *Humboldt County Office of Education*
Rick Hall, *San Bernandino County Superintendent of Schools*
Phil Lafontaine, *California Department of Education*
Marian Murphy-Shaw, *Siskiyou County Office of Education*
Nancy Pavelsky, *Riverside County Office of Education*
Nancy Taylor, *San Diego County Office of Education*
Deborah Tucker, *California Department of Education*

Writing and Review Team

Science education leaders who contributed additional writing and refinement of the *Strategic Science Teaching* lessons include;

K-12 Alliance
Cindy Anderson
Karen Cerwin
Kathy DiRanna
Jody Skidmore
Rita Starnes
Jo Topps

West Ed
Libby Rognier
Ursula Sexton
Art Sussman

Editors

Kathy DiRanna, Art Sussman, Nancy Taylor

Instructional Review Team

The following educators gave generously of their time to participate in the evaluation and review of each lesson and the subsequent drafts of the document. Specific contributions of educators, in addition to those above, with expertise in Language Arts, English-language development were considered in identifying Instructional Review Team members;

Christine Bertrand, California Science Teachers Association
Kim Bess, San Diego City Schools
Liselle Clark, Stockton Unified School District
Jennifer Collins, Poway Unified School District
Theresa Foote, Modesto City Schools
Martha Hall, San Bernardino County Superintendent of Schools
Dave Massey, Santee School District
Art Navan, Montebello Unified School District
Dolores Peters, La Mesa Spring Valley School District
Christine Petzar, San Bernardino County Superintendent of Schools
Ed Rodevich, Orange County Department of Education
Tina Sardina, La Mesa Spring Valley School District
Leah Saunders, La Mesa Spring Valley School District
Suzy Ward, Tulare City Schools
Janet Zierenberg, Big Oak Flat Groveland Unified School District

Scientific Review Team

Colleagues from the scientific community provided advisory and ongoing support during the document development process to each member of the Design and Writing Team. Their expertise in science lends an important credibility to the development of this document.

Paul Doherty, the Exploratorium
Michael Rettig, University of California, Riverside
Larry Woolf, General Atomics
Thomas Gates, NASA Ames Educator
Don Scott, NASA Aerospace Education Specialist
Art Sussman, WestEd

Introduction

Learning Strategy

"To develop competence in an area of inquiry, students must: a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application."

John Bransford, *How People Learn*, 2000.

The essence of teaching is helping students make connections. In so doing, the student constructs meaning and understanding from his/her experiences. The development of *Strategic Science Teaching, Grades K-12: A Sampler of Lessons Connecting Literature with the California Standards* is an effort to identify important connections that teachers and students make in classrooms to facilitate understanding of science concepts.

The concept for this document evolved from conversations with practitioners. Faced with numerous standards to address and the need to maximize student understanding, teachers wanted examples of interdisciplinary lessons that integrate concepts and ideas in a meaningful way. The Curriculum and Instruction Steering Committee-Science Subcommittee took up the challenge to develop a K-12 resource that embodies this vision. County office science consultants statewide developed the conceptual framework. The framework for the lesson design is based on the following features:

This document provides grade-level specific lessons that represent the integration of science concepts, literature readings, and teaching strategies.

The content basis for the grade- level specific lessons are the Content Standards for California Public Schools in Science, English-Language Arts, Mathematics and English Language Development, and the connections among them at the specific grade level.

The science instructional model is based on the 5E learning cycle that addresses five stages for learning: **ENGAGE, EXPLORE, EXPLAIN, ELABORATE** and **EVALUATE**. The model, used extensively in science curriculum and adopted instructional materials, is cyclical in nature, and is sequenced to increase student understanding.

Selected literature readings accurately address the science content concepts, are engaging , and are included in the California Department of Education's web list of suggested readings in science and mathematics.

Learning strategies from the California Department of Education's *Strategic Teaching and Learning* publication are incorporated into each lesson. These strategies help all students "read to learn" and comprehend at grade level for content literacy. The strategies are re-printed with permission. A special emphasis is made to include the English Language Development Standards.

The lesson sequence begins with an essential question that students should be able to master as a result of an intensive science learning experience. The exemplar lesson is one part of that experience. Student outcomes for each lesson address: science content understanding; exploration of the science concepts through investigation and experimentation; and application of literacy strategies to enhance learning using a literature selection.

Strategic Science Teaching provides K-12 teachers with a variety of research-based instructional strategies to address their students' content literacy needs. The strategies found in the document help scaffold learning to bridge the gap that too often exists between understanding science concepts, student reading ability and the difficulty of the text. By utilizing scientific investigation/experimentation and readings from literature to gain content knowledge, teachers can increase the achievement and motivation of all students, and particularly meet the needs of English language learners.

As teachers implement rigorous standards across the curriculum, they need to meet the challenges of implementation and embrace changes necessary to ensure quality science education for their students. It is no easy task, but one that has great rewards. This book is intended to contribute to that effort. Enjoy!

How to Use Strategic Science Teaching

Conceptual Statement
These statements represent the California Science Standards re-stated to express the deep understanding of the content standards. They are stated in grade level language.

Essential Questions
These questions serve as doorways into focused yet lively discussion, inquiry and research. Essential Questions are designed to elicit a variety of plausible approaches to the more specific understandings of the lesson.

Conceptual Learning Sequence
The lesson provided represents only a portion of a unit of study in the content area. The lesson is planned as an introductory, embedded or culminating experience, within an expanded unit of study.

Student Outcomes
The learning experiences in the lesson will result in the student outcomes stated here that reflect both science learning and the use of a learning strategy that supports the use of literature and expository text.

Lesson Overview
This statement provides a sequential synopsis of the lesson. It identifies how students will use the specific literature selection with a "Learning Strategy" and a science investigation that will lead to the "Student Outcomes."

English Language Learners
The learning strategies for English Language Learners are identified by the hand icon and are explained within the lessons.

Literature in the Science Learning Cycle
The 5 E instructional model is used as a template for the holistic lesson design. Each lesson identifies where in the 5 E model or the Science Learning Cycle the literature selection is introduced and is emphasized and a science learning activity. Specific icons for each "E" in the Science Learning Cycle accompany this description.

Grade 6

Title of Lesson:

Quake Safe Buildings

Conceptual Statement:

Human habitats can be changed due to earthquakes resulting from plate movements.

Essential Question:

How do movements of Earth's surface impact human and wildlife habitats?

Conceptual Learning Sequence:

This lesson is the culmination of a conceptual unit focusing on Earth's plates, the movement of those plates, and the effects of earthquakes on human environments. As the lesson unfolds, students discover how the motion of Earth and the structural design of a building can determine the ability of a building to withstand the powerful force of an earthquake.

Student Outcomes:

- Students review the natural phenomena of earthquakes and learn how the force released in an earthquake can cause structural damage to buildings.
- Students test various structural designs of building to determine "quake-safeness."
- Students use "Graphic Outlining" as they review the book *Earthquakes* by Seymour Simon.

Lesson Overview:

In this lesson, students read the book *Earthquakes* and use "Graphic Outlining," to graphically organize information on earthquakes and their consequences. The literature selection serves as a review as well as leading students to predict and discover new information about earthquake motion and its consequences. Students test various structural designs for a building.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English language learners.

Learning Strategy
Specific strategies from *Strategic Teaching and Learning*, (CDE, 2000) are identified for each lesson. The specific Learning Strategy is explained in the context of the lesson and is included in it's generic form in the appendix.

Literature Selection
Each book used as the basis for a Strategic Science Teaching lesson is annotated here. The book title is also found on the California Department of Education Recommended Readings in Science Related Literature list http://www.cde.gov

Literature in the Science Learning Cycle:

The book *Earthquakes* is utilized in the ENGAGE stage to connect to students' prior knowledge and in the EXPLORE stage to focus the students' investigation on structural stability as it relates to surface motion.

Learning Strategy:

Students use "Graphic Outlining" with *Earthquakes* to highlight the organizational pattern of the text. This strategy helps students organize what they read, leads them to predict what may come next, and integrate the new information they encounter. (See Appendix, pages 162-163).

Literature Selection:

Title: *Earthquakes*
Author: Simon, Seymour
Publisher: William Morrow, 1991 ISBN: 0688096336
Annotation: This book, from award-winning science writer Seymour Simon, examines the mysteries surrounding earthquakes. Why do they happen? Why are they more frequent in certain areas? What can people do to protect themselves and their property? Simon combines a detailed, clear text with actual photographs to provide some surprising answers.
Genre: Nonfiction

How to Use Strategic Science Teaching

Grade 6

California Content Standards:*

Science: Grade 6, Earth Science

Plate Tectonics and Earth's Structure

1. Plate tectonics accounts for important features of Earth's surface and major geologic events. As a basis for understanding this concept:
   - c. Students know lithospheric plates the size of continents and oceans move at rates of centimeters per year in response to move ments in the mantle.
   - d. Students know that earthquakes are sudden motions along breaks in the crust called faults and that volcanoes and fissures are locations where magma reaches the surface.
   - e. Students know major geologic events, such as earthquakes, volcanic eruptions, and mountain building, result from plate motions.
   - g. Students know how to determine the epicenter of an earthquake and know that the effects of an earthquake on any region vary, depending on the size of the earthquake, the distance of the region from the epicenter, the local geology, and the type of construc tion in the region.

2. Topography is reshaped by the weathering of rock and soil and by the transportation and deposition of sediment. As a basis for understanding this concept:
   - d. Students know earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

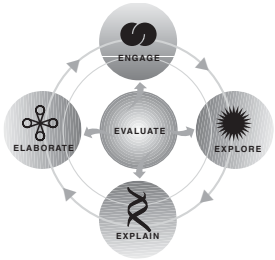
7. Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

- a. Develop a hypothesis.
- b. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
- c. Construct appropriate graphs from data and develop qualitative statements about the relationships between variables.
- d. Communicate the steps and results from an investigation in written reports and oral presentations.
- g. Interpret events by sequence and time from natural phenomena (e.g., the relative ages of rocks and intrusions).

*Selected standards addressed within this lesson.

Science Standard
The Science Content Standards for California Public Schools, Kindergarten through Grade 12 (CDE, 2000) that are addressed in the lesson are specifically cited.

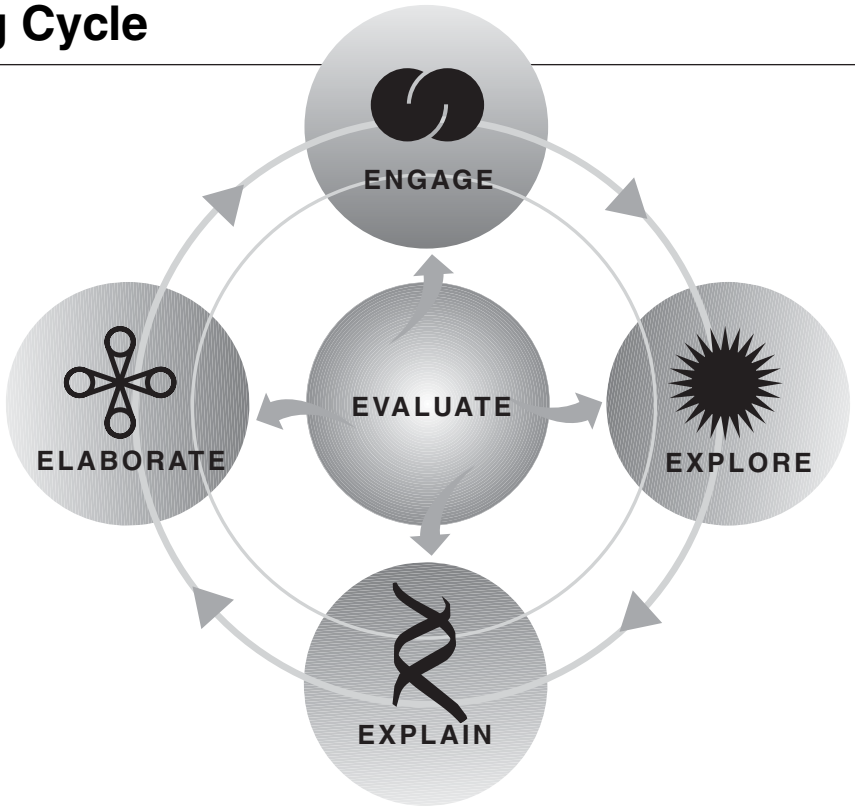
Lesson at  a Glance

Lesson at a Glance
This visual overview of the Science Learning Cycle for the selected reading selection and science investigation not only prepares the teacher for the grade level lesson but also provides the teacher with a template that can be replicated to develop additional lessons.

Science Learning Cycle	Objective Science Thinking Process	Suggested Time
ENGAGE	Students read *Earthquakes* to engage them in thinking about the causes of earthquakes. They graphically outline the literature selection, making connections to their prior knowledge. Communicating, Categorizing	30 minutes
EXPLORE	Students explore the literature selection for evidence of structural damage. They connect photos in the text to a teacher demonstration and the students' own investigation of structural design to determine "quake-safeness." Observing, Comparing, Analyzing	1 hour
EXPLAIN	Students whiteboard, relate their findings, and explain their data to the class while comparing information found in *Earthquakes*. Communicating, Relating, Contrasting	1 hour
EVALUATE	Students evaluate their understanding of force and structural design as they build models and test them for structural integrity. Students compare their findings to real scenarios. Teacher evaluates student understanding of student outcomes in this activity as well as throughout the lesson. Communicating, Inferring, Applying	2 hours
ELABORATE	Using a variety of resources, students research building destruction caused by earthquakes and relate the building design to "quake-safeness." Communicating, Inferring, Applying	1 hour

Icons
Icons identify where the book (literature selection) or learning strategy is applied or where English Language Learners are supported in the cycle.

The Learning Cycle



Students come to our classroom with prior knowledge and experiences. Through their participation in active learning, student extend this knowledge, challenge their assumptions and conceptions, and build meaning out of their experiences. There are many instructional models that address the basis of learning.

In the scientific community, the instructional model known as the 5E's is commonly recognized as an excellent "learning cycle." This model aligns closely with the processes used in scientific and technological enterprises, and builds on the work of Karplus and Atkin. The model is supported by educational research on conceptual change; congruence with the general process of scientific inquiry and technological design; utility for designing and developing curriculum materials; and practical uses by science teachers (Bybee, 1997). The 5E Instructional Model can be used to help frame the sequence and organizations of lessons, units and programs. It can inform the many instantaneous instructional decisions a science teacher must make in teaching to meet student needs.

Each lesson in *Strategic Science Teaching* was developed using the 5E Instructional Model. In so doing, the authors of this document have emphasized science teaching that envisions students as both knowing and doing science. The model provides a framework for teachers to reflect on their own lesson designs and practices. It helps teachers refine or re-design their intended student outcomes and the related strategies/activities that support and maximize learning.

The model consists of five stages: **ENGAGE, EXPLORE, EXPLAIN, ELABORATE** and **EVALUATE**. These stages have specific functions that contribute to students' construction of a better understanding of scientific and technological knowledge, attitudes and skills. The actual application of each stage might not be as clear in a classroom setting as outlined below; still the model contributes to better, more consistent and coherent instruction. The 5E sequence includes:

ENGAGE: This stage initiates the learning task and is designed to make connections between past and present learning experiences. The teacher designs the ENGAGE stage to create interest, generate curiosity, raise questions and problems, and elicit student prior/current knowledge about the concept/topic.

EXPLORE: This stage provides the student with a common basis of experiences within which current concepts, processes and skills are identified and developed. The teacher designs activities that encourage students to think creatively within the limits of the activity; to propose preliminary predictions and hypotheses; to "puzzle" through problems; and to try alternatives to solve a problem.

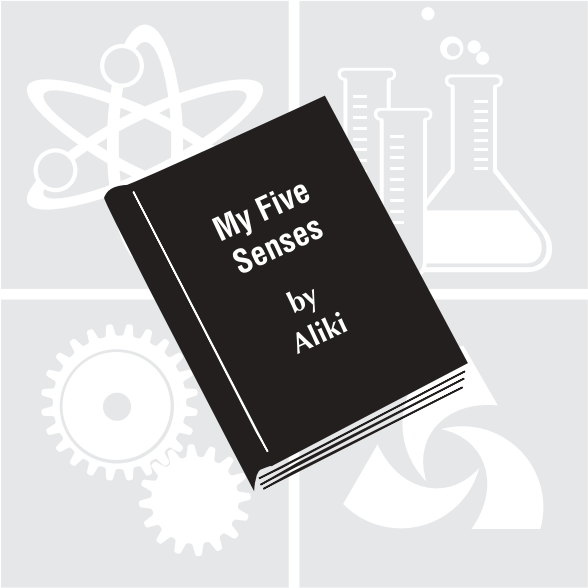
EXPLAIN: In this stage, students have opportunities to demonstrate/explain their conceptual understanding, process skills or behaviors. Students question each other's explanations as well as interact with the teacher who directs student attention to specific aspects of the ENGAGE and EXPLORE experiences. The EXPLAIN stage provides a way or ordering and giving common language to the exploratory experiences.

ELABORATE: The teacher provides activities that challenge and extend the students' conceptual understanding and skills. Through new experiences, the students apply their learning to different experiences in order to develop deeper understanding, more information and necessary skills.

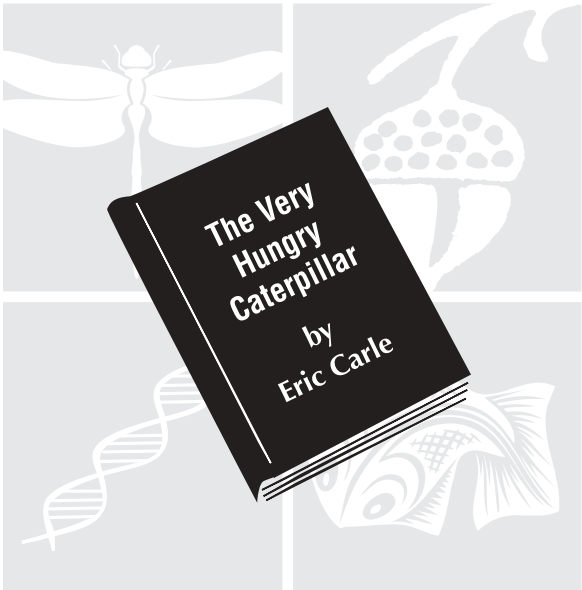
EVALUATE: While evaluation of learning goals is done throughout the 5E's, the EVALUATE stage provides a distinct opportunity to encourage students to assess their understanding and abilities. This stage also provides opportunities for teachers to evaluate student progress and look for evidence that students have changed or deepened their thinking.

Grades

K-2



Strategic Science Teaching



Grades K-2

Grade	Lesson Title	Book Title	Science Standard	Language Arts Standard	Math Standard	English Language Development (ELD) Standard	Learning Strategy	Literature in the Learning Cycle "E"	Science Thinking Process	Pages
K	What Does Matter Look Like?	My Five Senses	Physical 1a Investigation & Experimentation 4a, b, c,	Reading 1.0, 1.17, 1.18 Reading Comp. 2.0, 2.3 Literacy Response & Analysis 3.0, 3.1 Writing 1.0, 1.1, 1.3 Conventions 1.0, 1.1, 1.2 Listen & Speak 1.0, 1.2	Measurement & Geometry 1.0, 1.1, 2.0	Listening & Speaking Reading Word Analysis Reading Fluency Reading Comp. Writing	Concept Wheel	Engage	Observe Communicate Compare	4-12
1	Air Throughout the Day	Weather Words and What They Mean Air is All Around	Earth 3a, b, c Investigation & Experimentation 4a, b, c	Reading 1.0, 1.1, 1.3 Reading Comp. 2.0, 2.4, 2.6 Writing 1.0, 1.1, 1.3 Conventions 1.0, 1.1, 1.5, 1.7 Listen & Speak 1.0, 1.1,1.2, 1.3	Measurement & Geometry 1.0, 1.2 Statistics, Data Analysis and Probability 1.0, 1.2	Listening & Speaking Reading Word Analysis Reading Fluency Reading Comp. Writing	Think Aloud	Explain Evaluate	Communicate Compare Observe	13-28
2	Caterpillar Capers	The Very Hungry Caterpillar	Life 2a, b Investigation & Experimentation 4d, f	Reading Comp. 2.5 Writing 2.1a Listen & Speak 1.7	Measurement & Geometry 1.3 Statistics, Data Analysis and Probability 1.1	Reading Comprehension Writing Strategies and Application	Graphic Outlining	Explore	Apply Communicate Compare Observe Order	29-38

Grades K-2

Title of Lesson:

What Does Matter Look Like?

Essential Question:

What can

we observe

about matter?

Conceptual Statement:

Our five senses help us observe and describe the physical properties of matter.

Conceptual Learning Sequence:

This lesson is part of a conceptual unit on observing, measuring and predicting properties of matter. Before beginning this lesson, students should know that everything is made of matter. The lesson introduces them to using their senses to observe and describe the properties of matter.

Student Outcomes:

- Students learn how to use their five senses to observe and describe matter.
- Students observe, compare and describe objects.
- Students gain an understanding of vocabulary associated with the five senses from *My Five Senses* and generate words for a "Concept Wheel."

Lesson Overview:

In this lesson, the teacher reads *My Five Senses* to students as they contribute words to a “Concept Wheel.” Students collect objects from the classroom or school grounds. Students observe the objects and use words from the “Concept Wheel” to record the properties that describe the objects.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

The book, *My Five Senses*, is read in the ENGAGE stage to clarify vocabulary words related to senses. During reading and lesson activities, students are engaged in learning how their five senses help them experience and describe the world around them.

Learning Strategy:

Students use the “Concept Wheel” as an instructional strategy to build on their prior knowledge. Brainstorming, discussion and visual displays help students connect the printed word, pictures and conceptual knowledge. (See Appendix pages 184-185.)

Literature Selection:

Title: *My Five Senses*
Author: Aliki
Illustrations: Aliki
Publisher: Harper Collins, 1989
Annotation: The text and illustrations invite children to share in the wonder of their five senses and in the different ways they use their senses.
Genre: Nonfiction

California Science Content Standards:*

Science: Grade K, Physical Science

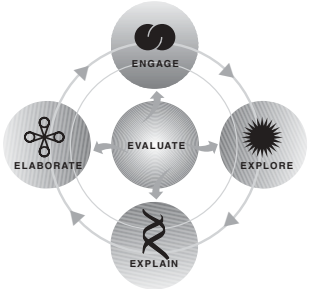
1. Properties of materials can be observed, measured, and predicted. As a basis for understanding this concept:
   a. Students know objects can be described in terms of the materials they are made of (e.g., clay cloth, paper) and their physical properties (e.g., color, size, shape, weight, texture, flexibility, attraction to magnets, floating, sinking).

4. Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

a. Observe common objects using the five senses.
b. Describe the properties of common objects.
c. Communicate observations orally and through drawings.

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Science Thinking Process	Suggested Time
ENGAGE	Students engage in observing and communicating properties of an object. Students listen to *My Five Senses* and think how senses help describe the properties of matter. Observing, Communicating, Comparing	35 minutes
EXPLORE	Students explore properties of matter using their five senses. Observing, Communicating, Comparing	30 minutes
EXPLAIN	Students explain how to describe properties of matter. Observing, Comparing, Communicating	40 minutes
EVALUATE	While evaluation occurs throughout the lesson, the teacher evaluates student understanding as demonstrated in the students' matter booklet. Observing, Comparing, Communicating	45 minutes
ELABORATE	Students apply their skills in describing properties of matter through activities at school and at home. Observing, Communicating, Comparing	2-10 minute sessions

ENGAGE
ELABORATE
EVALUATE
EXPLORE
EXPLAIN

What Does Matter Look Like?

Teacher Background:

Matter is defined as anything that has mass and takes up space. Everything in our world is made of matter. People, cars, trees, lakes, clouds, and air all have mass and take up space, so they are made of matter.

We can observe the properties of matter with our five senses. Everything we can see, hear, taste, touch, and smell is made of matter. The properties we observe may include: size, shape, mass, volume, color, texture, sound, smell, and taste.

The information we receive through our five senses makes it possible for us to interpret our environment.

Related California Content Standards

Math: Grade K

Measurement and Geometry

1.0 Students understand the concept that objects have properties, such as length, weight, and capacity, and that comparisons may be made by referring to those properties.

1.1 Compare the length, weight, and capacity of objects by making direct comparisons with reference objects.

2.0 Students identify common objects in their environment and describe their geometric features.

Language Arts: Grade K

Reading

1.0 Word Analysis, Fluency, and Systematic Vocabulary Development
Students know about letters, words, and sounds. They apply this knowledge in reading simple sentences.

Vocabulary and Concept Development

1.17 Identify and sort common words from within basic categories (e.g. colors, shapes, foods).

1.18 Describe common objects and events in both general and specific language

2.0 Reading Comprehension
Students identify the basic facts and ideas in what they have read, heard, or viewed.

Comprehension & Analysis of Grade-level-Appropriate Text

2.3 Connect to life experiences the information and events in texts

3.0 Literacy Response and Analysis
Students listen and respond to stories based on well-known characters, themes, plots and settings.

Narrative Analysis of Grade-Level-Appropriate Text

3.1 Distinguish fantasy from realistic text

Writing

1.0 Writing Strategies
Students write words and brief sentences that are legible.

Organization and Focus

1.1 Use letters and phonetically-spelled words to write about experiences, stories, people, objects, or events

1.3 Write by moving left-to-right and top-to-bottom

Written and Oral English Language Conventions

1.0 Written and Oral English Language Conventions
Students write and speak with a command of standard English conventions

Sentence Structure

1.1 Recognize and use complete and coherent sentences when speaking

Spelling

1.2 Spell independently using pre-to-early-phonetic knowledge, sounds of the alphabet, and knowledge of letter names

Listening and Speaking

1.0 Listening and Speaking Strategies
Students listen and respond to oral communication. They speak in clear and coherent sentences.

Comprehension

1.2 Share information and ideas, speaking audibly in coherent, complete sentences

English Language Development: Grades K

Listening and Speaking:
Early Intermediate-Ask and answer questions using phrases or simple sentences

Reading Word Analysis:
Intermediate-Understand that printed materials provide information.

Reading Fluency and Systemic Vocabulary Development
Intermediate-Apply knowledge of content-related vocabulary to discussions and reading.
Advanced-Read simple one-syllable and high-frequency words

Reading Comprehension:
Beginning-Draw pictures from student's own experiences related to a story or topic.

Writing:
Beginning-Write a phrase or simple sentence about an experience generated from a group story.

Grouping: Whole class and partners
When working in partners, pair EL with native speakers.

Materials:

Per Class

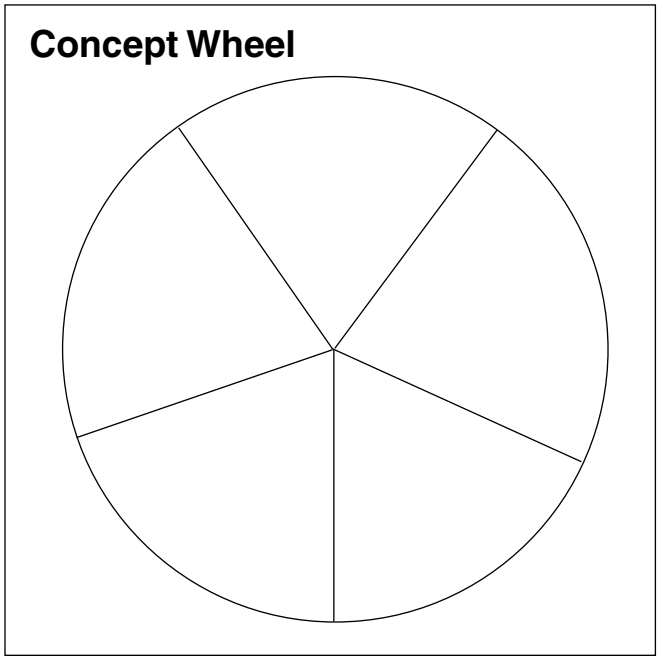
Pocket chart
Sentence strips
Ball or other object
Class Senses Chart
Class "Concept Wheel"
My Five Senses, Aliki (big book preferred)

Per Student

1 Object from the classroom or school grounds
1 Sentence strip
6 Pages of "My Matter" booklet (Student page 1.0)

Advanced Preparation:

1. Set-up a table or shelf for students to place their matter (objects).
2. Cut sentence strips (one per student) 2"x10" long.
3. Recruit parent volunteers or peer tutors to help in the EXPLAIN stage with students who cannot yet write.
4. Duplicate 3 pages of "My Matter" booklet (Student page 1.0) for each student. Cut these pages and staple into a 6-page booklet.
5. Write the sentence frame, "My Matter _____" (from the My Matter booklet) on 6 sentence strips and display in a pocket chart. Complete each sentence on a separate sentence strip using these (or similar) words if the object described is a ball.
   My matter is red.
   My matter smells like rubber.
   My matter has white spots.
   My matter can bounce.
   My matter is a ball. (The last sentence strip tells what the matter is.)
   Prepare a Class "Concept Wheel" on chart or butcher paper to write and draw ideas about the five senses after reading the literature selection, *My Five Senses*. See example below.



VOCABULARY

feel – to touch or be aware through the senses

hear – to receive sound through the ears

matter – what all things are made of

observe – to use the five senses to gather information about the world around you

properties – special characteristics

see – the sense of eyesight

senses – how a living thing gathers information about its environment

smell – to notice the odor of something

taste – to be aware of the flavor of something in the mouth

touch – the sense in the skin, especially in the fingers

6. Prepare a "Class Senses Chart" on chart or butcher paper. Write headings for each sense and a sentence frame in the box. When students explain properties of their matter, have them describe their matter in a complete sentence (e.g., "My matter tastes sweet."). Include pictures for visual cues. See example below.

Senses Chart

See	Hear	Feel	Taste	Smell
My matter is . . . (color, shape, size)	My matter sounds . . .	My matter feels . . .	My matter tastes . . .	My matter smells . . .

Teacher Resources:

Southwest Educational Development Laboratory, http://www.sedl.org/work/literacy.html

Teacher Tips:

- If using an object other than a ball, create your own sentence strips to describe the object, making sure that the last one states what the object is.
- Expect students to have different observations. All students may not perceive the properties in the same way; however, it is important to make sure that all observations are qualitative or quantitative statements and are not inferences. Naming objects is an inference, not an example of an observation.
- Duplicate extra pages for the "My Matter" booklet in case students want to describe more than 6 pages worth of properties!

Related Student Resources:

Broekel, R., *Tus Cinco Sentidos*, Children's Press, 1988.

Hewitt, Sally, *The Five Senses*, Children's Press, 1999.

Miller, Margaret, *My Five Senses*, Econo-Clad, 1999.

Rius, Maria, *The Five Senses*, Hearing, Econo-Clad, 1999.

Slater, Teddy, *Busy Bunnies Five Senses*, Scholastic, 2000.

Lesson Credits:

This lesson is adapted from *Matter, A Storyline Unit*, developed by the K-12 Alliance (CSIN-SPAN-SS&C), 2000

The Science Learning Cycle:

What Does Matter Look Like?

ENGAGE:

1. Look around the room and tell students you are thinking of some matter that is in the classroom (e.g., ball). Give clues to describe the matter (e.g., The matter I am thinking of is round, red, and squishy). Ask students how they know what is being described. How do they know it isn't something else? Remind students that all matter has properties by which it can be identified or described. After students guess the matter you were thinking of, provide examples of additional ways of describing the matter, "One of the properties of this object or matter is that it has bumps on it," or "This matter is soft," etc.

2. Display the "Concept Wheel" where students can clearly see it. Read *My Five Senses* by Aliki. After reading, ask students to name the five senses. Add one of the sense words (see, hear, feel, touch and taste) in each section of the "Concept Wheel." Ask students to think of other words that come to mind for each sense word (e.g., see-eyes, look, sight; hear-ears, listen, sounds, noise; etc.) and add these words and pictures to the appropriate section of the "Concept Wheel." Ask students to add words/pictures from the book *My Five Senses*, state where that word belongs on the wheel, and explain why they placed it there (e.g., drum is placed in the "Hear" section because it makes noise). This activity is an opportunity for EL to understand that printed materials provide information.

3. Ask students, "How do our five senses help us describe the properties of matter?"

4. Ask students to look at the same object you began with (e.g., ball). Model for students a way to describe the object more fully using complete sentences (e.g., "My matter looks red with white spots all over it. It looks round and can bounce as high as me. My matter feels soft and squishy. My matter smells like rubber. My matter makes a sound when I bounce it"). Explain that the sense of taste was not included in this description and remind students about precautions for tasting objects.

EXPLORE:

5. Have students look around the room or allow them to go outside to collect one piece of matter they will use for the next activity.

6. Have students put their matter on their desk or table. Ask students to observe their matter with their senses. Ask students to think of ways to describe their matter using as many of their senses as possible.

7. Ask students to share their observations with their partner. Then provide time for students to share their description of their matter with other students in the class. When describing their matter, encourage students to use the sentence frame (e.g., "My matter looks/is ____.", "My matter feels _____.", etc.). This provides an opportunity for EL to answer questions using phrases or simple sentences.

EXPLAIN:

8. Display the "Class Senses" chart. Have students raise their hands when they have discovered a "property" of their matter using one or more of their five senses. Ask students to explain the property and tell which sense they used to find it. Write the property of the object in the appropriate column on the "Class Senses" chart for the sense used (e.g., "red" in the sight column, "rough" in the touch column). Encourage students to respond in complete sentences without actually naming the object.

9. After each observation is shared, ask other students to stand if they have objects that have the same property. Complete the "Class Senses" chart with words or phrases that describe the properties of the matter students are holding.

10. Distribute a sentence strip to each student and ask students (or volunteers) to write on the strip at least five properties (e.g., -red, rubber, round, white spots, bounces) that describe their matter. Students may use words from the "Class Senses" chart or the "Concept Wheel." Collect the sentence strips and the pieces of matter to use with the "What's My Matter?" game (step 11). You will return the strips and objects (step 15) to students to use while making their own booklet, "My Matter."

EVALUATE:

11. Introduce the "What's My Matter?" game. Display the objects (pieces of matter) and gather students where they can easily see the pieces of matter. Choose a sentence strip completed by one of the students and read it aloud. When the students think they can identify the matter described, ask them to raise their hand and name the object. Play this game several times.

12. Tell the students they will be making a “My Matter” booklet. Model how to complete the pages of the booklet: display a sentence frame from the “My Matter” booklet in the pocket chart; read the sentence frame, “My matter _____.”, aloud slowly and then read together several times with the students. Next, using the object from step 1 (the ball), model how to complete each sentence by adding the remaining part of the sentence. Read each sentence with the students. In this part of the lesson, it is appropriate for EL at beginning reading comprehension level to draw pictures for prewritten sentences strips.

13. Ask students which senses were used to describe the object. Add a picture of the sense used to each sentence strip. (For example, “My matter is red.” Draw a picture of an eye at the end of the sentence. “My matter smells like rubber.” Add a picture of a nose at the end of the sentence.) Ask students if there are other senses that could have been used.

14. Show students the blank pages of the student “My Matter” booklet (Student page 1.0) and explain that they will now make their own booklet using their piece of matter. Each page will have one property and a picture.

15. Return the appropriate sentence strip to each student to use to complete their “My Matter” booklet. Using parent volunteers or older student helpers, ask students to complete the observations/descriptions of their matter. The last page of the booklet should tell what the matter is. Ask students to draw a picture to go with each page.

16. Provide time for students to read their booklets to each other.

ELABORATE:

17. Play “What’s My Matter?” game with other items in the classroom.

18. Provide "touch and feely" boxes (boxes in which students can feel, but cannot see, the objects) to partners and ask them to describe the objects. After each item is described, ask students to open the boxes and compare their descriptions with the actual object.

19. Send a "Surprise Box" home with a different student each night. Ask the student to place an object in the box and have their parents help write five properties about this object. Ask students to return the box to the classroom. The next day, have students listen to the properties and guess what might be in the box.

Teacher Reflection:

1. How does the student work provide evidence of student understanding that matter has properties that can be described using the five senses?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts?
4. How would you modify instruction to ensure understanding of student outcomes by all students?

My matter _____ .

cut here

My matter _____ .

Grade

1

Strategic Science Teaching

Title of Lesson:

Air Throughout the Day

Conceptual Statement:

The temperature of air changes throughout the day.

Conceptual Learning Sequence:

This lesson is part of a conceptual unit on weather that addresses the concept that the sun, land, water and air interact to create weather. It is appropriate after students have observed weather patterns over a period of time and have learned some of the properties of air. This lesson explores air's ability to be heated and cooled. Following this lesson, students learn that the sun warms the water and the land which, in turn, heats the air.

Essential Question:

What can we observe about weather?

Student Outcomes:

- Students learn that air temperature changes throughout the day.
- Student record observations and data during an investigation of air temperature during the day.
- Students experience and practice the "Think Aloud" strategy to link prior knowledge with new information in the reading selection.

Lesson Overview:

In this lesson, students use an outdoor thermometer to record the changes in air temperature throughout the day. They analyze their data to compare temperature changes over time and write a conclusion.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

The book *Weather Words and What They Mean* is used in the EXPLAIN stage of the learning cycle and *Air is All Around You* is used in the lesson during the EVALUATE stage.

Learning Strategy:

Teachers model "Think Aloud" in the EXPLAIN stage by verbalizing their own thought processes while reading orally to students. Students practice "Think Aloud" with a second reading selection to revisit their understanding about air changing temperature. (See Appendix pages 90-91.)

Literature Selections:

Title: *Weather Words and What They Mean*
Author: Gail Gibbons
Publisher: Holiday House, 1992 ISBN: 082340952X
Annotation: Common weather words and other weather related phenomena are explained in *Weather Words and What They Mean*. Air pressure, fog, clouds, moisture, temperature and wind are just a few of the vocabulary words defined in a simple dictionary-like book for young readers.
Genre: Non-fiction

Title: *Air is All Around You*
Author: Franklyn M. Branley
Illustrations: Holly Keller
Publisher: Harper Collins, 1986 ISBN: 0064450481
Annotation: The author makes science concepts understandable in *Air is All Around You*. Young children learn the various properties of air and investigate that air takes up space and that air is dissolved in water in this "Let's Read and Find Out Science" series (Stage 1).
Genre: Non-fiction

California Science Content Standards:*

Science: Grade 1, Earth Science

3. Weather can be observed, measured, and described. As a basis for understanding this concept:
   a. Students know how to use simple tools (e.g. thermometer, wind vane) to measure weather conditions and record changes from day to day and over the seasons.
   b. Students know that the weather changes from day to day, but trends in temperature of rain (or snow) tend to be predictable during a season.
   c. Students know the sun warms the land, air, and water.

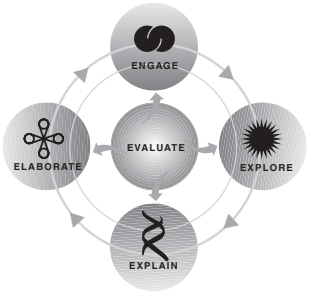
4. Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

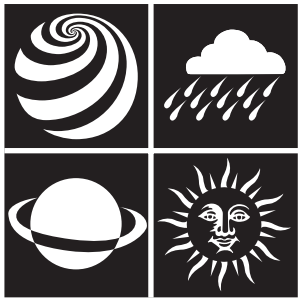
a. Draw pictures that correctly portray at least some features of the thing being described.
b. Record observations and data with pictures, numbers, and/or written statements.
c. Record observations on a bar graph.

*Selected standards addressed within this lesson.

Lesson at a Glance



Science Learning Cycle	Objective Science Thinking Process	Suggested Time Entire lesson could be completed in 5 days.
ENGAGE	Students engage in making observations of how the air feels. They compare this data with how the air feels at other times of the day and year. Observing, Comparing, Communicating	20 minutes
EXPLORE	Students discuss their observations from the ENGAGE stage and make predictions about the temperature changes they observe. Students explore ideas about scientific procedures and develop a plan for observation. Students explore changes in air temperature throughout the day. Observing, Comparing, Communicating	Part I: 40 minutes Part II: 15 minutes four times during the day
EXPLAIN	Students use their observations and data to explain what they know about changes in air temperature. Students listen as the teacher models using the "Think Aloud" strategy while reading selection pages in *Weather Words and What They Mean.* Observing, Comparing, Communicating	30 minutes Part IV: 30 minutes
EVALUATE	With a partner, students use the "Think Aloud" strategy to read selected pages in *Air is All Around You.* In so doing, students evaluate their prior knowledge and new information they learned. The EVALUATE stage is used here rather than at the end of the lesson to maximize the use of the learning strategy. The Teacher continues to evaluate in other stages of this lesson. Observing, Comparing, Communicating	40 minutes
ELABORATE	Students elaborate on their understanding as they conduct additional investigations of temperature and/or other properties of air from *Air is All Around You.* Observing, Comparing, Communicating, Applying	45 minutes



Air Throughout the Day

Teacher Background:

The sun is the source of most of the energy that warms Earth. A small amount of energy that warms Earth comes from Earth's interior but this generally has little effect on everyday temperature changes.

Many people think the air temperature is warmest when the sun is directly overhead. However, a temperature log generally shows a rapid temperature increase in the morning, a slow increase in the early afternoon, a slow decrease in the late afternoon, and a fairly steady but rapid decrease during the night. The coolest temperature is just before sunrise. The warmest air temperature is generally about 3 P.M. Of course, a cold wind, cloud cover, rain, and other weather conditions can cause changes in this normal pattern.

What causes this regular air temperature pattern? The air is not heated directly by the sun's energy. Instead, the sun's energy is absorbed directly by the land and water. This energy is then transferred to the air molecules around the land and water, thus warming the air.

Related California Content Standards

Math: Grade 1

Measurement and Geometry
- 1.0 Students use direct comparison and non-standard units to describe the measurement of objects.
- 1.2 tell time to the nearest half hour and relate time to events

Statistics, Data Analysis and Probability
- 1.0 Students organize, represent, and compare data by category on simple graphs and charts:
- 1.2 represent and compare data by using pictures, bar graphs, tally charts and picture graphs.

Language Arts: Grade 1

Reading
- 1.0 Word Analysis, Fluency, and Systematic Vocabulary Development
  Students understand the basic features of a reading.

Concepts About Print
- 1.1 match oral words to printed words
- 1.3 identify letters, words and sentences
- 2.0 Reading Comprehension
  Students read and understand grade-level-appropriate material.

Comprehension & Analysis of Grade-Level-Appropriate Text
- 2.4 use context to resolve ambiguities about word and sentence meanings
- 2.6 relate prior knowledge to textual information

Writing
- 1.0 Writing Strategies
  Students write clear and coherent sentences and paragraphs that develop a central idea.

Organization and Focus
- 1.1 select a focus when writing

Penmanship:
- 1.3 print legibly and space letters, words, and sentences appropriately

Written and Oral English Language Conventions
- 1.0 Written and Oral English Language Conventions
  Students write and speak with a command of standard English conventions.

Sentence Structure
- 1.1 write and speak in complete, coherent sentences

Punctuation:
- 1.5 use period, exclamation point, or question mark at the end of sentences.

Capitalization:
- 1.7 correctly capitalize the first word of a sentence

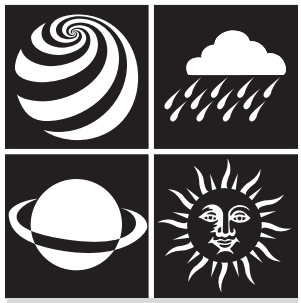
Listening and Speaking
- 1.0 Listening and Speaking Strategies
  Students listen and respond critically to oral communication.

Comprehension
- 1.1 listen attentively
- 1.2 ask questions for clarification and understanding
- 1.3 give, restate, and follow simple two-step directions

Related California Content Standards

English Language Development: Grade 1

Listening and Speaking:
Early Intermediate–Ask and answer questions using phrases or simple sentences
Reading Work Analysis:
Intermediate–Understand that printed materials provide information.
Reading Fluency and Systemic Vocabulary Development:
Intermediate–Apply knowledge of content-related vocabulary to discussions and reading.
Advanced–Read simple one-syllable and high-frequency words
Reading Comprehension:
Beginning–Draw pictures from student's own experiences related to a story or topic.
Writing:
Beginning–Write a phrase or simple sentence about an experience generated from a group story.



VOCABULARY

air – a mixture of gases that is all around Earth

energy – the power of certain forces in nature to do work

heat – warmth; a form of energy

sun – the very hot, bright star that is the center of our solar system and creates daylight

temperature – the degree of heat or cold in something

thermometer – a device for measuring temperature

Grouping:

Whole class, partner, individual
For hands-on activities, mix the EL with the native speakers.

Materials:

Per Class

Air Investigation Class Chart (Teacher Page 1.0)
Four large paper thermometers, each drawn on a separate piece of chart paper
Literature selection *Weather Words and What They Mean* by Gail Gibbons
(Big Book if possible, or one book per group)
Chart paper

Per Group

1 outdoor thermometer
Sign that says, Do Not Disturb–Science Experiment

Per Student

Copies of Student Pages 1.1-1.5
Red crayon
Pencil
Literature selection, *Air is All Around You*, by Franklyn Branley

Advanced Prep:

1. Prepare the Air Investigation Class Chart (Teacher Page 1.0)
2. Prepare four large class thermometers on chart paper, Fahrenheit or Celsius to match the scan on the actual thermometer the class will use.
3. Prepare the "What We Know About Air" chart for recording brainstorming.
4. Duplicate Student Pages 1.0 -1.2, 1.5, and the appropriate thermometer Student Page 1.3 or 1.4 according the thermometers used for the investigation (Celsius, Student Page 1.3 or Fahrenheit, Student Page 1.4)

Teacher Resources:

Kerrod, Robin, *Fantastic Facts about Weather,* Southwater, 2000.

Teacher Tips:

- Teach this lesson on a warm, sunny day.
- Have students place the group's outdoor thermometer in the shade and not in the sun. If the thermometer is in the sun it isn't measuring the air temperature; it is measuring the sun's radiant energy on the thermometer.
- Use either all Celsius or all Fahrenheit thermometers for the investigation.
- Students should have some experience with reading a thermometer before conducting the investigation.
- Duplicate extra worksheets if you want students to make more than four temperature readings.
- If students need more hands-on explorations to learn about the properties of air, conduct the two investigations in the book, *Air is All Around You*, pages 8-17.
- Student summaries should state what is directly in the data, not attempt to explain data.

Common Misconceptions:

Some students might think the sun is warming the air rather than understand that the sun heats the land and water, which in turn heats the air. Further investigations in the unit should help students understand this concept of heat transfer.

Related Student Resources:

Dewitt, L., Carol, C.. *What Will the Weather Be?*, Harper Trophy, 1993.

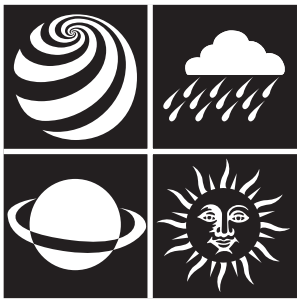
Dorros, Arthur. *Feel the Wind*, Harper Collins, 1989.

Gibbons, Gail. *The Reason for Season*s, Holiday House, 1996.

Gibbons, Gail. *Sun Up, Sun Down*, Scholastic, 1983.

Lesson Credits:

This lesson is adapted from *Weather, a Storyline Unit for 1st grade*, developed by the K-12 Alliance (CSIN-SPAN-SS&C), 2000.



ENGAGE
EXPLORE
EXPLAIN
ELABORATE
EVALUATE

The Science Learning Cycle:

Air Throughout the Day

ENGAGE: Day 1

1. Ask students to briefly step outside the classroom and observe the weather. Have students return to the classroom and ask them to share their descriptions. How did the air feel on their skin? Do they think it would feel the same in the afternoon? In the evening? How might it feel at those times? Record the student's ideas on a class chart **What We Know About Air**.

2. Have students tell you other words that help describe how the air feels during other parts of the day or during other seasons.

3. Read the recorded statements/words aloud with the class. Ask students if there are other words or phrases that tell what else they know about air. (For example – air is a gas, air is invisible, wind is moving air)

4. Remind students they already know a lot about the air. Over the next couple of days they will do some additional investigations to learn more about air.

EXPLORE: Part I: Day 2

5. Tell students that, like scientists, they made observations about how the air feels on their skin. Ask students what questions they have about their observations. If necessary prompt with questions such as: “What do you think causes the air to feel differently during the day?” “Do you think the air temperature is the same all day long, or does it change?”

6. Explain to students that if they are going to investigate air temperature they will need to keep a record of their thinking. Show students the **Air Investigation Class Chart** Teacher Page 1.0. Review the different parts of the **Air Investigation Class Chart**. (Teacher Page 1.0)

7. Read the question "Does the air temperature change throughout the day?" on the class chart. Ask students to think about this question for the investigation and predict what will happen as they observe air temperature throughout the day. Have students discuss their predictions with a partner. Write examples of the predictions on the **Air Investigation Class Chart** Teacher Page 1.0 under "Our Predictions."

8. Distribute Student Page 1.0 and ask students to write their name on the top of the page. Explain to students they will also record information (data) about the investigation on air, just like a scientist. Ask students; “Why is it important to record information from the investigation?”

9. Ask students to write their own prediction and complete the sentence frame on Student Page 1.0, "I predict the air temperature will _____."

10. Ask students how they can find out if the air temperature changes during the day. If necessary lead the discussion towards placing thermometers outside and measuring the temperature throughout the day.

11. Help students think about the materials they would need to conduct the investigation. How will they measure the temperature (thermometer); where will they record their data (student sheet); how will they know when to take a measurement? (clock, timepiece). Record the word and a picture of the materials under the Materials section of the **Class Chart** Teacher Page 1.0 and ask students to record it on Student Page 1.0.

12. Ask students what would the first step be if they wanted to find out if the air temperature changed throughout the day. Check to see that the steps include at least four readings at times that students think are best for recording the air temperature. Record procedures on the **Air Investigation Class Chart** Teacher Page 1.0 with times in the data column (include illustrations for visual cues e.g., clock with times, picture of a thermometer, etc.). Have students record the procedures on Student Page 1.0.

    An example of a procedure is
    1. Find a safe place outside to set the thermometer in the shade.
    2. Take the temperature of the air at different times 9:00AM, 11:00AM, 12:30PM, 2:00PM
    3. Record the temperatures on the chart.
    4. Use the data to understand the question that we investigated.

13. Ask students to record the four agreed upon times in the data chart under “Time of Day” on Student Page 1.1. Ask students what time of the day do they think the air will be the warmest? Have students use a red crayon to circle the box on the data section with the time of day they think will be the warmest.

14. Explain to students they are now prepared to conduct the investigation. When they return the next day they will complete the investigation.

Part II: Day 3

15. Put students in groups of three or four and assign a number to each group. Have students read and review Student Page 1.0 with a partner. As a class, also review the procedures. Distribute one thermometer to each group. Ask students to take a pencil and their Student Page 1.1 with them. Ask each group to go outside and find a safe place in the shade to set their thermometer for the day. Place a "Do Not Disturb-Science Experiment” sign by the thermometer. Have students record their first temperature reading and location of their thermometer on the data chart on Student Page 1.1.

16. Upon return to the classroom, ask groups to report their data. Record temperatures on the data section of the class **Air Investigation Chart** Teacher Page 1.0 next to the corresponding time for each group.

17. Demonstrate how to color the thermometer on the large classroom thermometer. Distribute Student Page 1.2 or 1.3 and ask students to record their data (the time and temperature) in the appropriate boxes. Ask them to color the thermometer red to show the temperature for the first reading.

18. Repeat step 15-17 for the other three readings.

EXPLAIN: Part III: Day 4

19. Have students look at the data on the **Class Air Investigation Chart** Teacher Page 1.0 and their own recordings on Student Pages 1.0-1.1 and 1.2 or 1.3. Ask the students to discuss the data from their investigations. Did the temperature change or stay the same? How do you know? When was the temperature the warmest? When was the temperature the coolest? How did their prediction compare with the actual data? Record student responses in the "Summary" section of the **Air Investigation Class Chart** Teacher Page 1.0. Ask students to write at least one sentence summarizing what they noticed about the data on Student Page 1.1. (A summary of the data simply states what is in the data, (e.g., At 2:00 it was 83 degrees. It was warmer at 2:00 than at 11:00.)

20. Ask students what they think caused the air to get warmer. Record their ideas on chart paper. Based on student answers, lead a discussion about the sun's role in the temperature differences. What did students learn about air temperature from the investigation? Record responses in the Conclusion section of **Class Air Investigation Chart** Teacher Page 1.0 and ask students to record their understanding on Student Page 1.1. (Example-The air temperature changes from the morning to the afternoon. Air is not the same temperature all day.) Note: A discussion of night time temperature is addressed in the ELABORATE section #29.

Part IV:

21. Distribute the book, *Weather Words and What They Mean* to each group (or use book as a read aloud). Ask students to turn to page 6 and find the word TEMPERATURE in the box at the top.

22. Use the “Think Aloud” strategy for pages 6-7 from *Weather Words and What They Mean*. Take this opportunity to model for students the kinds of strategies a skilled reader uses to construct meaning and cope with comprehension problems.

    Example:
    Read the two pages aloud, telling students to follow along silently and listen to how you construct meaning and think through trouble spots. (For example "This word must be temp-er-a-ture and not ther-mo-meter because it doesn't begin with a th.")

    - Describe any pictures forming in your head while you read. Use examples from the Air Investigation. (For example "It says that the temperature goes up and down. My data chart also showed that the air temperature goes up and down.")

- Show how to link prior knowledge with new information in the reading selection. ("I remember talking about how the air temperature is different at nighttime and in the winter and summer.")

- Show how you monitor your ongoing comprehension and become aware of problems. ("I wonder what the word 'mild' means?" What does it mean when the sun is 'low in the sky'?)

24. Refer to the **"What We Know About Air"** class chart. Ask students if there is any new information or phrases from the Air Investigation or the two pages they just read that can be added to the chart.

EVALUATE:

25. Distribute the literature selection to each student, *Air is All Around You*. Review the "Think Aloud" strategy modeled in the EXPLAIN section of the lesson. If necessary, model the strategy again for students while reading pages 3-7. If students are ready, pair them and ask partners to read pages 3-7 with each other. After reading, ask students if there are any new words or phrases that can be added to the "What We Know About Air" chart.

26. Depending on student reading level, either have students continue to read pages 18-32 with their partner or read the selection aloud to students while they follow along. (Do not read pages 8-17.) Add new information or phrases to the **"What We Know About Air"** chart.

27. Ask students to think about what they have learned about the temperature of air throughout the day. Distribute Student Page 1.4. Ask students to write and draw at least two new things they learned from the lesson. Tell students they can use the "What We Know About Air "chart, their Student Pages, or the literature books to help them explain their thinking. Note: Student responses should demonstrate understanding that temperature of the air changes throughout the day.

28. Combine the pages into a class book "What We Learned About Air Temperature!" for others to read and enjoy.

ELABORATE:

29. Ask students who have thermometers at home to record the air temperature in the evening and bring the temperature readings to school the next day. Discuss their results: How does the night temperature differ from the daytime temperature? Why? Link this discussion to the changes they noted during the day.

30. Ask students to think about a cloudy or rainy day. How do they think the temperature will change on those days? What is the basis for their thinking? Repeat this activity on a cloudy day or a rainy day and compare results to the student discussion.

Teacher Reflection:

1. How does the student work provide evidence that they learned air temperature changes throughout the day?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts?
4. How would you modify instruction to ensure understanding of student outcomes by all students?

Air Temperature Investigation Chart

Question: **Does the air temperature change throughout the day?**

Our Predictions:

Materials:

Our Procedures:

1.
2.
3.

Our Data: (make as many data charts as you have groups and label, Group 1, Group 2, etc.)

Group #_____

Location_____

Time of Day	Temperature

Summary of Data: (Sentences that state the observations)

Our Conclusions: (Interpretations of why temperature changes.)

Air Temperature Investigation

Question:

Does the air temperature change throughout the day?

My Prediction:

I predict the air temperature will_____

Materials:

Procedure:

My Data: Group _____
Location: _____

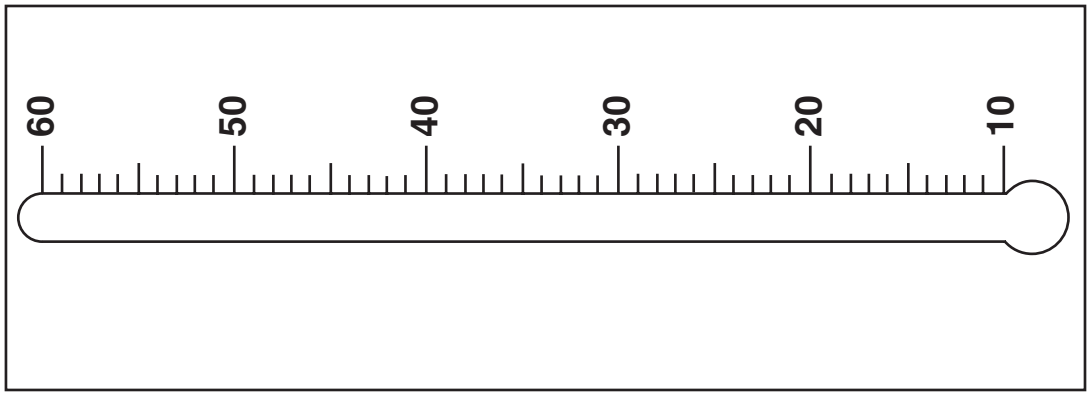
Time of Day	Temperature

Summary:

My Conclusions:

Celsius

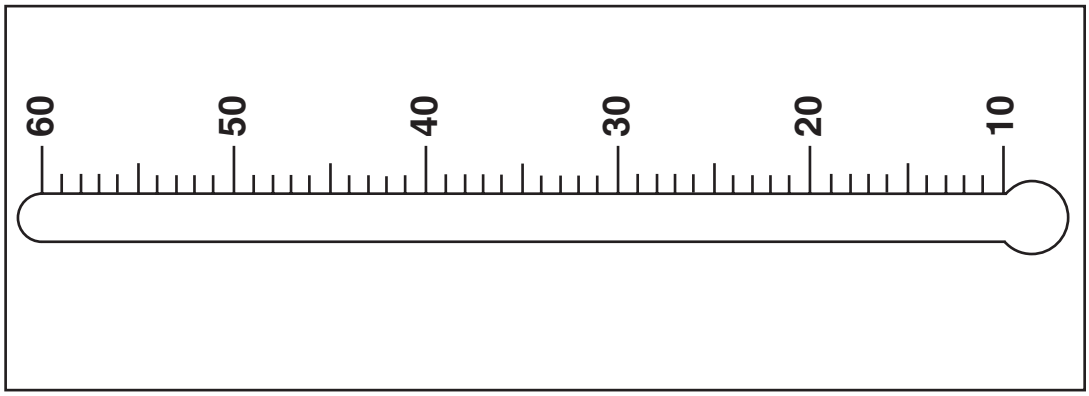
1st Reading



Temperature

Time

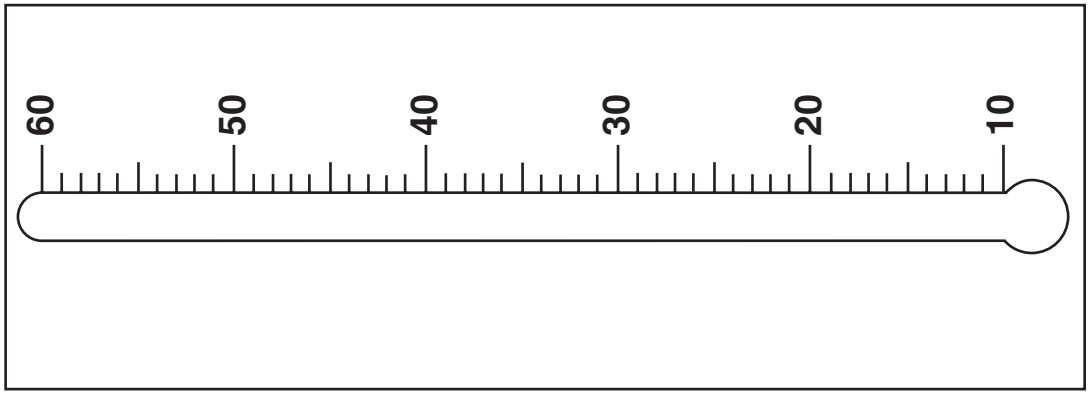
2nd Reading



Temperature

Time

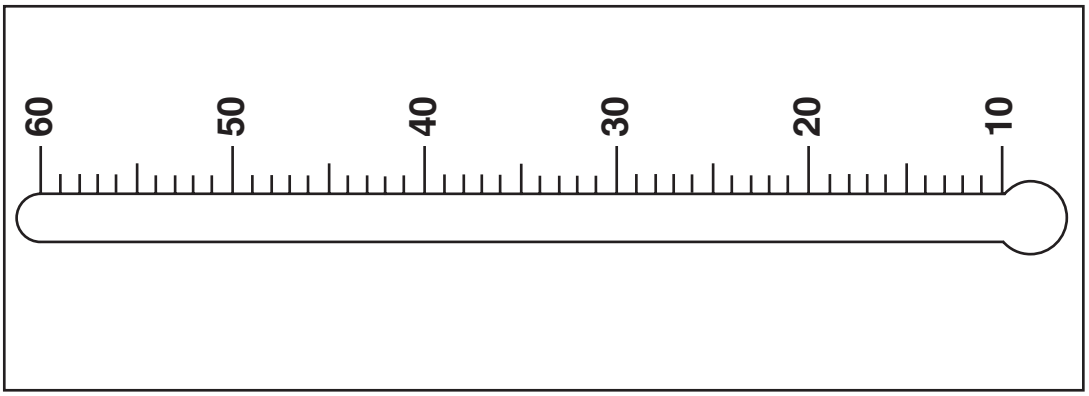
3rd Reading



Temperature

Time

4th Reading

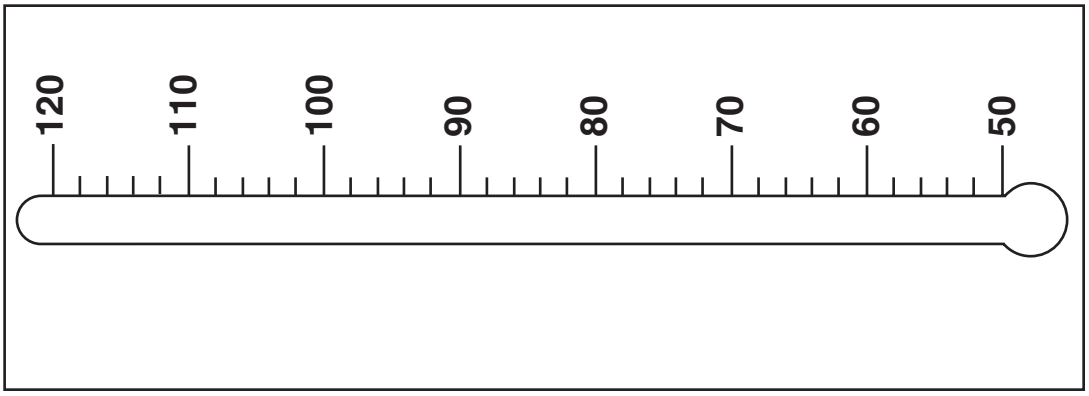


Temperature

Time

Fahrenheit

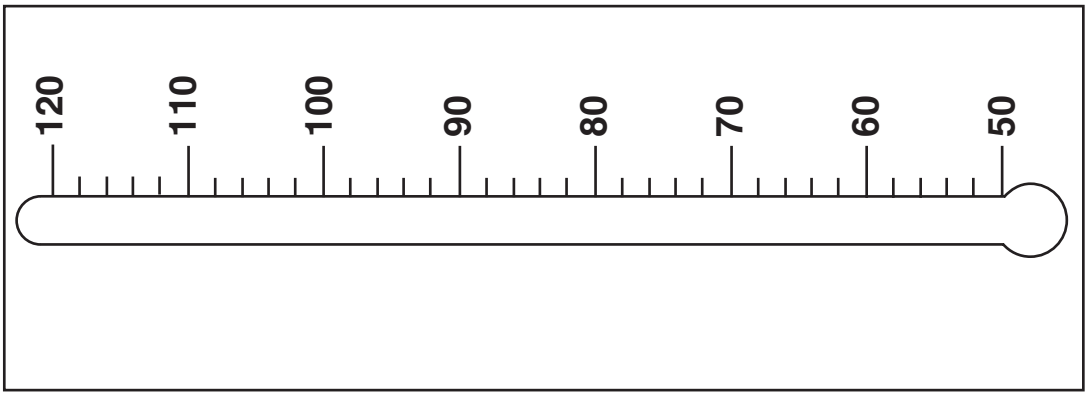
1st Reading



Temperature

Time

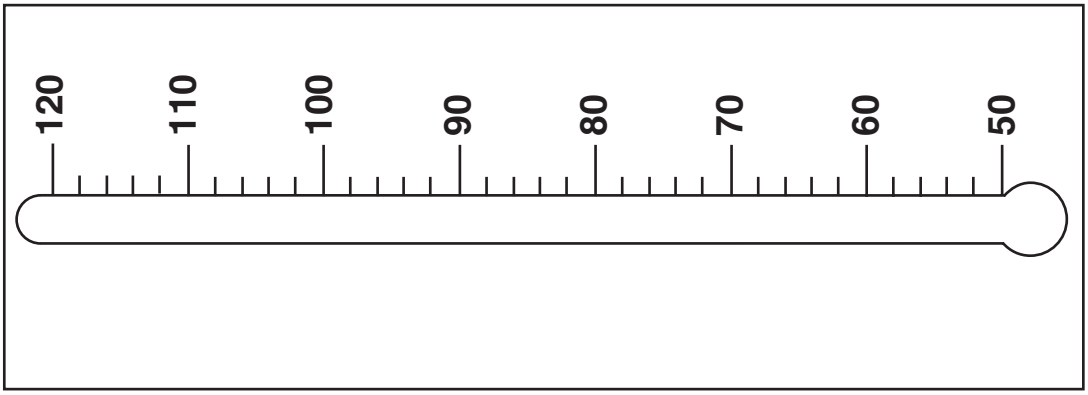
2nd Reading



Temperature

Time

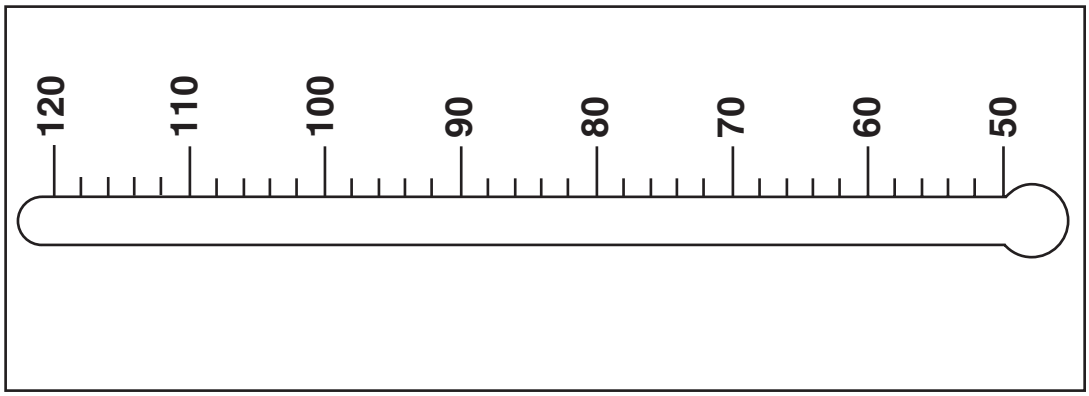
3rd Reading



Temperature

Time

4th Reading



Temperature

Time

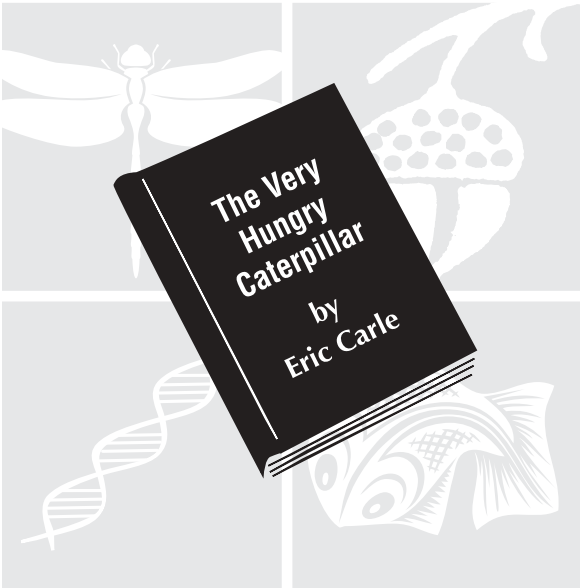
Air is All Around

What have you learned about air temperature?

Grade

2

Strategic Science Teaching



Title of Lesson:

Caterpillar Capers

Essential Question:

How do the changes that occur in the life cycle of a butterfly compare with the changes in the life cycle of other living things?

Conceptual Statement:

All living things have a predictable life cycle that is characteristic of the species. Within a life cycle, all living things change as they grow.

Conceptual Learning Sequence:

This lesson is part of a conceptual unit on life cycles. It follows an introductory lesson that addresses the concepts that all living things reproduce their own kind and have offspring that either resemble their parents from birth, or through a series of body changes.

Student Outcomes:

- Students learn about the stages in a butterfly's life cycle and recognize the similarities/differences to the life cycle stages of other living things.
- Students observe the life cycle of a butterfly and compare this life cycle to those of other living things.
- Students use "Graphic Outlining" to illustrate information from a fictional story and compare this information to their observations.

Lesson Overview:

In this lesson, students review their prior knowledge that living things produce offspring that resembles their parents and extend their understanding that all living things have life cycles. Students observe the life cycle stages of a live butterfly over several weeks and use "Graphic Outlining" to record the butterfly's stages of metamorphosis. Reading *The Very Hungry Caterpillar*, students continue to use "Graphic Outlining" to sequence the stages of the life cycle. Students compare their observations with the story, and identify and explain the stages of the life cycle. Students then compare the changes they observed with the life cycle of a frog and two other living things.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

The book, *The Very Hungry Caterpillar*, is used in the EXPLORE stage in the learning cycle. It is placed after the students make their first exploration with real butterflies so that students can compare information gained through their observation with information gained from their text.

Learning Strategy:

Students use the "Graphic Outlining" strategy in their first exploration as they observe the life cycle of a real butterfly. Students continue to use this strategy to record information after reading the literature selection. "Graphic Outlining" is a method for representing information from a text so that the organization and sequence of a text is highlighted. (See Appendix pages 162-163.)

Literature Selection:

Title: *The Very Hungry Caterpillar*
Author: Carle, Eric
Publisher, Year: Putnam Publishing Group, 1984 ISBN: 039921301S
Annotation: This award-winning book illustrates the changes that occur as a caterpillar becomes a butterfly. The activities of the caterpillar in the story include factual information and illustrations of the stages in the butterfly life cycle. The caterpillar in the story exhibits some fictionalized attributes which allow for discussion of how stories sometimes give plants and/or animals attributes which they do not have.
Genre: Fiction

California Science Content Standards:*

Science: Grade 2, Life Science

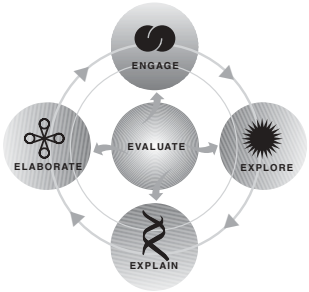
2. Plants and animals have predictable life cycles. As a basis for understanding this concept:
   a. Students know that organisms reproduce offspring of their own kind and that the offspring resemble their parents and each other.
   b. Students know the sequential stages of life cycles are different for different animals, for example butterflies, frogs, and mice.

4. Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

d. Write or draw descriptions of a sequence of steps, events, and observations.
f. Use magnifiers or microscopes to observe and draw descriptions of small objects or small features of objects.

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Science Thinking Process	Suggested Time
ENGAGE	Students observe pictures of animals at various stages in their life cycle and discuss the differences between the stages (newborn, young, adult). Observing, Comparing, Communicating	15 minutes
EXPLORE	Part 1. Students use their senses and hand lenses to observe the various stages of a live butterfly's life cycle. They record and sequence their observations and share their information with other students. 1-2 hours set-up; 30 minute instruction for observations and recording; brief observations for 30-60 days Part 2. Students graphically outline stages as they read (or listen to) *The Very Hungry Caterpillar*. Students identify what is real and not real about the story based on their observations of the live butterfly. Students confirm the names of each stage. Observing, Comparing, Communicating	Extended over time
EXPLAIN	Part 1. Students share their observations of the live butterfly and discuss similarities and differences. Part 2. Students compare their observations and sequences from the live butterfly life cycle with the pictures and sequences from the book and note similarities and differences. Observing, Comparing, Ordering, Communicating	15 minutes 25 minutes
ELABORATE	Students observe and sequence pictures of a frog's life cycle. They make comparisons with the stages of a butterfly's life cycle. Observing, Comparing, Communicating, Applying	30 minutes
EVALUATE	Students research, through books and/or the internet, information about the life cycle of two other living things. Students evaluate their understanding by creating illustrations and sequences for the life cycle stages of each animal. Teacher evaluates student understanding of the student outcomes in this activity as well as throughout the lesson. Observing, Ordering, Communicating, Applying	60 minutes several sessions with adult or older student assistance

Caterpillar Capers

Teacher Background:

Plants and animals have life cycles that are characteristic of their species. In the cycles, living organisms reproduce offspring of their own kind that either resemble the parents from birth or go through distinct stages and eventually resemble the parent. This latter process is known as metamorphosis or change in body shape. Animals such as butterflies, moths and frogs undergo metamorphosis.

In the case of the butterfly or moth, the change is called complete metamorphosis in which the animal changes from an egg to a larva (caterpillar), to a pupa (cocoon/moth; chrysalis/butterfly) and to an adult. The larval stage is a feeding stage; the adult stage is a reproducing stage. In the case of a frog, the animal undergoes incomplete metamorphosis (less than four stages) in which the body changes from an egg to a tadpole to a frog.

Related California Content Standards

Math: Grade 2
Statistics, Data analysis, and Probability
1.1 Record numerical data.
Measurement and Geometry
1.3 Measure an object to the nearest inch and/or centimeter.

Language Arts: Grade 2
Reading Comprehension
2.5 - Restate facts and details in text to clarify and organize ideas.
Writing
2.1.a - Move through a logical sequence of events.
Listening and Speaking
1.7 - Recount experiences in a logical sequence.

English Language Development:
Reading Comprehension
Use the content of a story to draw logical inferences.
Writing Strategies and Applications
Write simple sentences about events and characters from familiar stories read by the teacher.

Grouping: Whole class, partner, individual

Materials:

Per Class

The Very Hungry Caterpillar (big book if possible) or one book per student if they can read the material
Butterfly or other insect (e.g., silkworm) metamorphosis/life cycle kit, live specimens
Terrarium and other items listed in the kit for the butterfly habitat
Pictures of adult and young animals (e.g., whale, human, frog)

Per Partner

Hand lens

Per Student

4 or more copies of Student Page 1.0 (see Teacher Tips)
1 blank sheet of paper (8 1/2" x 11")
Copy of picture cards from Teacher Page 1.0

Advanced Preparation:

1. Order a butterfly/moth kit from a biological (e.g., Carolina Biological, Niles Biological) or local supply company.
2. Use the Internet or other sources to locate real pictures of the stages in the butterfly's life cycle. Duplicate enough picture sets so that each partner has one.
3. Duplicate Student Page 1.0 (see Teacher Tips).
4. Duplicate Teacher Page 1.0 (enough for each student) and cut the butterfly pictures to use in EXPLAIN and the frog pictures to use in ELABORATE.
5. Check websites, books, or magazines for pictures of life cycles of other animals for ENGAGE. Cut out for display (See Teacher Tips).

Teacher Resources:

California Science Framework (pages 128; 144-152) CDE, 1990

Carolina Biological Supply Company, www.carolina.com

Insects, Full Option Science System Module, Lawrence Hall of Science, 1995

Kid Pix Studio, www.kidpix.com

Niles Biological, www.nilesbio.com

Teacher Tips:

- Plan the activity and the learning unit for spring when visible changes in life cycles occur in many species.
- Allow several weeks for the complete butterfly life cycle observation.
- Use the following web sites for additional pictures to use in this lesson:
  - Zoom Butterflies, Enchanted Learning Web Site
    http://www.enchantedlearning.com/subjects/butterfly
  - Life Cycle Master
    http://www.enchantedlearning.com/subjects/butterfly/activities/printouts/lifecycle.shtml
  - London Butterfly House Life Cycle Illustrated page
    http://www.butterflies.org.uk/lbh_home/cycle/lifecycl.htm
  - Butterfly and Moth Printouts
    http://www.enchantedlearning.com/subjects/butterfly/activities/printouts/index.shtml
  - Frog Pictures
    http://www.ccsd.k12.wy.us/Science/04/0403lifecycle.html
- Duplicate at least four Student Pages 1.0 for each student so they can make observations on the four stages (egg, larva, pupa and adult). You might also want to make additional pages so that students can make multiple observations within a stage (e.g., larva as it changes from first appearance to forming the pupa).

Common Misconceptions:

Student may think that:

- Animals and plants have the same form throughout their life cycles.
- Moths and butterflies are the same animal.
- A cocoon and chrysalis is the same item.
- The pupa is a resting stage.

VOCABULARY

adult – a plant, animal, or person that is fully grown or developed

egg – the reproductive cell made by a female animal

fertilized egg – the developing cell formed by the union of the male and female nuclei that begins the life cycle

insect – a small invertebrate animal with a head, thorax, and abdomen

larva – the immature stage of a developing animal between the egg and the pupae stage; often the "feeding" stage (plural: larvae)

life cycle – the complete series of stages or forms that a living thing passes through in its lifetime

metamorphosis – changes in body form that some animals go through as they develop through their lifetime

pupa – an insect in the stage of development between larvae and adult (plural: pupae or pupas)

The Science Learning Cycle:

Caterpillar Capers

Engage:

1. Explain to students that they will be learning about the changes a living thing goes through during its life cycle. Hold up a picture of an adult animal (e.g., whale). Ask students what they think this animal looked like when it was born. When it was young? How is the adult animal like or different than the young animal? Chart the student responses and post the young and adult pictures on the wall. Continue the process in step #1 with two other sets of pictures (human and frog).

2. Ask students how the frog is different from the human or the whale. Chart responses. Summarize that all living things change in their life cycle, some are like their parents when they are born and just grow bigger. Others do not look like their parents when born, but go through body changes as they grow until they look like their parents.

3. Explain to students that they will be observing the life cycle of a living thing - a butterfly over the next several weeks.

Explore:

Part 1

4. Set up the butterfly or moth habitat in an appropriate container (e.g., terrarium) for student observation.

5. Distribute Student Page 1.0 to each student. Provide a hand lens to each student and ask students to make observations of the insect's egg. Ask students to draw and write about their observation on their Student Page ("Graphic Outlining") on the left side of the page.

6. Continue to provide observation time over several weeks for students as the butterfly/moth goes through its different stages. Ask students to continue to draw and write about their observations and record their information on the left side of additional Student Pages 1.0.

Explain:

Part 1

7. At each stage, ask students to share their observations with the class. Facilitate a discussion on the similarities or differences of their observations.

8. Help students label each of their drawings with the appropriate name for the stage: egg, larva/caterpillar, pupa/chrysalis, adult/butterfly. Add these words to a class word wall.

Explore:

Part 2

9. Show the cover of *The Very Hungry Caterpillar* to students. Ask students to predict what the story is about. Chart student responses.

10. Ask students to pay attention to the changes that happen to the caterpillar in the story as you read aloud or have students read. After reading, ask students to tell what they observed about the butterfly and chart their responses. (Example - It doesn't look like a butterfly until the end of the story. It started as an egg. It eats a lot of food. A caterpillar turns into a butterfly, etc.). This is an opportunity for EL to use the content of a story to draw logical inferences.

11. Ask students what they thought was real in the story. What did they think was not real or accurate? Chart their responses. (Example - The stages of the cycle are real, but the food the caterpillar eats is not.) Explain to students that sometimes an author mixes real information with parts that are not real. It is important to realize what parts are "make-believe" and what parts are factual when reading books about living things.

12. Explain to students that they will review the story by just looking at the pictures. Slowly turn the pages and ask students to tell you to stop every time the butterfly changes. As a group, ask students to name the stage in the picture, beginning with the egg.

The Science Learning Cycle: Caterpillar Capers

Explain:

Part 2

13. Distribute picture cards from *The Very Hungry Caterpillar*. Ask students to glue on the right side of Student Page 1.0 the correct picture card that corresponds to the stage that they recorded from their observations.

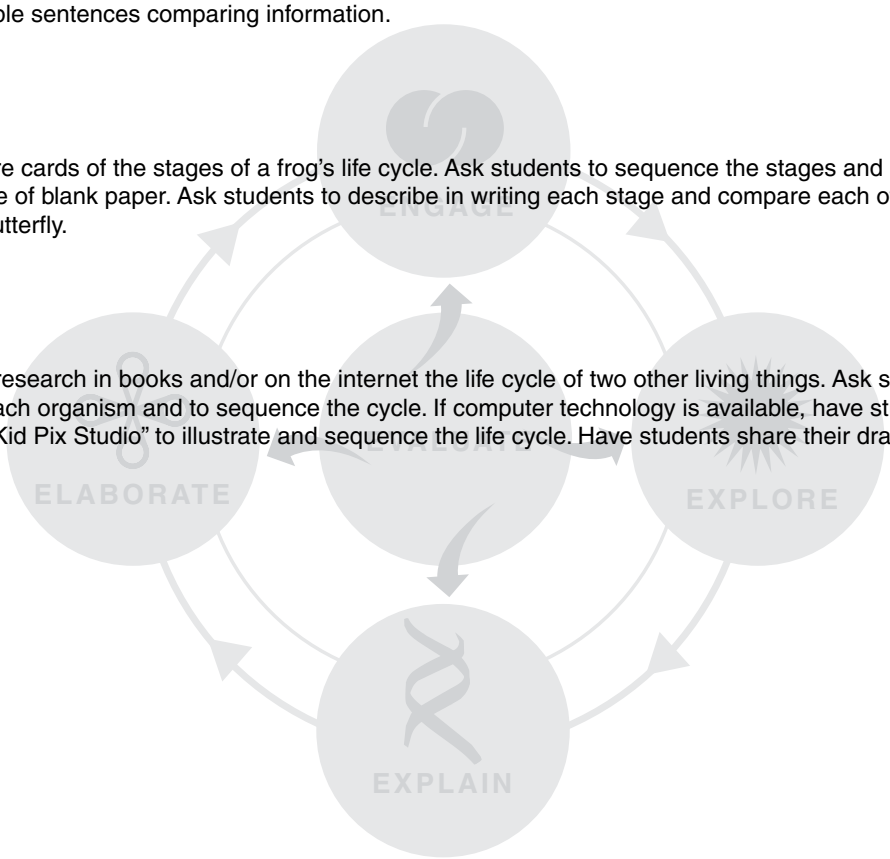
14. Have students compare their observations with the pictures from *The Very Hungry Caterpillar*. How are they alike? How are they different? Ask students to write their ideas on the right hand side of Student Page 1.0. This is an opportunity for EL to write simple sentences comparing information.

Elaborate:

15. Distribute picture cards of the stages of a frog's life cycle. Ask students to sequence the stages and glue pictures in order on a piece of blank paper. Ask students to describe in writing each stage and compare each of the stages with the stages of the butterfly.

Evaluate:

16. Have students research in books and/or on the internet the life cycle of two other living things. Ask students to illustrate the stages of each organism and to sequence the cycle. If computer technology is available, have students use a program such as "Kid Pix Studio" to illustrate and sequence the life cycle. Have students share their drawings.

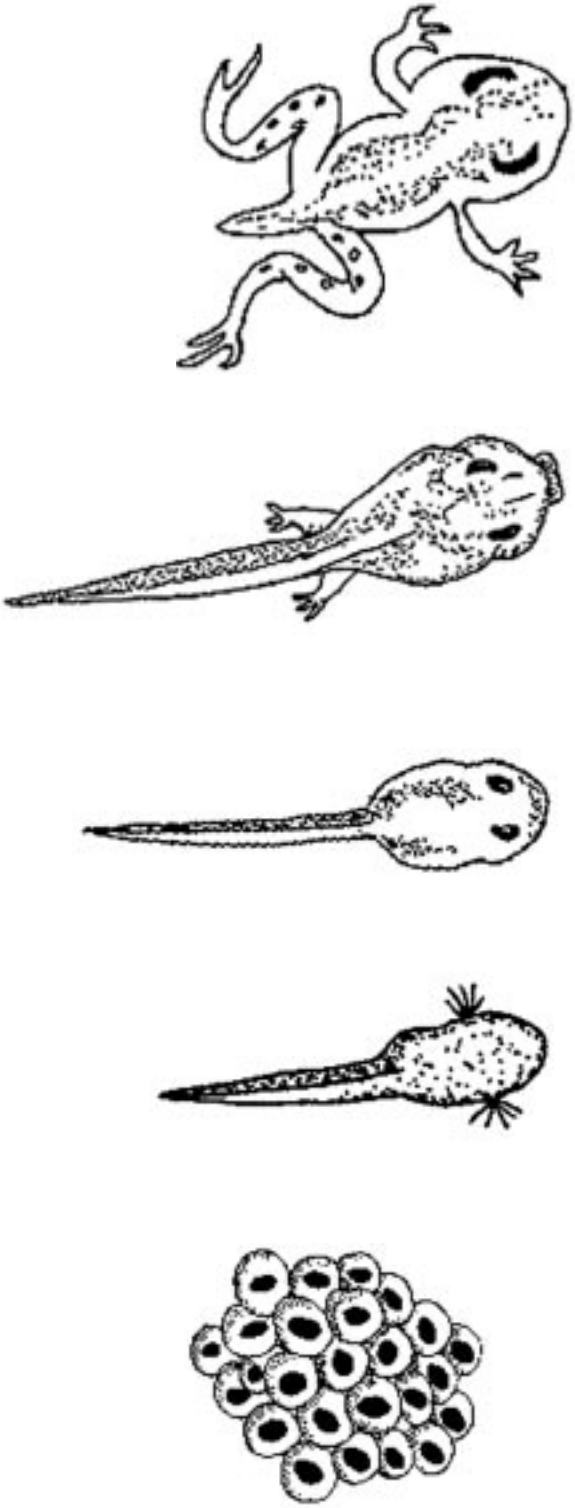


Teacher Reflection:

1. How does the student work provide evidence that they learned that all organisms have a life cycle with identifiable stages and can explain the four stages in the butterfly's life cycle?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts?
4. How would you modify instruction to ensure understanding of student outcomes by all students?

TEACHER NOTE:

Place similar pictures of life cycle from "Very Hungry Caterpillar."



Picture from *The Very Hungry Caterpillar*

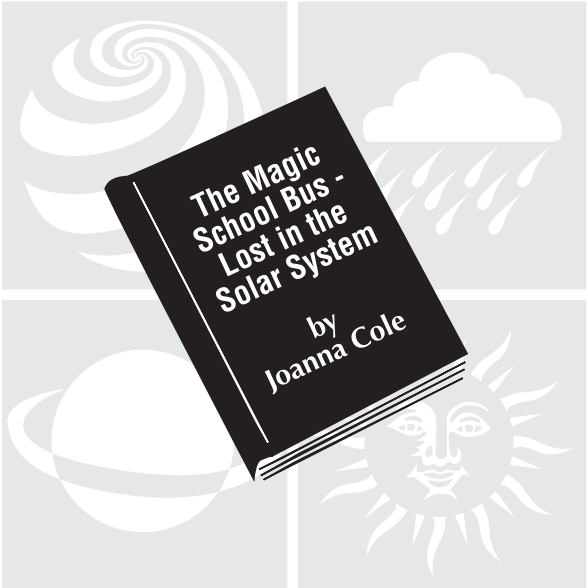
Alike	Different

Observations From the Live Butterfly

My Observations

Grades

3-5



Strategic Science Teaching

Grades 3-5

Grade	Lesson Title	Book Title	Science Standard	Language Arts Standard	Math Standard	English Language Development (ELD) Standard	Learning Strategy	Literature in the Learning Cycle "E"	Science Thinking Process	Pages
3	Moon Motion	The Magic School Bus: Lost in the Solar System	Earth 4b, d Physical 1d, 2b Investigation & Experimentation 5a, b	Reading 1.6, 2.3, 2.6	Number Sense 1.0, 3.1	Reading Comp.	Contextual Redefinition	Engage	Relating Communicating Inferring Observing Ordering Comparing	39-52
4	Who Eats What?	Who Eats What? Food Chains and Food Webs	Life 2a, 3c Investigation & Experimentation 6c	Reading Comp. 2.1 Writing Strategies 1.3, 2.1a	N/A	Reading Comp. Writing Strategy & Application	Graphic Outlining	Engage Explain	Applying Communicating Evaluating Inferring Observing Organizing	53-62
5	Unlocking Mysteries	Marie Curie's Search for Radium	Physical 1c, f, l Investigation & Experimentation 6c, f,	Reading Comp. 2.1, 2.2 Writing 2.3	N/A	Writing Language Arts	Guided Reading	Explore	Observing Comparing Communicating Inferring Applying Relating	63-72

Title of Lesson:

Moon Motion

Essential Question:

How does the appearance of Earth's moon change in the sky?

Conceptual Statement:

Earth and its moon move in predictable patterns that can be noted by regular observation.

Conceptual Learning Sequence:

This lesson is part of a conceptual unit on the motion of objects in the sky. It is appropriate after students have a general understanding of the kinds of objects in the sky and that observation can reveal patterns. This lesson introduces the study of observable patterns of Earth's moon.

Student Outcomes:

- Students demonstrate their understanding of how the moon changes during a month.
- Students observe and record the phases of the moon during a 6-week period.
- Students use "Contextual Redefinition" to find word meanings using context within the literature selection.

Lesson Overview:

In this lesson, students use the learning strategy "Contextual Redefinition" with *The Magic School Bus Lost in the Solar System* to check their understanding of unknown or difficult words. This literature selection provides an overview of facts and concepts found in an instructional unit about Earth and its moon. Students record, describe and sequence the phases of the moon.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

The Magic School Bus Lost in the Solar System is used in the ENGAGE stage. The selected reading introduces how the moon shines and how it orbits Earth.

Learning Strategy:

Students use "Contextual Redefinition" as a method of checking their understanding of new vocabulary and related concepts. This strategy encourages students to look for meaning by using context clues. (See Appendix pages 188-189.)

Literature Selection:

Title: *The Magic School Bus Lost in the Solar System*
Author: Cole, Joanna
Publisher, Year: Scholastic, 1990 ISBN: 0590414283
Annotation: In a fantastical field trip through the solar system, facts are presented in a clever manner as the school bus travels past the Sun and around the planets.
Genre: Narrative Fiction.

California Science Content Standards:*

Science: Grade 3, Earth Science

4. Objects in the sky move in regular and predictable patterns. As a basis for understanding this concept:
   b. Students know the way in which the Moon's appearance changes during the four-week lunar cycle.
   d. Students know that Earth is one of several planets that orbit the Sun and that the Moon orbits Earth.

Science: Grade 3, Physical Science

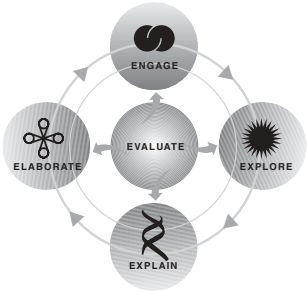
1. Energy and matter have multiple forms and can be changed from one form to another. As a basis for understanding this concept:
   a. Students know energy comes from the Sun to Earth in the form of light.
2. Light has a source and travels in a direction. As a basis for understanding this concept:
   b. Students know light is reflected from mirrors and other surfaces.

5. Investigation and Experimentation

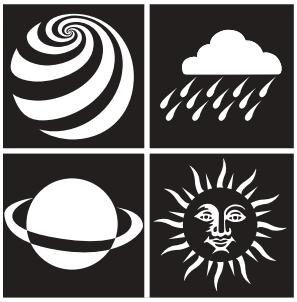
Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

a. Repeat observations to improve accuracy and know that the results of similar scientific investigations seldom turn out exactly the same because of differences in the things being investigated, methods being used, or uncertainty in the observation.
b. Differentiate evidence from opinion and know that scientists do not rely on claims or conclusions unless they are backed by observations that can be confirmed.

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Science Thinking Process	Suggested Time
ENGAGE	Students engage in a discussion on why the students' pictures of the moon look different and find contextual clues from the reading to understand the meanings of new vocabulary. Observing, Communicating, Comparing	30 minutes
EXPLORE	Students predict, then observe and record how the moon looks each day for 4 weeks. Observing, Communicating, Comparing	4 weeks
EXPLAIN	Students explain how the moon changes during the month by sequencing moon phase pictures of their observations. They provide evidence of the moon's phase-change pattern. Communicating, Comparing, Relating	45 minutes
ELABORATE	Students predict the appearance of the moon for the next 2 weeks. Then, they make observations and discuss their findings in relationship to their prediction. Students participate in a physical model that demonstrates the relative position and motion of the sun, Earth and moon. Observing, Communicating, Comparing, Relating, Inferring	2 weeks
EVALUATE	Students further demonstrate their understanding by making a flip-book of the phases of the moon to share with their parents. Teacher evaluates student understanding to inform instruction in the EXPLAIN and ELABORATE stages. Communicating, Ordering, Relating	45 minutes



Moon Motion

Teacher Background:

On Earth, we can observe important clues that provide evidence that phases of the moon are caused by the moon's position relative to the sun. Like the sun and stars, the moon rises east and sets west, as a result of Earth's rotation from west to east. Every day, the moon rises about 50 minutes later, on the average, than the day before. This daily retardation brings the moon out of step with the sun and then into step again over a period of a month or, more exactly of 29.5 days. The moon's appearance is evenly spread over night and day over the course of a complete lunar cycle. The moon's phases can be understood as it is followed throughout one complete period as described below.

NEW MOON: When the moon is between Earth and the sun and appears in the same region of the sky where the sun is. Therefore it rises, roughly, when the sun rises and sets when the sun does. A New Moon is strictly a day fixture and the only reason we don't see it is that the sunlight falls on the far side of the moon.

WAXING (NEW) CRESENT: A few days after New Moon, because of the daily retardation, the moon rises a few hours later than the sun and appears as a narrow crescent, lighted from the right, just before noon. It is in the sky during the day, and follows the apparent movement of the sun across the sky. In this phase, the New Crescent and the sun appear in close proximity.

FIRST QUARTER: About seven days after New Moon, the moon appears half by day and half by night. It rises about 6 hours later than the sun and appears to follow the sun about half the sky away from the sun. It is typically called "half-moon" even though the technical expression is First Quarter. As the moon continues to wax it becomes Gibbous (from Latin *gibbus*, hump).

GIBBOUS (NEW GIBBOUS): Rising later in the afternoon, the moon appears Gibbous into the small hours of the morning.

FULL MOON: Two weeks after the New Moon, we observe Full Moon rising at about sunset. It is opposite the sun in the sky, and sets at about sunrise.

LAST QUARTER: The moon begins to wane and is again gibbous, with its left side lit by the sun until it reaches its Last Quarter (commonly know as a "half-moon"). The Last Quarter, observed more than three weeks after New Moon, rises in the middle of the night and sets around noon.

WANING (OLD) CRESCENT: Rising about 50 minutes later each night, the moon becomes a narrow crescent, shaped like a "C" (when waxing, the crescent was shaped like the curved part of a "D"). It can be observed in the afternoon sky, followed by the sun.

The moon always turns the same side to Earth. We observe the moon as reflected sunlight which varies with the relative positions of the moon and the sun (see description above for each phase). The moon's orbit is not in the same plane as Earth's orbit; it is slightly inclined against the orbit of Earth. If the orbit were on the same plane, we would observe a solar eclipse at every New Moon and a lunar eclipse at every Full Moon. Eclipses and phases of the moon are different phenomena.

Related California Content Standards

Math: Grade 3

Number Sense
1.0 Students understand the place value of whole numbers.

Number Sense
3.1 Compare fractions represented by drawings or concrete materials to show equivalency and to add and subtract fractions in context.

Language Arts: Grade 3

Reading
1.6 Use sentence and word context to find the meaning and other features of unknown words.
2.3 Demonstrate comprehension by identifying answers in the text.
2.6 Extract appropriate and significant information from the text, including problems and solutions.

English Language Development: Grade 3

Reading Comprehension
Read and listen to simple stories and demonstrate understanding by using simple sentences to respond to explicit detailed questions.
Read and use detailed sentences to orally identify main ideas and use them to make predictions and provide supporting details for predictions made.

Grouping: Whole class, groups of 4, groups of 2, individuals

Materials:

Per Class:

Overhead transparency of Teacher Page 1.0
Class Moon Phase Calendar (Enlarged Student Page 1.0)
Index cards, 4x6
Glue sticks
Stapler
Lamp with bare light bulb

Per Group of 4:

Enlarged row only of Moon Phase Calendar (Student Page 1.0)

Per group of 2

Dictionary

Per Individual:

The Magic School Bus Lost in the Solar System
2 Moon Phase Calendars (Student Page 1.0)
Lunar Flipbook (Student Page 2.0)
8, 4x6 Index cards cut in half (large enough for flip book-see Student Page 2.0)
Styrofoam/polystyrene ball, 3"
Pencil
Glue stick

Advanced Preparation:

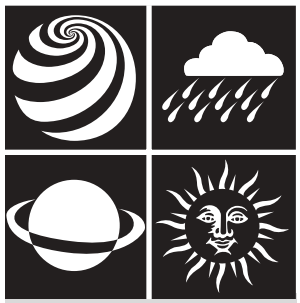
1. Duplicate materials as indicated.
2. Assemble Teacher Page 1.0 Transparency as indicated at the bottom of the page.
3. Identify the words you want the students to focus on using "Contextual Redefinition."
4. Enlarge and cut strips of top row only from Moon Phase Calendar (Student Page 1.0), one per group of four.

Teacher Resources:

Daily newspaper: weather section, including moon phases.
Great Explorations in Math and Science (GEMS) "Earth, Moon, and Stars," Lawrence Hall of Science, University of California, Berkeley, 1986.
Gerald Foster, *"Look to the Moon," Science and Children* (November/December) Vol. pages 30-33, 1996.
Science Framework for California Public Schools, California Department of Education 1990 and 2002.

Teacher Tips:

- Gather alternate sources of images of the moon. Some suggestions are:
  - Take a picture of the moon each night. Be sure to stand in the same place each night and have a "reference point" in the picture (tree, housetop, etc.).
  - Copy moon phases from a newspaper weather section
  - Use printed images from a web source, magazines or other literature books (See Teacher and Student Resources)
- Check a newspaper or calendar to find the date of the next Full Moon. If possible, schedule this unit to begin three or four days after the Full Moon. During this part of the cycle, the moon will be visible most of the day. If you can schedule the observation activities for the whole class during the morning, when the moon is visible sooner, you will be able to start sooner after the Full Moon and therefore observe for a greater number of days.
- If observations are scheduled for evenings, not all students may observe the moon every night. Use students observations, plus your own.
- Remind students to hold their moon model elevated slightly above their heads during the whole class experience observing the light reflecting from Styrofoam balls as a model of the phases of the moon.



VOCABULARY

Provide still and video images to support understanding of new vocabulary

crater – A bowl-shaped depression on the surface of the moon or a planet caused by the impact of a meteorite

cycle – A period of time between repetitions of an event or phenomenon that occurs regularly

gibbous – Seen with more than half but not all of the surface illuminated

gravity – The force that the Earth or another celestial body exerts on any small mass close to its surface

lunar – Relating to a moon or its movement around a planet, especially the moon in relation to Earth

meteorite – a stony or metallic object from space that remains after burning in the atmosphere and strikes a planet

observation – use of the senses or an extension of the senses (e.g., telescope) to acquire information from the environment

orbit – The path that a planet, moon or man-made satellite follows around a larger celestial body such as the Sun

pattern – A regular or repetitive form, order, or arrangement

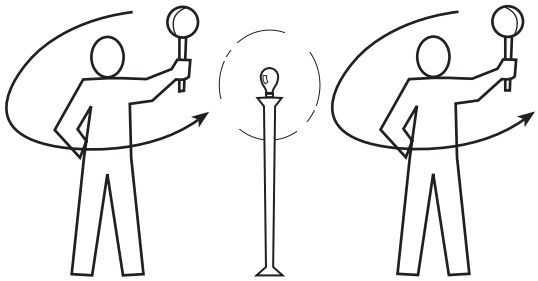
phase – any of the forms, recurring in cycles, in the moon or a planet appearance

reflect – To redirect something (light) that strikes a surface, usually back toward to point of origin

wane – To show a progressively smaller lighted surface, as the moon does when passing from full to new

wax – To show a progressively larger lighted surface, as the moon does in passing from new to full

- Be sure to place the lamp so that its exposed bulb is positioned approximately at students' shoulder height.



In this model the light source represents the sun, the child's head represents Earth, and the syrofoam ball represents the moon.

See ELABORATE steps 20-27.

- A "Word Wall" is a vocabulary reference source kept visible during an entire instructional unit, usually in a bulletin board format.
- Plan a trip to a planetarium for a show on the solar system.

Common Misconceptions:

Students might think that there is a "dark side" of the moon. There is no "dark side." The side we never see is facing way from Earth due to the synchronous rotations of Earth and the moon. A better term is "far side." A New Moon is when the far side is lit.

Related Student Resources:

Asimov, Isaac. *Nuestra luna (The Earth's Moon)*. SM, 1989.

Branley, Franklyn M. *What the Moon is Like*. HarperCollins Children's Books, 2000.

– *The Moon Seems to Change*. HarperCollins Children's Books, 1999.

Rey, H.A. *Find The Constellations*. Houghton Mifflin, 1976.

Silver, Donald M. *The Night Sky (One Small Square)*. McGraw hill, 1998.

Willis, Shirley and FranklinWatts. *Dime porqué cambia de forma la luna (Tell Me Why the Moon Changes Shape)*. 1999.

Lesson Credits:

The lunar calendar graphics in this lesson are from the *What's In the Sky?* curriculum from the Fresno Unified School District, Third Grade Writing Team, 1991.

The overhead solar system diagram is from Tom Campbell of the T.C. Bird Planetarium in Boise, Idaho.

Hands-on ELABORATE activity adapted from GEMS guide, *Earth, Moon, and Stars.*

ENGAGE
EXPLORE
EXPLAIN
ELABORATE
EVALUATE

The Science Learning Cycle:

Moon Motion

ENGAGE:

1. Ask students, individually, to draw a picture of the moon. Select students with different drawings (e.g., Full Moon, Quarter Moons, Crescents) and have them share their drawings with the class. Ask the class "Why do the pictures look different?" Engage students in a discussion by asking questions regarding the differences in the pictures. Focus on the different shapes and the use of descriptive words.
2. Use "Contextual Redefinition" while reading pages 11-13 in *The Magic School Bus Lost in the Solar System* aloud to the class. Use the strategy as follows:
   a. Write these vocabulary words on the board; moon, crater, gravity, meteorite, orbit, reflect, New Moon, Crescent, Gibbous, Quarter Moon, and Full Moon.
3. Have students work in groups of four. Ask students to provide a meaning for each word using a sentence or short paragraph (e.g., The Earth's orbit around the sun is an oval.)
4. Ask groups to share out their contextual definitions.
5. Ask pairs of students to read pages 7-13. Have students focus on the vocabulary words, looking for contextual clues in the illustrations and text to clarify and verify the meaning of the words. Ask students to draw a picture of the words.
6. Ask students to verify and compare their definitions by using a dictionary. Call on several partners to share the meanings they have learned for various words.

EXPLORE:

7. Divide students into groups of four. Provide images of the moon and moon's phases (see Teacher Tips) and ask students to describe and discuss what they see. Encourage students to use accurate math and science vocabulary as they describe the images. As new words are used by the students, add the words to the Word Wall.
8. Distribute an enlarged copy of the top row of blank circles (one week's worth of circles) from Student Page 1.0 to each group. Display a picture of what the moon looked like the night before and ask groups to predict what they think the moon will look like for the next six days. Have groups color their predictions in the circles.
9. Ask groups to share their predictions and explain the information on which they based their ideas. Post the strips. Discuss similarities and differences among the groups' predictions.
10. Distribute a **Moon Phase Calendar** (Student Page 1.0) to each student and assign as homework ongoing observations and recording. Ask students to go outside each day/evening, observe the moon and draw a picture of how it looks for that day's observation. (See Teacher Tips.)
11. After a week of observing the moon, have the students review their observations and compare it with their original prediction. How is their observation like or different than their prediction? Ask students to write at least one sentence describing their observations of the moon so far.
12. Get a consensus from the students as to how the moon looked each day. Ask several students to come to the **Class Moon Phase Calendar Chart** and record the consensus shape for each day. Ask students to draw in the shapes on the **Class Moon Phase Calendar Chart.**

EXPLAIN:

13. Continue to provide time each day during the next four weeks to have students share their daily observations. At the end of each week, get a consensus as to how the moon looked each day for that week and ask students to record shapes on the **Class Moon Phase Calendar Chart**.
14. Ask students to review their four-week observations. What patterns do they notice? How does the shape of the moon appear to change?
15. Ask students to compare their own four-week observations with the **Class Moon Phase Calendar Chart**. What similarities and differences do they notice? How does the shape of the moon appear to change as it approaches the New Moon or the Full Moon?
16. Help students label the phases of the moon on their Moon Calendar. Provide the following words: New Moon, Crescent, Gibbous, Quarter Moon, Full Moon. Remind students that they can use their definitions from the "Contextual Redefinition" and their class discussions to help them identify the phases.

ELABORATE:

17. Based on their four-week observation, ask students to predict what they think the pattern of the moon's appearance will be for the next two weeks. Distribute Student Page 1.0 to each student. Ask students to continue their observations and recordings. At the end of two weeks, have students compare their predictions with their actual observations. How did their observations for the 4-weeks help them understand the 2-week observation?
18. Ask students to think about how the moon's orbit helps explain the pattern that they observed. Ask students to think about how a model might help explain what they have observed. Help students understand that their explanations for phases of the moon are models.
19. Demonstrate a common model for moon phases by placing an exposed light bulb in a lamp in the center of the room at about student shoulder height. Darken the room so that the only light comes from the lamp in the center (the lamp represents the sun in the model).
20. Distribute a Styrofoam/polystryene ball and pencil to each student. Ask students to mount their ball on the pencil point. Explain that the ball represents a model of the moon. Arrange students with their moon model in a circle around the lamp. Explain to students that each of their heads represents Earth in this model.
21. Instruct students to hold their moon models at arm's length, slightly elevated from the shoulder, facing the sun (lamp). Ask students if they observe any reflected light from the lamp on the side of the moon model facing them.
22. Instruct students to move the moon model a little to the left until they can see a thin crescent lit up. Circulate to make sure everyone is holding the moon model a little to the left of the sun.
23. When everyone can see the crescent, ask; "Is the bright curved side of your moon model facing toward the sun, or away from it?" (Toward the sun, just like the actual New Crescent Moon.) Ask students to describe the shape of the reflected light (curved shape of the letter "D").
24. Tell students to continue moving their moon models around their heads in the same direction, until exactly half of the moon is lit. Ask; "To make the moon appear fuller (Gibbous), does it have to move toward the sun or away from it?" (Away from the sun, just as in the actual phases of the moon leading to Quarter Moon.)
25. Tell students to continue moving the moon in a circle until the part they see is fully lit. Remind students to keep their moon model elevated above their shoulders. Ask; "When the moon is full, is it between you and the sun, or on the opposite side of you from the sun?" (It is on the opposite side of you from the sun.) Students continue moving their moon model in the same direction until it is just half-full (Last Quarter). Ask; "As the moon moves toward the sun, does it appear to get fuller or thinner?" (Thinner.)
26. Finally, tell the students to move their moon models so they are very thin crescents (Old Crescent). Explain that most of the time the moon does not pass directly in front of the sun, but just above or below the sun, relative to Earth (their head in this model). When the moon is between Earth and the sun we cannot see it in the day or night since the sun is so bright. When the moon cannot be seen at all, this phase is called New Moon.
27. Have students move their moon models in circles slowly, while standing in the same place, several times until they can fully describe the phases of the moon. The movement of the moon from New Crescent to Full Moon models the two-week period when the moon is visible in the evening. The full circle represents about one month or 29.5 days.

EVALUATE:

28. Distribute Student Page 2.0 and ask students to cut into squares. Ask students to begin with the New Moon and sequence the squares as the moon's appearance changes until a New Moon reappears. Have students mount the pictures on index cards to create a flip-book to share with their family.
29. Ask students to demonstrate the model of the phases of the moon with family members.

Teacher Reflection:

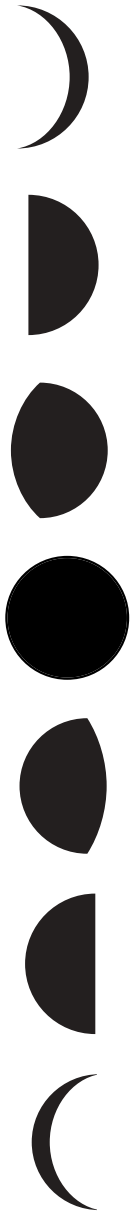
1. How does the student work provide evidence of student understanding that the moon moves in predictable patterns?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts?
4. How would you modify instruction to ensure understanding of student outcomes by all students?

My Moon Phase Calendar

Look for the moon each morning, afternoon, and night.
Draw its shape on your calendar.

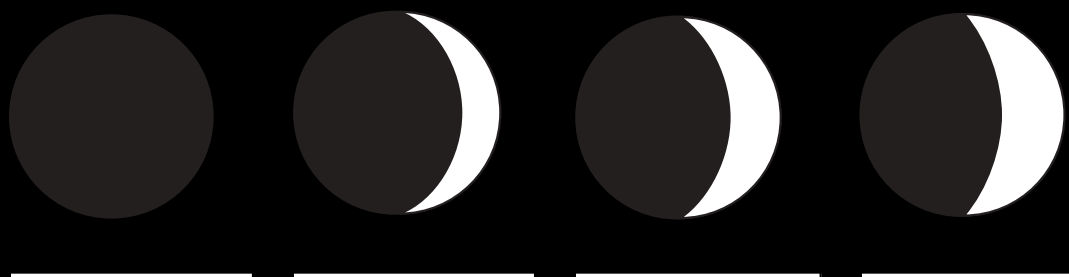
_____
Astronomer

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday



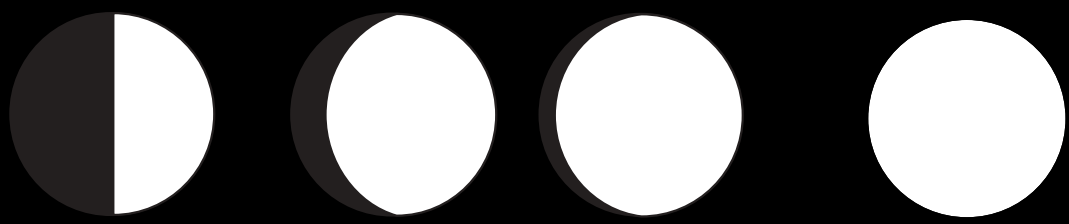
Cut Cut Cut

1 New Moon	2 New Crescent	3 New Crescent	4 New Crescent



Cut

5 Quarter	6 New Gibbous	7 New Gibbous	8 Full Moon

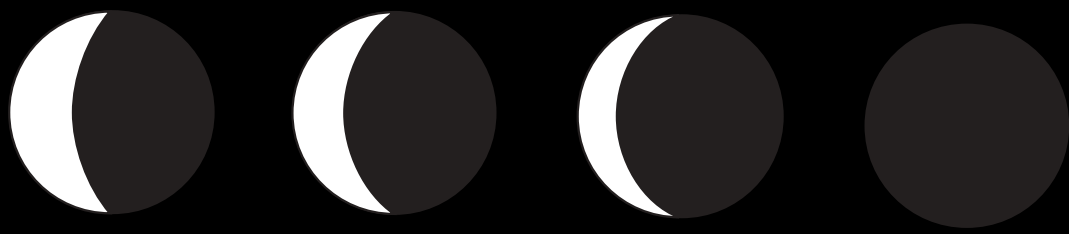


Cut

9 Old Gibbous	10 Old Gibbous	11 Old Gibbous	12 Last Quarter

Cut

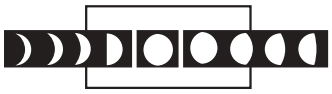
13 Old Crescent	14 Old Crescent	15 Old Crescent	16 New Moon



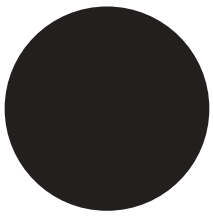
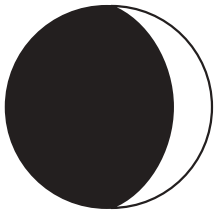
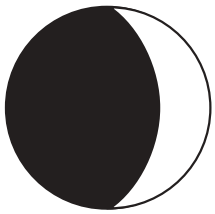
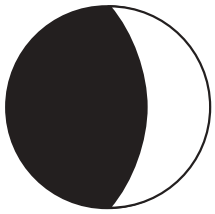
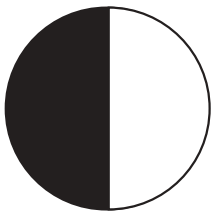
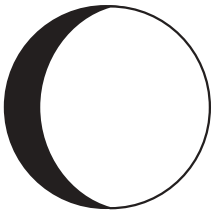
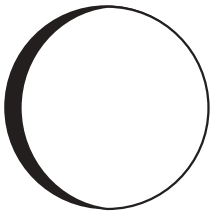
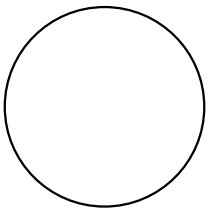
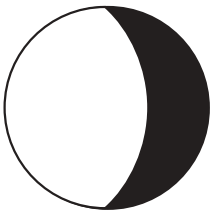
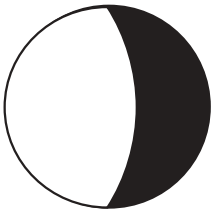
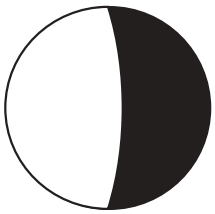
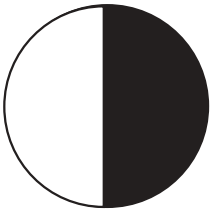
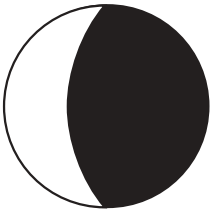
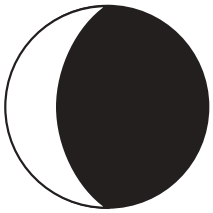
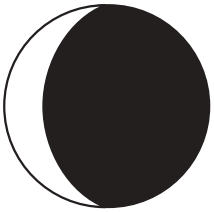
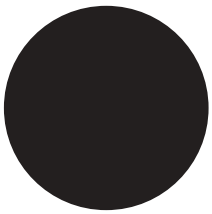
Old is also called Waning

New is also called waxing.

Make a transparency of this sheet. Cut each strip apart, then tape the 4 strips together to make one long strip. Use an index card to make a holder. Pull the transparency through on the overhead to show moon phases.

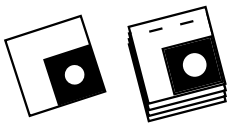


Cut Cut Cut

1 New Moon	**2** New Crescent	**3** New Crescent	**4** New Crescent
			
5 Quarter	**6** New Gibbous	**7** New Gibbous	**8** Full Moon
			
9 Old Gibbous	**10** Old Gibbous	**11** Old Gibbous	**12** Last Quarter
			
13 Old Crescent	**14** Old Crescent	**15** Old Crescent	**16** New Moon
			

Cut Cut Cut

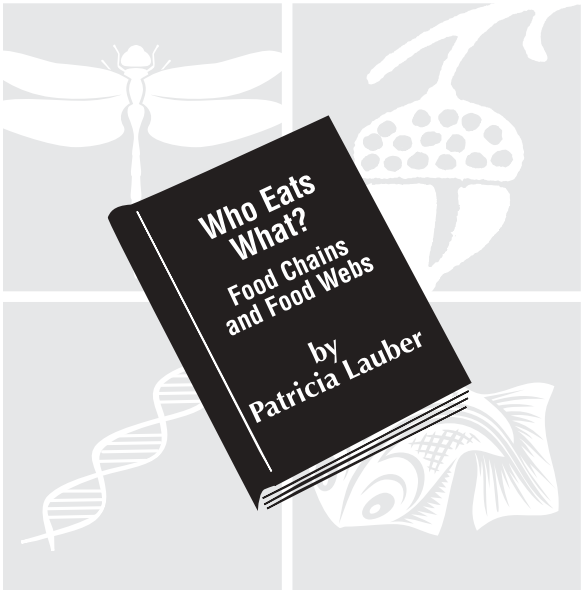
Leave the phases of the moon uncolored. Color all the other areas black.
Cut out the cards and glue them to the bottom corner of 1/2 pieces of index cards.
Staple together to make a flip book



Grade

4

Strategic Science Teaching



Title of Lesson:

Who Eats What?

Essential Question:

How do interactions among organisms within food webs transfer energy through an ecosystem?

Conceptual Statement:

Energy is transferred through food webs. Organisms compete for resources in food webs to obtain the energy and nutrients they need to live and grow.

Conceptual Learning Sequence:

This lesson is part of a conceptual unit on ecosystems focusing on the interactions that occur within ecosystems. It is appropriate after students understand the living and non-living components of an ecosystem; the interdependence of these components; and that all energy comes from the sun.

Student Outcomes:

- Students understand that the sun's energy is transferred from one organism to another in a food web.
- Students gather evidence of who eats what in specific environments and create examples of food webs for those environments.
- Students use "Graphic Outlining" to show the flow of energy in a variety of environments.

Lesson Overview:

In this lesson, students use the learning strategy “Graphic Outlining” to draw a diagram of a typical food chain and a food web for various environments presented in the book, *Who Eats What?* Using paper chains, students construct a 3 dimensional representation of a food chain, and then create a food web by connecting related food chains.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English Learners (EL).

Literature in the Science Learning Cycle:

The book *Who Eats What?* is used in the ENGAGE stage to provide specific examples of organisms and their relationships. It is also used in the EXPLAIN stage for students to compare information gained through the activity with the information in the text.

Learning Strategy:

Students use “Graphic Outlining” to illustrate the relationship of one organism to another by identifying the flow of energy from the sun through various organisms to the top organisms in a food web. Arrows on the graphic organizer show the direction of the flow of energy from one organism to another. (See Appendix pages 162-163.)

Literature Selection:

Title: *Who Eats What?*
Author: Lauber, Patricia
Publisher: Harper Collins Publishers Inc., New York, New York, 1995. ISBN: 0064451305
Annotation: This book introduces the concept of how the sun's energy is transferred from one organism to another, creating food chains and food webs in various environments.
Genre: Nonfiction

California Science Content Standards:*

Science: Grade 4, Life Science

2. All organisms need energy and matter to live and grow. As a basis for understanding this concept:
   a. Students know plants are the primary source of matter and energy entering most food chains.

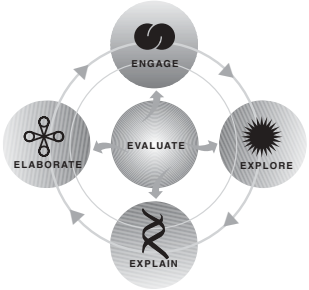
3. Living organisms depend on one another and their environment for survival. As a basis for understanding this concept:
   c. Students know many plants depend on animals for pollination and seed dispersal, and animals depend on plants for food and shelter.

6. Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

c. Formulate and justify predictions based on cause-and-effect relationships.

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Science Thinking Process	Suggested Time
ENGAGE	Students engage in sharing ideas about what humans and tuna have in common, and establish the concept of a food chain. Students read *Who Eats What?* and discuss examples of food chains. Communicating	10 minutes
EXPLORE	Using picture cards, students explore possible arrangements of organisms in food chains. Student groups share and comment on each other's food chains. Observing, Communicating, Organizing, Inferring, Evaluating	20 minutes
EXPLAIN	Students use information from the text and their graphic organizer flow chart to explain a typical food chain and its related energy flow. Communicating, Organizing, Inferring, Applying	50 minutes
ELABORATE	Building on their understanding of interrelationships within an ecosystem, students make a 3-D representation of a food chain and connect the chains to form food webs. Students predict the impact of change on an ecosystem. The web is used as a class bulletin board. Communicating, Organizing, Inferring, Applying	50 minutes
EVALUATE	Students evaluate their understanding by considering other ecosystems and drawing/writing about the food web interrelationships of the organisms. Teacher evaluates student understanding of student outcomes in this activity as well throughout the lesson. Communicating, Organizing, Inferring, Applying, Evaluating	40 Minutes

Who Eats What?

Teacher Background:

All living organisms, including humans, are dependent on the living and non-living things in the environment. There are basic interrelationships among living organisms, which can be illustrated by diagrams, such as food chains and food webs. A typical food chain diagram begins with the sun's light energy being transferred and used by a plant to make its own food in a process called photosynthesis. The plant (producer) is then eaten by a plant eater (herbivore) which in turn, is eaten by various animals (carnivores), one after another, until a top predator completes the food chain. Decomposers will return nutrients, but not energy, to the producer level of the food chain.

Drawings show the interconnectedness of the diets of all organisms and how energy and nutrients are transferred from organism to organism. Arrows are often used to show the flow of energy from one organism to another. The arrow always points from an organism to the one that eats it and can be translated into the words, "is eaten by". For example: worm→bird means, “a worm is eaten by a bird.”

A food web refers to a diagram that connects two or more food chains in a given environment. For example, two different food chains may have crickets in common. Therefore, they may be connected by arrows to show how both food chains are connected and dependent upon the crickets to sustain all the other organisms in both of their food chains. If anything happened to the cricket population in a given area, then all the organisms in both food chains would be at risk. The food webs illustrate the interconnections in nature.

Related California Content Standards

Language Arts: Grade 4
Reading Comprehension:
- 2.1 Identify structural patterns found in informational text (e.g., compare and contrast, cause and effect, sequential or chronological order, proposition and support) to strengthen comprehension.

Writing Strategies
- 1.3 Use traditional structures for conveying information (e.g., chronological order, cause and effect, similarity and difference, and posing and answering a question).
- 2.1.a Relate ideas, observations, or recollections of an event or experience.

English Language Development Standards
Reading Comprehension: Grades 3-5
- Early Advanced - Identify some significant structural (organizational) patterns in text, such as Sequence/chronological order, and cause/effect.
- Advanced - Identify significant structural (organizational) patterns in text, such as compare/contrast, cause/effect, and sequence/chronological order.

English Language Develpment Standards
Writing Strategies & Applications
- Early Intermediate: Use drawings, pictures, lists, charts, and tables to respond to familiar literature using simple sentences.

Grouping: Whole group, groups of 2-4

For hands-on activities, mix EL with fluent native speakers. For debriefing, partner at least two EL with fluent native speakers to form discussion groups.

Materials:

Per Class:

Paper for Word Wall (See Teacher Tips)
Pictures or illustrations of various ecosystems
Terrarium with appropriate organisms (optional)

Per Group:

1 Whiteboard or large piece of butcher paper
2 Dry erase markers
Picture card sheet (Student Page 1.0)
Scissors

Per Student:

Book: *Who Eats What?*
6 Strips of construction paper, 2" x 12": 1 yellow; 1 green; 4 additional all the same color
Glue stick
Crayons
2 Large paper clips
Science journal/notebook
1 copy of Student Page 1.1

Advanced Preparation:

1. Pre-cut enough strips for each student (see Per Student Materials)
2. Make a sample of the 3-D paper food chain following these directions:
   - Cut 6 strips of paper the same as in the per-student materials.
   - Label the yellow strip "Sun's Energy". Make a circle with this strip and glue it shut.
   - Write the name/drawing of a plant on the green strip. Link it to the sun and glue it shut.
   - Continue with the four other strips. Select names/drawings of animals that belong in the food chain and label each strip with one of these animals.
3. Link the strips in order of who eats whom, gluing each link shut.

Teacher Resources:

Terrarium: www.carolina.com
FOSS: *Environments*, Delta Education

Teacher Tips:

- A Word Wall is used to record vocabulary words and definitions. The words are added to the wall as the lessons progresses.
- When making the food webs make sure students link food chains together where they share the same organism. For example, if both food chains have crickets in them, clip together the links that say "crickets." Students can use string or yarn instead of paper clips.
- Share the student booklets with the library so that other students can enjoy the learning from this lesson.
- Before teaching this lesson, review the "Graphic Outlining" in the Appendix for detailed instruction on how to use this strategy.

Common Misconceptions:

Students often omit the sun when constructing examples of webs. Food webs begin with the sun as the primary energy source for green plants.

Students often use the terms food chain and food web interchangeably. Food chains are linear, indicating "who eats what" in a specific series. Food webs more accurately represent the complexity of what happens in ecosystems.

Related Student Resources:

Spanish book: Ventura, Piero. *Los alimentos: La evolucion de la alimentacion a traves del tiempo (Food: The Evolution of Food through Time)*; Everest Publishing, Spain, 1994.

VOCABULARY

ecosystem – the organisms that live in a particular place, their relationship with each other, and their interactions with their environment

food chain – a diagram showing the links of who eats whom in a community of living things

food web – a spider web-like diagram showing many interconnecting food chains

predator – an animal that hunts and eats other animals

prey – an animal hunted and eaten by another animal

The Science Learning Cycle:

Who Eats What?

ENGAGE:

1. Show students the back cover of *Who Eats What?* and read the question: what do you and a tuna have in common? Engage students in a discussion about their ideas.

2. Ask students to think about a specific habitat. What are all the living things you might find there? What does each organism eat? Partner students to discuss their ideas of a food chain. Ask partners to share with the class. Ask students to record ideas in their Science Journal/Notebook.

3. Make a “Word Wall” bulletin board. Write each new vocabulary word and its definition on a piece of paper and post to the word wall. Continue to add more words as the lesson continues.

4. Introduce book *Who Eats What?* and ask students to read pages to 4 - 12 by themselves or with a partner. EL students may be paired with fluent native speaking students if needed.
Ask: What is the first link in all food chains? (Sun) What does the "top of the food chain" mean? (e.g., hawk in the prairie ecosystem). Discuss and give examples.

EXPLORE:

5. In groups of 2 or 4, distribute a sheet of picture cards (Student Page 1.0) to each group. Have students cut the cards apart and arrange them in some way to represent a typical food chain.

6. Share and discuss food chains created by student groups. Make sure all chains begin with the transfer of energy from the sun to a plant.

EXPLAIN:

7. Have students read pages 13-16 and 20-27 independently or in pairs.

8. Using pictures from the cards discuss briefly and demonstrate how to illustrate the food chain on the board. Be sure to use the same format as the graphic organizer you are about to distribute. This lesson component supports EL students.

9. Distribute the graphic organizer (Student Page 1.1) to each student. Have students select any environment pictured in the book and draw a picture of typical food chain for that environment. Have students include at least 4 organisms in their food chain, excluding the sun. Remind students that arrows indicate who eats what and the flow of energy.

10. Have students share within their groups and with the whole class. Check for understanding.

11. Have the students read pages 17-19 and pages 28-31 individually or in pairs. Discuss food webs and add "food webs" to the Word Wall. Refer to the food web on page 19 in the book. Have pairs or groups of students make up a food web on their whiteboards or on construction paper. Share with the class.

The Science Learning Cycle: Who Eats What?

ELABORATE:

12. Show the 3-D paper chain model that you made to the class, and explain briefly how you made it.

13. Have groups select a specific ecosystem (either grassland, marine, or forest) for their 3-D paper food chain model. Make sure that each ecosystem has at least two groups of students working on it. Ask each student to make a quick drawing in their Science Journal/Notebook of a food chain within their ecosystem.

14. Distribute 6 strips of paper to each student. Ask students to label the yellow strip: Sun's Energy, bend it into a circle and glue the ends together to form a circle.

15. Have students label the green strip with the name/drawing of a plant. Ask them to thread the strip through the first circle so it forms a chain link and glue it closed. Continue labeling each strip with the name/drawing of the animal that comes next in their food chain. Have students continue to build the links as with the plant strip.

16. Have each student share their food chains with other students in their group.

17. Distribute two large paper clips to each student. Have each student examine the food chains of the students in their ecosystem group to see if they have a plant or animal in common. If they do, they can use the paper clips to link their food chains at their common link (e.g., grass to grass; cricket to cricket) to begin to form a food web. (See Teacher Tips).

18. Have each ecosystem group move to another identical ecosystem group and find other possible food web links in their ecosystem. For practical purposes, instruct students to make no more than 3 connections at a particular link.

19. Have the students display their complex food web by placing their food web on the floor or by pinning it to a large bulletin board.

20. Have ecosystems groups share their food webs, and discuss the similarities and differences among food webs.

21. Ask students to write a paragraph in their Science Journal/Notebook describing their ecosystem and the relationships among the organisms in their food webs.

22. Ask students to predict what will happen if a specific animal is removed from the food web. Ask them to also predict what will happen if a plant is removed from the web. Ask students to draw their food web on a whiteboard and indicate the impact of their predictions. Have groups share.

EVALUATE:

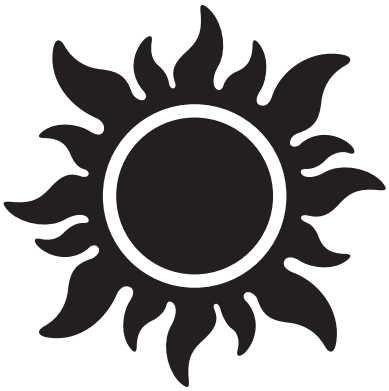
23. On the following day, take students outside and ask them to look for evidence (e.g., chewed leaves, droppings, nests, and holes in the ground) of plants and animals that could be a part of a food web.

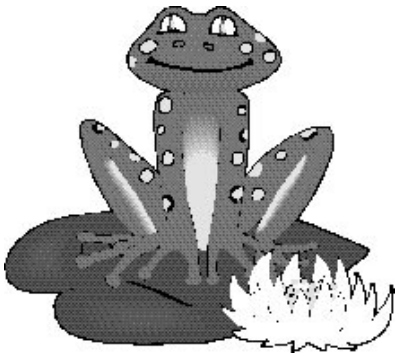
24. Construct a classroom terrarium and conduct observations over the course of several months relating to the flow of food energy within the terrarium.

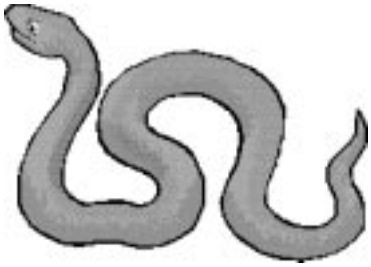
25. Have students write a summary, story, or mini-booklet about the food webs that they have observed over the course of study.

Teacher Reflection:

1. How does the student work provide evidence of student understanding of food webs and energy flow through an ecosystem?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How did the literature selection support student understanding of the science concepts?
4. How would you modify instruction to ensure understanding of student outcomes by all students?







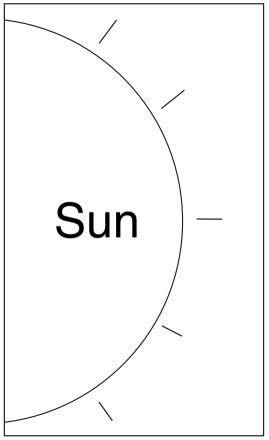
Who Eats What?

Name: _____

Draw and label a food chain in an environment that was shown in the book, *Who Eats What?* (Or select an environment of your own to draw.)

1. Write the names of the plants and animals that are in your food chain on the lines below.
2. Draw an arrow from the plant or animal to the animal who eats it.

Type of Environment: _____

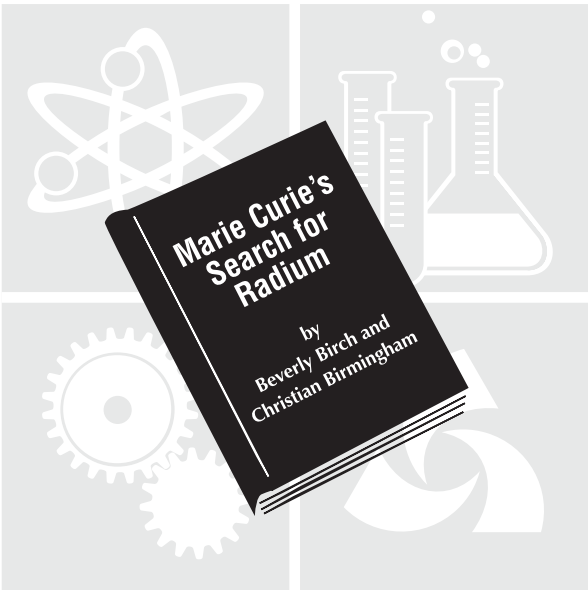


_____	_____	_____	_____	_____
Plant	**Plant Eater**	**Animal**	**Animal**	**Animal**

Grade

5

Strategic Science Teaching



Title of Lesson:

Unlocking Mysteries

Essential Question:

What are physical and chemical properties of some common elements?

Conceptual Statement:

Elements and their compounds account for all the varied types of matter in the world. These elements are organized in the periodic table based on their chemical and physical properties.

Conceptual Learning Sequence:

This lesson is part of conceptual unit on matter. It is appropriate after students understand that matter occurs in three states, is made of smaller particles (atoms), and has observable physical and chemical properties.

Student Outcomes:

- Students learn that matter can be identified by its properties, and that the periodic table organizes elements based on their properties.
- Students select appropriate tools and tests to observe and identify properties of common elements.
- Students use “Guided Reading” to connect the information in the literature selection to their own scientific investigation.

Lesson Overview:

In this lesson students separate a mixture of sand, iron, copper, and aluminum into the different materials, and investigate the properties of those materials. Students identify which materials are elements identified on the periodic table and which are not. Students explore by reading the process used by a scientist to identify properties of an unknown, and to purify small amounts of an element present in a mixture. Students use tools and tests to identify properties of an unknown material.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

The book *Marie Curie’s Search for Radium* is used with “Guided Reading” in the second EXPLORE stage. The literature connects the student’s experience with separating a mixture to that of a scientist.

Learning Strategy:

“Guided Reading” combines reading and teacher questions to help students apply their cognitive skills of predicting and confirming text information. The strategy guides students to connect text information with scientific investigation. (See Appendix pages 164-166.)

Literature Selection:

Title: *Marie Curie's Search for Radium*
Author: Beverly Birch and Christian Birmingham
Publisher: Barron's Publishers, 1996 ISBN: 0812097912
Annotation: The story of how Madame Curie’s persistence and determination proved the existence of radium.
Genre: Biography

California Science Content Standards:*

Science: Grade 5, Physical Science

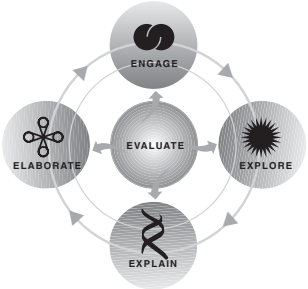
1. Elements and their compounds account for all the varied types of matter in the world. As a basis for understanding this concept:
   c. Students know metals have some properties in common, such as high electrical and thermal conductivity. Some metals, such as aluminum (Al), iron (Fe), nickel (Ni), copper (Cu), silver (Ag) and gold (Au), are pure elements; others, such as steel and brass, are composed of a combination of elemental metals.
   f. Students know differences in chemical and physical properties of substances are used to separate mixtures and identify compounds.

6. Investigation & Experimentation

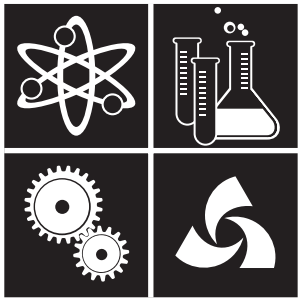
Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

c. Plan and conduct a simple investigation based on a student-developed question and write instructions others can follow to carry out the procedure.
f. Select appropriate tools (e.g., thermometers, meter sticks, balances, and graduated cylinders) and make quantitative observations and conduct tests.

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Science Thinking Process	Suggested Time
ENGAGE	Students engage in observing properties of a metal and locate it in the periodic table. Observing, Comparing, Communicating	45 minutes
EXPLORE #1	Students explore and separate a mixture of compounds and elements, and record properties on a data table. Observing, Comparing, Ordering, Communicating	45 minutes
EXPLAIN #1	Students explain information from the data table to locate placement of elements in the periodic table. Communicating, Comparing, Ordering	30 minutes
EXPLORE #2	Students, guided by the teacher, explore the literature selection to understand the author's intention. Communicating, Relating	60 minutes
EXPLAIN #2	Students explain connections between their investigation and the literature selection. Communicating, Relating	30 minutes
ELABORATE	Students apply skills and knowledge learned in this lesson to a new material (magnetite) and record their data. Observing, Comparing, Ordering, Communicating, Inferring	30 minutes
EVALUATE	Students evaluate their understanding by comparing the processes they used to those used by Madame Curie. Teacher evaluates student understanding of student outcomes in this activity as well throughout the lesson. Relating, Applying	15 minutes



Teacher Background:

All matter is made of atoms, which have definite physical and chemical properties. Each element is made of one kind of element, and the elements are organized in the periodic table according to their chemical properties.

The periodic table groups elements that have similar properties such as the metals, non-metals, and the noble gases. Dimitri Mendeleev, a Russian chemist, discovered the pattern used to create the periodic table.

The relatively small number of elements combine to form the millions of different kinds of materials in the world. These compounds are formed when two or more different atoms join to make a particular substance having its own physical and chemical properties. For example, water (a liquid that puts out fires) is a compound formed from hydrogen (an explosive gas) and oxygen (a gas necessary for fires).

Mixtures consist of several different compounds and/or elements, and can usually be separated by using different physical processes. These processes include sorting by size, solubility, magnetism, or evaporation. For example, sand and salt can be separated by adding water, filtering out the sand, and boiling the water to recover the salt.

Simple tests can be conducted to determine physical properties of elements and compounds. A magnet can be used to determine if a substance has magnetic properties (contains iron, cobalt or nickel). Battery and wires can be used to determine properties of electrical conductivity of a substance. A hammer can test malleability of a substance.

Related California Content Standards

Language Arts Grade 5

Reading Comprehension

2.1 Understand how text features make information accessible and usable.

2.2 Analyze text that is organized in sequential or chronological order.

English Language Development Standards

Advanced - Use text features such as format, diagrams, charts, glossaries, indexes, etc., to locate and draw information from text.

Early Advanced - Identify some significant structural (organizational) patterns in text, such as sequence/chronological order, and cause and effect.

Writing

Early Intermediate - Follow a model given by the teacher to independently write short paragraphs of at least four sentences.

Groupings: Whole group, groups of 4, Partners

For hands-on activities, mix the EL with the native speakers. For debriefing, include at least two EL with native speakers to form discussion groups.

Materials

Per Class:

1 Piece of scrap iron (palm-size, rectangle preferred)
1 Hammer with a rubber tip
1 Magnet
Balances and other measuring tools
1 D-cell battery, thin copper wire (ends stripped), 1.5-volt light bulb
Large periodic table with pictures of elements
Sand, iron filings, aluminum foil, copper wire for group mixture (see below)

Per Group:

1 Cup of mixture (sand, thin copper wire cut up into small pieces, small pieces of aluminum foil, iron fillings) in a container
1 Magnet (small bar or doughnut)
1 1.5 volt light bulb
1 D-cell battery
2 Pieces of thin copper wire (ends stripped)
1 Piece (6" x6") of 1/4" screening material
Chart paper or butcher paper for sorting placemat
Tray
Magnetite (use as the unknown)
1 Metric ruler

Per Student:

1 Student Page 1.0
Safety goggles
Book: *Marie Curie's Search for Radium*

Advanced Preparation:

1. Combine materials for sorting activity in EXPLORE #1 for each group:
   - Cut up thin copper wire into pieces about 1/2 inch long
   - Cut up aluminum foil into pieces about 1/4 inch square
   - Combine above pieces with a cup of sand
   - Add approximately a teaspoon of iron fillings to mixture
2. Set materials on a tray for each group.
3. Obtain a piece of scrap iron for the teacher demonstration in ENGAGE.

Teacher Resources:

Periodic tables with pictures of common uses of the elements can be obtained from Flinn Scientific, Inc. (www.flinnsci.com) and from Carolina (www.carolina.com).

VOCABULARY

atom – the smallest particle of an element that can exist either alone or in combination

compound – a combination of two or more elements with properties that are different from the elements that make it up

dissolve – the distribution of a small amount of one substance into a larger amount of another such that the molecules of the first substance become evenly distributed among the molecules of the other substance

element – the simplest type of a pure substance that cannot be broken down into simpler substances by common chemical or physical procedures

evaporation – a change in phase from a liquid to a gas or vapor

filtering – a way to separate one size particle from another

magnet – something that attracts iron or other metals such as steel and nickel

mixture – a substance made of two or more substances that could vary in amount and are often easily separated (e.g. sand and water)

molecule – the smallest participle of a substance that retains all its properties. a molecule is composed of two or more atoms combined with each other (e.g., H_2, O_2, H_20)

Periodic Table: – an organizational tool that groups elements according to their chemical properties

Teacher Tips:

- Be sure to have each student wear goggles when handling iron filings. They are sharp and can get into the eyes. You may borrow goggles from a local middle or high school if your school does not have a set. Teachers should also wear goggles during preparation.
- Caution students not to blow the mixture. It can get into student's eyes.
- Conduct this activity as an open-ended, problem-solving experiment.
- Place all materials on a central supply table for each group to access as needed and/or place materials on a tray for each group.
- Prompt students to think of other methods than "picking it out" to sort the materials in the mixture.
- Do not distribute the magnetite with the rest of the group material. Leave it for the "unknown" and do not reveal its identify.
- Before teaching this lesson, review "Guided Reading" in the Appendix for detailed instruction for how to use this strategy.

Common Misconceptions:

Students may think grains of sand or a piece of material is an individual atom of an element.
They may think sand is an element; it is however, a compound made of several elements.

Related Student Resources:

BCIT Chemistry Resource Center Alphabetical Elements: http://nobel.scas.bcit.ca/resource

Chemical Society Visual Elements Periodic Table: http://www.chemsoc.org

De Saulles, Tony. *Chemical Chaos*, Nick Arnold, Scholastic Publishers, 1998.

Garcia, Marie. *La caceria de lo inestable: Marie Curie- The Hunt of the Unstable: Marie Curie*, CONACULTA Publishers, Mexico, 1992.

O'Brien, Patrick. *The Hindenburg*, Henry Holt and Company, New York, New York, 2000.

Parker, Steve. *Marie Curie y el radio - Marie Curie and Radium*, Celeste Publishers, Spain,1992.

Yahooligans website - search for Period Table of Elements and uses.

The Science Learning Cycle:

Unlocking Mysteries

ENGAGE:

1. Hold up a piece of scrap iron and engage students in a discussion about the properties of iron. Record properties on chart paper (e.g. dull, dark, metal-like, brown, heavier than an eraser, smooth, etc.). Remind students they have used their five senses to observe the scrap of iron.

2. Ask students to brainstorm any tools that could be used to make additional observations on the scrap iron. Lead students to identify tools such as magnets, hammers, measuring tools, balances, batteries, wires and bulbs for conductivity, etc.

3. Select several students to help test the scrap iron using these different tools. (e.g., use battery, wires and bulb to observe conductivity). If necessary demonstrate how to use each tool. Have class make observations and add these observations to the class chart.

4. Display a large version of the periodic table and locate iron in the table. Point out the line in the table separating the metals and the non-metals. Explain to students that elements in the table are organized according to their properties. Are there more non-metals than metals in the periodic table? (No)

5. Ask students to look around the classroom and identify items that are metal or non-metal. Ask students if there are more metals or non-metals (Non-metals). Explain to students that we observe more non-metals in our class because these items are combinations of elements from the periodic table and they have completely different properties than the original elements. Many of the things in our room would be difficult to separate into their component elements.

EXPLORE #1:

6. Explain to students they will attempt to separate three different elements that are mixed with sand and determine their properties.

7. Distribute materials to each group. Make available a small hammer, measuring tools, and water.

8. Ask students to design a process to separate materials in the sand mixture and then use their process. Ask students to share how they separated their mixture: what types of materials were separated? What properties did you use for the separation of the materials? Chart responses.

9. Direct the students to Student Page 1.0. Ask students to conduct appropriate tests on each of their separated materials and records results.

EXPLAIN #1:

10. When done, ask students to look at their data table and discuss the following questions: Which samples conducted electricity? Which were magnetic? Which samples were malleable? What other properties did you observe? What do the tests tell you about the properties of the samples? (e.g., aluminum is bendable when thin, conducts electricity, shiny, smooth, is not magnetic; iron is magnetic, conducts electricity, black, non-malleable).

11. Ask students to look at the periodic table and identify if any of the materials from their sorting appear. (Copper, iron, aluminum). What materials are not in the table? (Sand)

12. Hold up a baggie of sand and explain to students that sand is a combination of two elements- silicon and oxygen. Show the pictures of silicon and oxygen on the periodic table. Ask students if sand looks like the two pictures on the periodic table? (No)

13. Explain that none of the methods that we used today would separate sand into its component elements, silicon and oxygen. Scientists have learned that sometimes elements are reasonably easy to separate because they exist in an uncombined state like iron and copper. Sometimes it is more difficult because the elements tend to exist combined with other elements or in such small quantities that extraction is difficult.

14. Explain that we will read a story about a woman scientist, Marie Curie, and her husband Pierre Curie, who worked for years to separate a new element from rock.

EXPLORE #2:

15. Introduce the literatures selection *Marie Curie's Search for Radium* by showing students the front and back cover. This is an opportunity for EL to understand information gathered from features of a book. Chart responses to the following questions. Ask Students:
    - What can we tell they about the book from the cover?
    - What do you expect to read about by looking at the cover?
    - Does the text on the back cover give you any clues?
    - Have you read any books similar to this?

    Before reading the selection, briefly show the pictures in the book. Ask students what additional clues the pictures provide?

16. Using "Guided Reading" begin reading to students as they follow along. Ask the following questions after the first page of reading.
    - What do you think Marie and Pierre are looking at? Do you think it is important? Why or why not?
    - Why do you think all the years of struggle and disappointment were forgotten?
    - Where does the author say the treasure came from?
    - Predict what you think you will find out about the treasure in this book.

    Chart responses.

17. Read the next two pages of text aloud. Ask students to partner to discuss things that surprised them. This is an opportunity for EL to hear text read and participate as appropriate. Conduct a whole group discussion using the following questions. Ask Students:
    - What was difficult for Marie Curie? Why do you think she felt like she was reaching the peak of a mountain after climbing for years?
    - After all that studying what did she read about that was very strange? (X-rays)
    - How were those x-rays similar to the properties we observed in our tests? (You can't see them, but find out they exist by using tools.)
    - Predict what test you think she will try on the samples to get the new element separated.

    Chart responses.

18. Ask students to read to their partner the three pages of text. Check the accuracy of the prediction from previous step. Continue to use "Guided Reading" by asking these questions:
    - What tests did Marie Curie try on the samples she collected? (Pounded, dried, checked for electrical currents, mixed with water, heated, cooled)

    Chart responses.
    - No matter what tests she conducted, what did Marie find out about the samples? (If uranium was present there were stronger rays, less uranium less rays)
    - What did she wonder about after conducting the tests? (If other rocks gave off rays).
    - What would you have named these rays?

19. Have students continue partner reading for the next two pages and find out what she named the rays (radioactive). Ask partners to continue reading the next two pages to find out what was four times more radioactive than uranium. Continue to use "Guided Reading" by asking these questions:
    - How did Marie know it was stronger?
    - Why is Marie so excited about the radioactivity? (She thinks she has discovered a new element)
    - Can we locate this element on the periodic table?

EXPLAIN #2:

20. Read aloud to the whole class the rest of the literature selection. Distribute a piece of blank paper to students and ask them to fold in half. Ask students to draw a picture of the sacks of pitch blend on the left side and on the right side, write notes about the process the Curie's used to separate the pitch blend. This is an opportunity for EL to make connections between cause and effect.

21. On the back of their paper ask students to compare the investigation they conducted with the sand mixture to what Marie Curie did in her experiments. How was it different? Use Student Page 1.0 to scaffold discussion.

22. Ask students to look at their predictions (Step #12) about the story. Discuss with students: Was the book what you expected? How was it the same as what you expected? How was it different? EL can make connections between predictions about the story and the actual story.

ELABORATE:

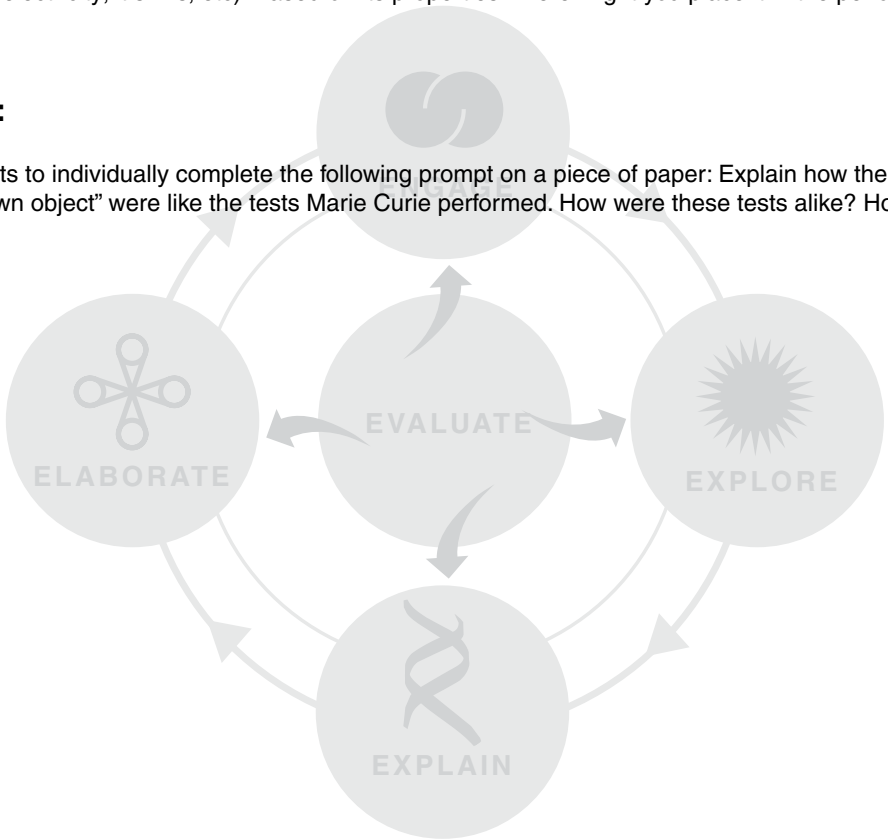
23. Show students the unknown object (magnetite). Explain that this unknown object has not broken down into elements, but contains several elements like the one Marie Curie worked with in her experiments.

24. Ask students what tests they could conduct on this object to determine its properties. Distribute pieces of the "unknown" to each group and ask students to conduct the same tests and record observations on their data chart. (Student Page 1.0)

25. From the tests you were able to conduct, what does your data tell you about the properties of the object? (It is magnetic; it conducts electricity; it sinks, etc). Based on its properties where might you place it in the periodic table: metal or non-metal?

EVALUATE:

26. Ask students to individually complete the following prompt on a piece of paper: Explain how the tests you performed on the "unknown object" were like the tests Marie Curie performed. How were these tests alike? How were these tests different?



Teacher Reflection:

1. How does the student work provide evidence of learning that matter can be described by properties (visible and invisible) and located on the periodic table?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts?
4. How would you modify instruction to ensure understanding of student outcomes by all students?

Unknown Object

Student Name: _____ Date: _____

1. Record properties for each material: copper, aluminum, sand, and iron.
2. Record properties for unknown.

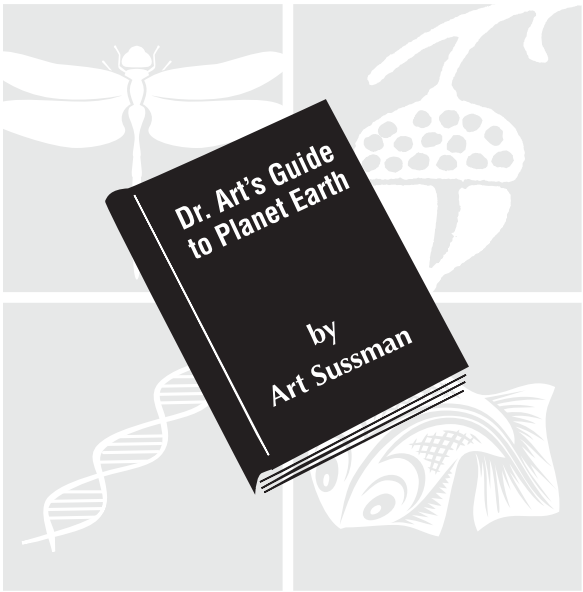
Data Table: Properties of Material

Material	Color	Texture	Malleable	Conducts Electricity	Attracted to Magnet	Sifts through 1/4 inch screen	Size	Bendable
Copper								
Aluminum								
Sand								
Iron								
Unknown								

Grades

6-8

Strategic Science Teaching



Grades 6-8

Grade	Lesson Title	Book Title	Science Standard	Language Arts Standard	Math Standard	English Language Development (ELD) Standard	Learning Strategy	Literature in the Learning Cycle "E"	Science Thinking Process	Pages
6	Quake Safe Homes	Earthquakes	Earth 1c, d, e, g 2d Investigation & Experimentation 7a, b, c, d, g	Reading Comprehension 2.3, 2.4	Statistics, Data Analysis, and Probability 2.4, 2.5	Reading Comprehension	Graphic Outlining Guided Reading	Engage Explore	Observe Communicate Compare Categorize Relate Analyze Infer Apply	73-86
7	How Long Ago Was That?	Dr. Art's Guide to Planet Earth	Earth and Life History 4d, e, g Investigation & Experimentation 7b, d	Reading 1.1	Measurement & Geometry 1.2 Mathematical Reasoning 2.5	Listening & Speaking Reading Word Analysis Reading Fluency and Systematic Vocabulary Development Writing Strategies and Applications	Analogy Graphic Organizer	Explore	Observe Communicate Compare Order Categorize Infer Apply	87-102
8	Chemical Reaction	October Sky	Physical Science 5a, c Investigation & Experimentation 9a, c	Reading Comprehension 2.0 Listening & Speaking 2.2a, b	N/A		Questioning the Author	Engage	Observe Communicate Compare Relate	103-112

Title of Lesson:

Quake Safe Buildings

Essential Question:

How do movements of Earth's surface impact human and wildlife habitats?

Conceptual Statement:

Human habitats can be changed due to earthquakes resulting from plate movements.

Conceptual Learning Sequence:

This lesson is the culmination of a conceptual unit focusing on Earth's plates, the movement of those plates, and the effects of earthquakes on human environments. As the lesson unfolds, students discover how the motion of Earth and the structural design of a building can determine the ability of a building to withstand the powerful force of an earthquake.

Student Outcomes:

- Students review the natural phenomena of earthquakes and learn how the force released in an earthquake can cause structural damage to buildings.
- Students test various structural designs of buildings to determine "quake-safeness."
- Students use "Graphic Outlining" as they review the book *Earthquakes* by Seymour Simon.

Lesson Overview:

In this lesson, students read the book *Earthquakes* and use "Graphic Outlining," to graphically organize information on earthquakes and their consequences. The literature selection serves as a review as well as leading students to predict and discover new information about earthquake motion and its consequences. Students test various structural designs for a building.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

The book *Earthquakes* is utilized in the ENGAGE stage to connect to students' prior knowledge and in the EXPLORE stage to focus the students' investigation on structural stability as it relates to surface motion.

Learning Strategy:

Students use "Graphic Outlining" with *Earthquakes* to highlight the organizational pattern of the text. This strategy helps students organize what they read, leads them to predict what may come next, and integrate the new information they encounter. (See Appendix pages 162-163.)

Literature Selection:

Title: *Earthquakes*
Author: Simon, Seymour
Publisher: William Morrow, 1991 ISBN: 0688096336
Annotation: This book, from award-winning science writer Seymour Simon, examines the mysteries surrounding earthquakes. Why do they happen? Why are they more frequent in certain areas? What can people do to protect themselves and their property? Simon combines a detailed, clear text with actual photographs to provide some surprising answers.
Genre: Nonfiction

California Science Content Standards:*

Science: Grade 6, Earth Science

Plate Tectonics and Earth's Structure

1. Plate tectonics accounts for important features of Earth's surface and major geologic events. As a basis for understanding this concept:
   - c. Students know lithospheric plates the size of continents and oceans move at rates of centimeters per year in response to movements in the mantle.
   - d. Students know that earthquakes are sudden motions along breaks in the crust called faults and that volcanoes and fissures are locations where magma reaches the surface.
   - e. Students know major geologic events, such as earthquakes, volcanic eruptions, and mountain building, result from plate motions.
   - g. Students know how to determine the epicenter of an earthquake and know that the effects of an earthquake on any region vary, depending on the size of the earthquake, the distance of the region from the epicenter, the local geology, and the type of construction in the region.

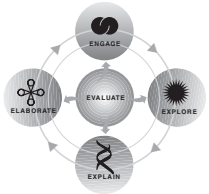
2. Topography is reshaped by the weathering of rock and soil and by the transportation and deposition of sediment. As a basis for understanding this concept:
   - d. Students know earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

7. Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

- a. Develop a hypothesis.
- b. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
- c. Construct appropriate graphs from data and develop qualitative statements about the relationships between variables.
- d. Communicate the steps and results from an investigation in written reports and oral presentations.
- g. Interpret events by sequence and time from natural phenomena (e.g., the relative ages of rocks and intrusions).

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Science Thinking Process, Learning Strategy	Suggested Time
ENGAGE	Students read *Earthquakes* to engage them in thinking about the causes of earthquakes. They graphically outline the literature selection, making connections to their prior knowledge. Communicating, Categorizing	30 minutes
EXPLORE	Students explore the literature selection for evidence of structural damage. They connect photos in the text to a teacher demonstration and the students' own investigation of structural design to determine "quake-safeness." Observing, Comparing, Analyzing	1 hour
EXPLAIN	Students whiteboard, relate their findings, and explain their data to the class while comparing information found in *Earthquakes*. Communicating, Relating, Comparing	1 hour
EVALUATE	Students evaluate their understanding of force and structural design as they build models and test them for structural integrity. Students compare their findings to real scenarios. Teacher evaluates student understanding of student outcomes in this activity as well throughout the lesson. Communicating, Inferring, Applying	2 hours
ELABORATE	Using a variety of resources, students research building destruction caused by earthquakes and relate the building design to "quake-safeness." Communicating, Inferring, Applying	1 hour

Quake Safe Buildings

Teacher Background:

During an earthquake, seismic waves move through the ground, causing it to shake and move. The movement of the ground determines the forces acting upon and transferring to surface structures. Ground motion depends on the magnitude of the earthquake, distance from the epicenter, and local geology. A house built on sandy soil where water is close to the surface will suffer much greater damage than if it were constructed on and bolted to rock.

A building with a mass of thousands of metric tons must withstand tremendous forces that may cause it to sway with a back-and-forth motion. If the forces and the sway of the building are strong enough, the building may faulter, lose its stability and collapse. To overcome the effects of the destructive forces, engineers rely on structural design, types and strengths of building materials, and different methods of anchoring to the ground. A considerable amount of research and testing has been conducted to develop building structures that withstand these destructive forces, and protect people's lives and property.

Grouping: Whole class, groups of 4

For hands-on activities, mix the EL with the native speakers. For debriefing, include at least two EL with native speakers to form discussion groups.

Related California Content Standards

Math: Grade 6 Statistics

Data Analysis, and Probability

2.4 Identify data that represents sampling errors and explain why the sample (and the display) might be biased.

2.5 Identify claims based on statistical data and, in simple cases, evaluate the validity of the claims.

Language Arts: Grade 6

Reading Comprehension

2.3 Connect and clarify main ideas by identifying their relationships to other sources and related topics.

2.4 Clarify an understanding of texts by creating outlines, logical notes, summaries, or reports.

English Language Development Standards: Grades 6-8

Reading Comprehension:

Early Advanced - Identify and explain the main ideas and critical details of informational materials, literary texts, and text in content areas.

Advanced - Identify and explain the main ideas and critical details of informational materials, literary texts, and text in content areas.

Materials:

Per Class (Demonstration Wall)

4 Styrofoam sticks, 3 cm x 13 cm,

4 Bolts #10-32 x 1", 4 Nuts to fit the bolts, 4 Washers to fit the bolts

Per Group

Whiteboard and markers

5 Styrofoam sticks, 3 cm x 13 cm (see Advanced Preparation)

2 Styrofoam sticks, 3 cm x 18 cm (see Advanced Preparation)

6 Bolts #10-32 x 1", 6 Nuts to fit the bolts, 6 Washers to fit the bolts

25 Cubes of sugar

2 oz Cake frosting

Plastic knife

1 Toothpick

1 Spring scale (must measure up to 500 grams)

Graph paper (1 cm scale)

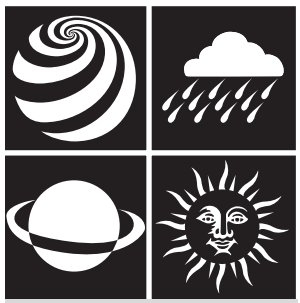
Masking tape

Various building materials for Investigation #2: toothpicks, white glue, cardboard, duct tape, popsicle sticks, strips of heavy paper, hot glue gun, plastic coffee stir sticks, etc.

Board (cardboard, wood, etc.) to attach building from Investigation #2

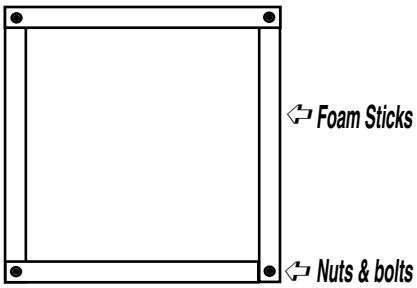
Per Student

Earthquakes by Seymour Simon



Advance Preparation:

1. Purchase a large piece of 1/4" Styrofoam sheet.
2. Prepare a square demonstration wall by cutting 4 foam sticks (3 cm x 13 cm) from the large sheet.
3. Punch a hole in each end of every stick about 1.5 cm from the end.
4. Using #10-32 x 1" bolts, washers and nuts, assemble the sticks to build a wall.
5. From the large sheet, cut 5 foam sticks (3 cm x 13 cm) and 2 foam sticks (3 cm x 18 cm) for each group; punch holes in each of the sticks about 1.5 cm from the end.
6. Duplicate Student Pages 1.0, 1.1, 2.0, 2.1



Teacher Resources:

Skinner, Brian J. and Porter, Stephen C. *The Dynamic Earth, An Introduction to Physical Geology*. John Wiley & Sons, William Morrow and Company, Inc., New York, 1995.

Teacher Tips:

- Draw the "Example Graphic for Earthquakes" (see Teacher Page 1.0) on the board. In your drawing, include only the shapes and titles for students to copy. Do not copy the bulleted text in the example. Instead, use this information as a guide for what students should be gathering from the text/pictures.
- Purchase foam board at craft stores; purchase nuts, bolts and washers at hardware stores.
- Provide time for buildings constructed from glue or frosting to dry before they are tested.
- Decide with the class what it means for a building to be "stressed." Use this description as a guide to observe the amount of force needed to stress the building in Investigations 1 and 2.
- For presentations of the results from Investigation 1, consider having students do a "gallery walk:" have one student stay with the whiteboard to explain the information and have the other members of a group rotate to see/discuss each group's work.
- For the second investigation, pre-determine how large the student projects can be. Provide a variety of materials for students to use in their building.
- Construct a class testing station for Investigation 2: create an edge for the table by taping a ruler or some other board to two sides meeting at a corner of the testing table. Have students place their building against these edges and tape their building to the table. Attach the spring scale to the top corner of the building and pull to measure the applied force.

Related Student Resources:

Disaster Science. Klutz Press, 1998.
Gallant, Roy A. *Earth, The Making of a Planet*. Cavendish Children's Book, 1998.
Pope, Mary. *Earthquake In The Early Morning.* Magic Tree House, July 2001.
Walker, Jane. *Terremotos* (Earthquakes). Aglo Publishers, Spain, 1995.

VOCABULARY

applied force – a push or pull exerted on a body (building)

focus – a point within Earth at which an earthquake originates or starts

force – cause of motion or change

seismic – related to, or caused by an earthquake

seismic waves – energy that moves through the ground after the earthquake happens

waves – rhythmic disturbances that travel through space or matter. In an earthquake, the wave is the movement of the energy released from the earthquake as it moves through the Earth

The Science Learning Cycle:

Quake Safe Buildings

ENGAGE:

1. Ask students, “Have you ever been in an earthquake? If so what did the earthquake feel like to you?” Have students describe what they felt, the motion of the ground, and how long the earthquake lasted. Chart their responses.

2. Link their comments to today’s lesson which is to review some of the causes of earthquakes and to learn more about the effects of earthquakes on structures–particularly buildings.

3. Introduce “Graphic Outlining” by reconstructing the skeleton of the graphic organizer (see Teacher Tips and Teacher Page 1.0) on the board. Ask students to copy it into their notebook.

4. In groups, ask students to brainstorm what they know about earthquakes and have each student write the ideas in the middle oval of his/her graphic outline.

5. Hold up the book, *Earthquakes*. Explain that students will use the graphic outline to extract information from this literature selection and will add that information to their brainstorm. Ask students to scan the text and examine the pictures that deal with causes of earthquakes (use the first ten pages starting with the crooked train tracks ending with the text opposite the map of “Earthquakes Around The World.”). Ask students to add this information to their brainstorm in the middle oval of the graphic outline.

6. Have students share the beginning of their graphic outline with their group.

EXPLORE:

7. Ask students to compare the pictures on pages describing events in Mexico City, Armenia, San Francisco, Niigata, and Anchorage. Have students add to their graphic outline in the appropriate city-box information about the different earthquakes and the structural damage they caused.

8. Ask several students to share their graphic organizer and their understanding of the organization of the text. What new information did they gain from the text about earthquakes or the destruction caused by earthquakes?

9. Discuss with students the similarities they noticed and the damage that was caused. What differences were there? What might account for the types of damage that the students noted? Summarize, noting things like building design, type of soil, and proximity to the focus.

10. Ask students to think of a building (e.g., their house, school, favorite store). What is the structure of the building? What types of materials were used to construct the building? List the various types of structures and discuss that even though the face of a building may be brick or rock, the structure or frame of the building may be wood or steel.

11. Show the demonstration wall to the students and tell them that it represents part of the frame of a building. Ask students to predict what will happen if you quickly push on one of the top corners of the wall. Push and have students observe the results.

12. Discuss the results. Ask students what they think would help the wall to withstand the forces of an earthquake. Be sure to discuss that the strength of any building depends on what it is made of, the construction of the frame and how the building is anchored to the ground.

13. Explain that students will investigate the effect of earthquakes on different frame constructions. Group students into "Seismic Engineering Teams" with two or three students per team. For this activity, be sure to group at least two EL students on the same Seismic Engineering Team.

14. Demonstrate how to attach the spring scale to various walls and to read the applied force on the spring scale. With the class, develop a consistent description of what it means for the wall to be "stressed." Remind students to read the spring scale measurement when and if their wall matches this "stressed" description.

15. Distribute materials for the first investigation and remind students that the instructions for the investigation are on their sheet. If necessary demonstrate how to construct a wall (Student Page 1.0).

16. Provide time for students to construct and test their walls. Ask them to make a bar graph of their results recorded in their data table (Student Page 1.1).

EXPLAIN:

17. Ask groups to synthesize on whiteboards what they learned from their graphic outline, the pictures of building damage in the book, and the results of their investigation. Have groups make a short presentation of their findings (See Teaching Tips).

18. After all the groups have presented, have the class discuss the similarities and differences in their findings. What structural design(s) seemed to work best? How did the sugar cube wall differ from the foam stick frames?

EVALUATE:

19. Using what students learned from their first investigation, the Seismic Engineering Teams will plan, construct, and test the strength of a building in the second investigation (Student Page 2.0 and 2.1). Ask students to read the instructions for this investigation.

20. Discuss your specifications for the project and show students the materials that are available to them. Remind them that they must have teacher approval before constructing their building and to record their progress on Student Page 2.0 and 2.1.

21. Provide time for construction. When teams are ready, explain that they will present their design and test its stability in front of the class.

22. Invite each group to describe to the class their design and the rationale for it. With the class, develop a consistent description of what it means for a building to be "stressed" in comparing their relative structural stability. Ask the class to discuss the designs and predict how they will do on the test.

23. Set up the "testing area" (see description in Teacher Tips). Invite each group, one at a time, to come to the testing area and test their structure. Record the results on a class chart. Continue until all groups have had a chance to test their building. Have students comment on the class results. Which designs worked best? Why?

ELABORATE:

24. As a culminating activity, have students conduct research of building destruction caused by earthquakes. Provide a variety of resources (e.g., books, magazine, web sites, government documents on building requirements, interviews with local building experts).

25. Based on their research, have students compare buildings for the amount of damage, the structural framing, and the materials used to build the structures. Ask students to compare and contrast their experimental data with observed damage of the real buildings.

Teacher Reflection:

1. How does the student work provide evidence of the student's understanding of the effects of earthquakes on structures?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts?
4. How would you modify the instruction to ensure understanding of student outcomes by all students?

Example Graphic for *Earthquakes* by S. Simon

Mexico City, Mexico

- September 19,1985
- 10,000 people killed
- Buildings destroyed: homes, stores, hotels, hospitals schools, and businesses
- Parking garage collapsed
- Neighboring buildings slight damage

San Francisco, CA

- 1906
- Quake felt over an area of 375,000 miles
- San Andres Fault offset (moved) 8 feet
- Homes on fire
- 28,000 buildings destroyed in the city
- More than 3 thousand lost lives

Earthquakes

- Ground shakes and sways
- Faults run through the crust
- Rocks snap
- The location where the earthquake begins is called the focus
- The San Andres fault is the boundary line between the North American and Pacific plates.

Armenia

- December 7, 1988
- Building destruction
- 1/2 million people homeless

Anchorage, Alaska

- March 27, 1964
- Most violent earthquake in America
- Elementary school split in two when ground beneath it dropped
- Houses slid, cracks in pavement as ground rolled
- Earthquake caused huge tsunami waves in ocean that hit the city causing buildings to break apart

Niigata, Japan

- Leaning buildings
- Soil beneath foundations turned to quicksand
- 1/3 city sunk as much as six feet

Student Name: _____ Date: _____

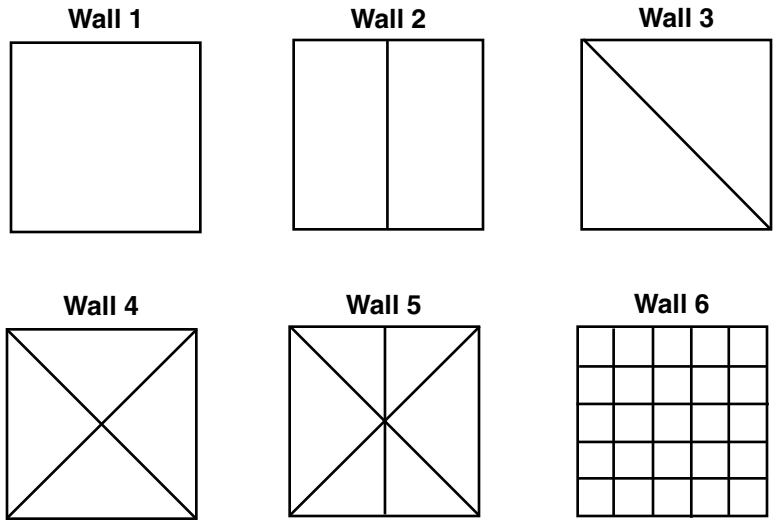
I'm Still Standing

Investigation 1: Building Structure

A major earthquake happened in your area. Many people were injured in tall buildings as a result of the building collapsing. You and your "Seismic Engineering Team" have been selected to conduct research on the construction of buildings and what structural features would help it to withstand the forces of an earthquake.

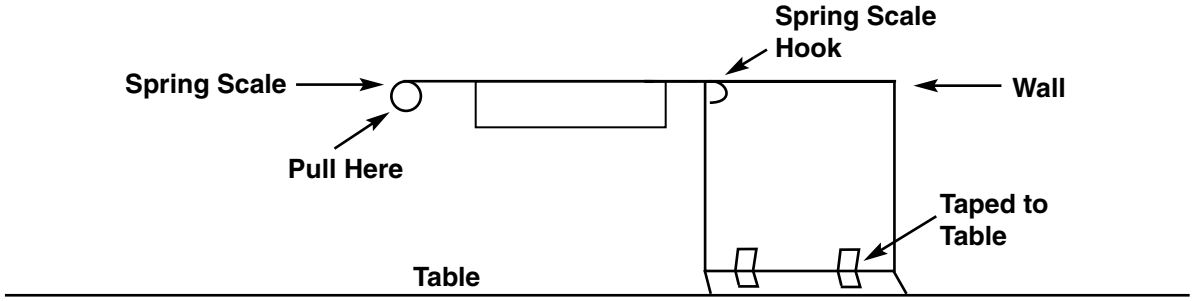
Prediction:

Which wall do you think will be able to hold up to the greatest force as it is applied to one of the top corners? In the table on the next page, record your predictions from 1 to 6 (Note: 1 being the strongest and 6 the weakest).



Construct the first wall as pictured above. Each line represents a Styrofoam stick. The diagonals are the 3 cm x 18 cm sticks; all others are 3 cm x 13 cm sticks. The walls are held together with bolts, washers, and nuts at each joint. Be sure to tighten the bolts.

Each wall will be tested using the spring scale. For your first test, tape Wall 1 tightly to the table. Hook the end of the spring scale to the upper corner of the wall. Hold the spring scale in the horizontal position and gently pull on the end the spring scale that is not attached to the wall (see diagram below).



Observations

Observe what happens as the force is applied to the wall. Record your observations on the data table. Record the applied force when the wall is stressed (as defined by the class). Continue to construct walls 2-5. Apply a force as you did for the first wall, and record all observations on the chart.

Wall 6 is constructed out of frosting and 25 sugar cubes. Spread frosting only on the surfaces you want to stick together. Once the wall is complete, push a toothpick into the frosting between the second and third column so that 1 cm of the toothpick is sticking out. Allow time for drying. Hook the spring scale onto the top of the toothpick to apply the force. Observe and record on the data table.

Wall	Prediction Rank 1-6	Applied Force	Observations
1			
2			
3			
4			
5			
6			

1. Compare your predictions with your actual test results. How close were your predictions to what happened in the investigation?

2. Construct a graph of the applied force observed to stress each wall.

3. What do you think helped the strongest wall to hold up to the greatest force?

4. How would you made the weakest wall stronger?

Student Name: _____ Date: _____

Investigation 2: Engineering Challenge

You and your "Seismic Engineering Team" are now ready to construct a building that may save lives in the event of an earthquake. Your task is to construct a structural model of a building that will withstand the forces applied to it.

Your teacher will discuss the timeline for the planning, construction, and the testing phases of the buildings. All buildings will be constructed using only the materials provided. Your building must be at least _____cm tall and no more than _____cm wide.

All buildings must be attached to the board your teacher will provide.

Phase 1 - Plan

What materials does your group plan to use in the construction of the building? List them.

Record the steps your team will use in order to construct the building. Be sure to use your knowledge of what makes a strong building.

Sketch what your building will look like from the front and from the side.

Front

Side

Explain why you think your team's building design will hold up structurally in an earthquake.

Phase 2 - Build

What materials does your group plan to use in the construction of the building? List them.

Stop! Have the building inspector (your teacher) review your building plan and sign here.

Building Inspector Signature _____

Gather all materials and begin building according to the approved plan.

Phase 3 - Test

Test your building. Record your results using sketches and words.

Explain your results in terms of building design, force applied, and damage.

Grade

7

Strategic Science Teaching

Title of Lesson:

How Long Ago Was That?

Essential Question:

How does evidence found on Earth help us understand the evolution of life?

Conceptual Statement:

Researchers use evidence from rocks to build the geologic time scale that tells us about the history of life on Earth.

Conceptual Learning Sequence:

This lesson is part of a conceptual unit focused on understanding the evidence for the evolution of life on Earth. This lesson introduces the scale of geologic time and how to position significant developments and extinctions in evolutionary history on the geologic time scale.

Student Outcomes:

- Students understand the relationships between major geologic events and the evolution of life on Earth.
- Students construct a geologic time scale using their own calculations to determine positions of events in Earth's history
- Students use an "Analogy Graphic Organizer" to enhance their understanding of the concepts of time and scale.

Lesson Overview:

Students use proportion and data collected to respond to the question: "How can we use the geologic time scale to help us understand Earth's age, and the significant developments and extinctions of plant and animal life on Earth?"

Students develop the familiar concept of their own life timeline, citing evidence of major events in their lives. Students next create a geologic time scale, determining positions of given time periods in Earth's history. Using an "Analogy Graphic Organizer" students then compare and contrast their life timeline to Earth's time scale. They further investigate sources of information on significant developments and extinctions of plant and animal life on Earth and add these events to their geologic time scale.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

Sections of the book *Dr. Art's Guide to Planet Earth* are used in the EXPLORE stage. The book serves as a source of information as the students gather data to build their geologic time scale.

Learning Strategy:

Students use the "Analogy Graphic Organizer" and proportional thinking to help them determine the positions of the geologic events on their time scale. The "Analogy Graphic Organizer" strategy enhances their comprehension of Earth's history by providing a visual framework for students to identify similarities and differences between a new concept and something with which they are already familiar. (See Appendix pages 182-183.)

Literature Selection:

Title: *Dr. Art's Guide to Planet Earth*
Author: Sussman, Art
Publisher: Chelsea Green Publishing, 2000 ISBN: 189013273X
Annotation: This book focuses on big ideas and uses systems thinking to help the reader understand Earth's cycles of matter, flows of energy, and web of life. From evolution and extinction, to carbon and climate change, this book demonstrates the interdependence of the Earth as a system. The book is linked to http://www.planetguide.net which contains activities, animations, and discussions.
Genre: Nonfiction

California Science Content Standards:*

Science: Grade 7 - Earth and Life History (Earth Science)

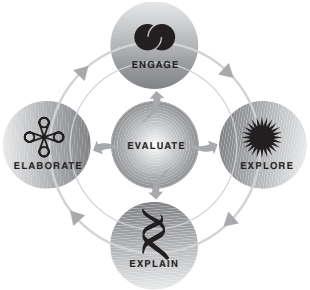
4. Evidence from rocks allows us to understand the evolution of life on Earth. As a basis for understanding this concept:
   - d. Students know that evidence from geologic layers and radioactive dating indicates Earth is approximately 4.6 billion years old and that life on this planet has existed for more than 3 billion years.
   - e. Students know fossils provide evidence of how life and environmental conditions have changed.
   - g. Students know how to explain significant developments and extinctions of plant and animal life on the geologic time scale.

7. Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

- b. Use a variety of print and electronic resources (including the World Wide Web) to collect information and evidence as part of a research project.
- d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge.

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Science Thinking Process	Suggested Time
ENGAGE	The students respond to prompts to make connections to past learning experiences and to focus their thinking on the fossil and rock records. Communicating, Ordering	20-30 minutes
EXPLORE	The students use analogy and scale to create a personal timeline, and then construct a geologic time scale. Using the selections from *Dr. Art's Guide to Planet Earth*, students research major geologic events. Students complete an "Analogy Graphic Organizer" to compare and contrast their lifetime with Earth's time scale. Communicating, Comparing, Ordering	80-100 minutes
EXPLAIN	The students explain the geologic time scales that they constructed and critique each other's explanations. Communicating, Organizing, Categorizing	40-50 minutes
ELABORATE	The students use on-line and print resources to further research additional information and compare with the time scale they constructed. Communicating, Comparing, Ordering, Categorizing	60-90 minutes
EVALUATE	While evaluation occurs throughout the lesson, the teachers now assesses student understanding of analogies and Earth history as the students share their "Analogy Graphic Organizers" and their research on Earth's significant developments. Communicating, Comparing, Ordering, Categorizing, Inferring, Applying	40-50 minutes

How Long Ago Was That?

Teacher Background:

Scientists use a variety of terms to identify and label stretches of time in Earth's history. While our planet is 4.5 billion years old, most of the events for which we have reasonably accurate dates have occurred in the past 570 million years. From that time, the first organisms possessing hard body parts (external shells and internal skeletons) have left their remains as fossils that we find today.

Although scientists originally thought that life began about 570 million years, we now know that the earliest cells appeared on Earth about 4 billion years ago. Unfortunately, the single-celled organisms that were Earth's only life forms for billions of years have left few remains. In contrast, we have many fossils and other forms of evidence regarding events of the past 570 million years.

This stretch of time has been categorized into three major divisions, the eras known as Cenozoic, Mesozoic, and Paleozoic. The "zoic" part of the word comes from the root "zoo" meaning animal. "Cen" means recent, "Meso" means middle, and "Paleo" means ancient. These divisions reflect major changes in the composition of ancient faunas, each era being recognized by its apparent domination by a particular group of animals. The Cenozoic has sometimes been called the "Age of Mammals," the Mesozoic the "Age of Dinosaurs," and the Paleozoic the "Age of Fishes." This is an overly simplified view, which has some value for the beginning learner but is also misleading. For instance, other groups of animals lived during the Mesozoic. In addition to the dinosaurs, animals such as mammals, turtles, crocodiles, frogs, and countless species of insects also lived on land. Additionally, these animal-focused phrases neglect the plants, which are the basis for virtually all ecosystems. Ancient flora went through great changes, and not always at the same time that the animal groups changed.

Geologists and paleontologists use principles, techniques and tools based in many scientific disciplines to reconstruct Earth's history. The study of layered rock is called stratigraphy. Sedimentary rocks deposited layer by layer stacked on top of one another. In any sequence of undisturbed layered rocks, a given layer is older than any layer on top of it. This Principle of Superposition is fundamental to determining the relative age of rocks and the fossils found in them. The use of radioactive dating enables scientists to more accurately determine absolute ages of fossils and rocks.

Related California Content Standards

Math: Grade 7
Measurement and Geometry
1.2 Construct and read drawings and models made to scale.
Mathematical Reasoning
2.5 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.

Language Arts: Grade 7
Reading
1.1 Identify idioms, analogies, metaphors, and similes in prose and poetry.

English Language Development: 6-8
Listening and Speaking
Early Advanced-Prepare and deliver presentations that use a variety of sources.

Reading Word Analysis
Early Advanced/Advanced-Apply knowledge of word relationships, such as roots and affixes, to derive meaning from literature and texts in content areas.

Reading Fluency and Systematic Vocabulary Development
Early Advanced/Advanced-Use idioms, analogies, and metaphors in content areas.

Writing Strategies and Applications
Beginning-Organize and record expository information on pictures, lists, charts, and tables for literature and content areas.

Writing Strategies and Applications
Intermediate-Narrate a sequence of events and communicate their significance to the audience.

Grouping: Groups of 2-3 students

For hands-on activities, mix the EL with the native speakers. For debriefing, include at least two EL with native speakers to form discussion groups.

Materials:

Per Group:

Meter stick
30 cm Ruler
1 5-meter Strip of adding machine tape
2 Pieces of masking Tape
Pencils (colored pencils optional)

Per Student:

Student Pages:

1.0 Analogies and Scale
2.0 Directions for Constructing a Geologic Time Scale
2.1 Part B Directions
3.0 Analogy Graphic Organizer

Book, *Dr. Art's Guide to Planet Earth*

Advanced Preparation:

1. Assemble all materials and duplicate Student Pages
2. Prepare transparencies of the Student Pages
3. Create an example of the geologic time scale on adding machine tape
4. Review Teacher Pages 1.0 (Student's Personal Timeline Activity), 2.0 (Sample Analogy Graphic Organizer), and Teacher Tips
5. Select a book for ENGAGE (see related student resources)

Teacher Resources:

California Journal of Science Education, Controversy in the Classroom II: Evolution, Volume 1, Issue 2, Spring 2001

Evolution, PBS video series in eight parts, 60 minutes, available on video and DVD from www.pbs.org

Marzano, Robert J., Pickering, Debra J., Pollock, Jane E. *Classroom Instruction that Works, Research-based Strategies for Increasing Student Achievement*, ASCD, Alexandria, VA, 2001

Pojeta, John Jr. and Dale A. Springer. *Evolution and the Fossil Record*, American Geologic Institute, 2001

Science Framework for California Public Schools Kindergarten through Grade Twelve, California Department of Education, Sacramento, 1990

Teaching About Evolution and the Nature of Science, National Academy of Sciences, 1998

Understanding Geologic Time http://www.ucmp.berkeley.edu/exhibit/geology/html

United States Geologic Survey, http://www.usgs.gov

VOCABULARY

word roots:

cen – recent

geo – earth

meso – middle

paleo – ancient

zoo – animal

analogy – using words or symbols to compare things that resemble each other

evolution – the historical development and changes of living organisms, the universe or other subjects

fossils – the remains, impressions, or traces of organisms from past geologic ages preserved in Earth's crust

geology – the scientific study of the history of Earth as recorded in rocks and other parts of Earth

proportion – a part, portion or share

time scale – an arrangement of events in history or time

Teacher Tips:

- Before beginning this lesson, review student's familiarity with similes, analogies and ratios/proportions. Make links to their understanding of these topics in other content areas (e.g., math, language arts).
- If necessary, review metric measurement with students.
- Help students with the difference between a timeline and a time scale: timeline is used for short periods of time as in a human's life; time scale is used to indicate much longer periods of time as in the age of Earth.
- Consider assigning the student's personal timeline as homework since the "evidence" is at home (e.g., pictures, teeth, report cards).
- Suggest that students use time intervals of one year or 24-months to create their personal timeline.
- Suggest that students use a color-coding system to help discriminate the confirming from the discrepant information in Step 13.
- For more examples of analogies, use test prep books for the Miller Analogies Test.
- As an alternative activity, use "What Came First?" from this web site: http://www.ucmp.berkeley.edu/fosrec/ScotchmoorFirst.html

Misconceptions:

Students might think that:

Earth is not as old as it is.
Dinosaurs and humans existed at the same time.
Plants and animals appeared on Earth at the same time.

Related Student Resources:

Aliki. *Digging Up Dinosaurs*, HarperCollins, 1988.
Aliki. *Dinosaur Bones*, Thomas Y. Crowell, 1988.
Aliki. *Fossils Tell of Long Ago*, Harper Trophy, 1990.
Baylor, Byrd and Parnall, Peter. *If You Are a Hunter of Fossils*, AladdinBooks, MacMillan Publishing Co., 1980.
Brighton, Catherine. *The Fossil Girl*, Millbrook Press, 1999.
Dixon, Dougal. *Dougal Dixon's Dinosaurs Updated*, Second Edition, BoydsMills Press, 1998.
Duke, Kate. *Archaeologists Dig for Clues*, Harper Collins, 1997.
Facklam, Margery. *Tracking Dinosaurs of the Gobi*, Twenty-First Century Books, 1997.
Gurney, James. *The World of Dinosaurs*, Greenwich Workshop Press, 1998.
Oliver, Ray. *Rocas y fosiles*, Debate, 1993.
Ryder, Joanne. *Tyrannosaurus Time*, Morrow Junior Books, 1999.
Tanaka, Shelley. *Graveyards of the Dinosaurs*, Hyperion, 1998.
Taylor, Paul D. *Los fosiles*, Altea/Santillana, 1990.

American Geological Institute AGIWEB http://www.agiweb.org
Dr. Art's Guide to Planet Earth http://www.planetguide.net
National Academy Press http://www.nap.edu/readingroom/books/evolution98
Understanding Geologic Time (UC Berkeley and National Science Foundation)
http://www.ucmp.berkeley.edu/geotime
http:// www.ucmp.berkeley.edu/exhibit/geology.html

Lesson Credits:

This lesson is adapted from Geology, A Storyline Unit, developed by Project Storyline, a collaboration between the California Science Implementation Network (CSIN) and the University of California, Irvine, 1992.

ENGAGE
EXPLORE
EXPLAIN
ELABORATE
EVALUATE

The Science Learning Cycle:

How Long Ago Was That?

ENGAGE:

1. To initiate the learning, create interest and curiosity by reading aloud a short selection in a book such as *Fossils Tell of Long Ago* by Aliki. (See Student Resources).

2. Ask students to respond in journals to the following prompts:
   - What do I already know about fossils and the history of life on Earth?
   - What do I want to know more about?

3. Chart (or record on a transparency) responses to the two prompts from the class. Date the chart and keep for future reference and assessment.

EXPLORE:

4. Review scale and proportion with students, using the questions on Student Page 1.0.

5. Introduce the Personal Timeline Activity (Teacher Page 1.0). As a group, brainstorm possible milestones, evidence of major events, and what scale they would use to draw their life timeline. Students each create a personal timeline, choosing their own major events and sources of evidence. (You may want to have students create their timelines at home, and then share their personal timelines in their small group.)

6. Introduce the geologic time scale using the teacher-prepared example and directions from Student Page 2.0 "Directions for Constructing a Geologic Time Scale." Read directions aloud and clarify if necessary. Then ask students to do Part A - completing the "Position on Time Scale" column and then complete Part B of Student Page 2.1.

7. Have students research major geologic events, such as mass extinctions, that influenced the diversity of life on Earth, using the literature selections. (See *Dr. Art's Guide to Planet Earth*, pages 80-85, 20-23, 87-88, and 92-95.) Ask students to add any information they choose to their time scale. Remind students that all additions must include the source of the information on the Student Page 2.1, Part B.

8. Have students complete the “Analogy Graphic Organizer” (Student Page 3.0, Teacher Page 2.0), identifying similarities and differences using the relationship categories listed on the page. Ask students to add relationship categories if appropriate.

EXPLAIN:

9. Have students demonstrate their conceptual understanding by explaining to the class the geologic time scale they constructed. Note: This is a place in the instructional model where the teacher evaluates student understanding of the second student outcome.

10. Ask students to listen to and critique each other's explanations.

11. Return to the originally charted ENGAGE questions and to the student-generated questions which were charted. Ask students to review their initial answers in their journal and revise those answers based on their learning. Ask for additional student-generated questions and add them to the class chart.

The Science Learning Cycle: How Long Ago Was That?

ELABORATE:

12. Have students use the web (see student resources: understanding geologic time) to gather additional evidence to answer new questions and compare their findings to the time scale they constructed.

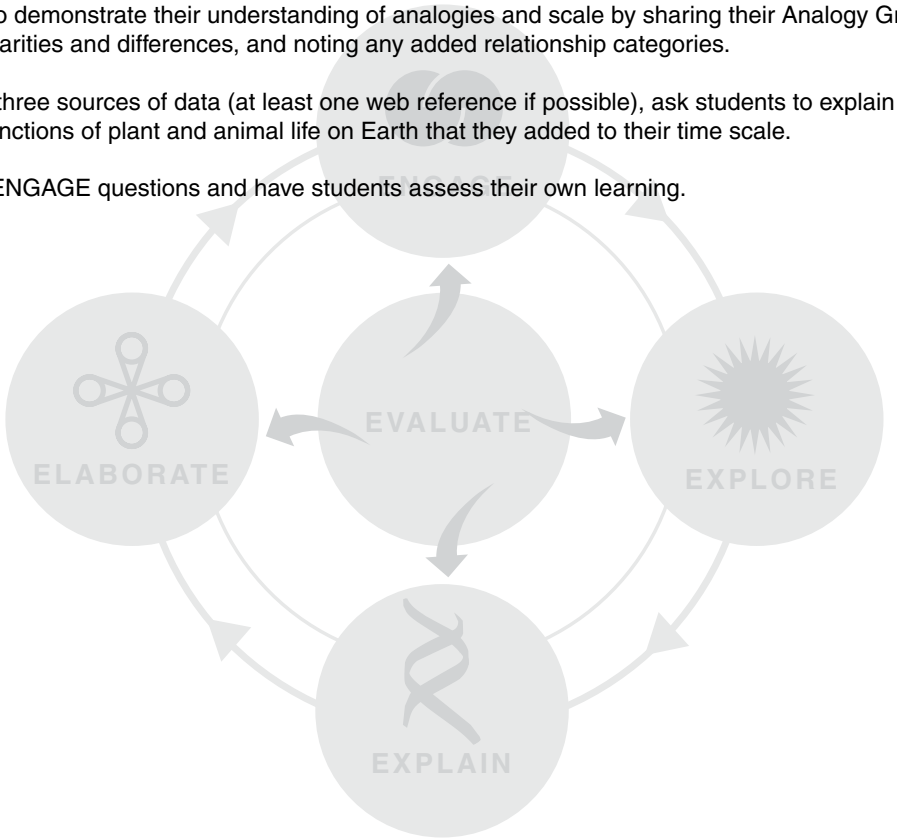
13. Ask students to record new information in their journals and include discrepant as well as confirming information on their time scales. Ask students to record new questions as they arise.

EVALUATE:

14. Ask students to demonstrate their understanding of analogies and scale by sharing their Analogy Graphic Organizers, listing the similarities and differences, and noting any added relationship categories.

15. Using at least three sources of data (at least one web reference if possible), ask students to explain significant developments and extinctions of plant and animal life on Earth that they added to their time scale.

16. Return to the ENGAGE questions and have students assess their own learning.



Teacher Reflection:

1. How does the student work provide evidence that the student understands about the relationship between geologic time and major events in Earth's history?

2. What instructional strategies used in this lesson promote student understanding? How do you know?

3. How does the literature selection support student understanding of the science concept?

4. How would you modify instruction to ensure understanding of student outcomes by all students?

Students' Personal Timeline Activity

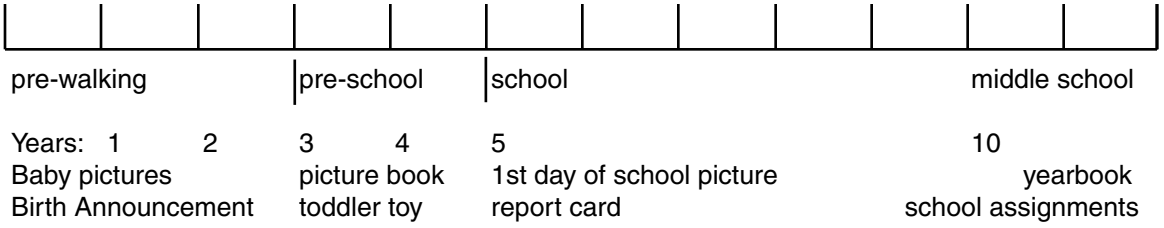
1. Ask students to name major milestones or "major events" in their lives (e.g., learning to walk, learning to talk, learning to feed themselves, learning to read, going to school). List these on the board or on a chart.

2. Ask students, "What evidence do you have that could demonstrate different time periods in your life?" If necessary, prompt the discussion with "evidence" such as: baby book, videos, school yearbooks, baby teeth, report cards, sports team photos, letters or birthday cards.

3. Discuss how the evidence could be arranged in sequence to create a timeline of the students' lives. What dividers might they use on a timeline to show these major milestones? (e.g., pre-walking, pre-school, pre-reading, reading.)

4. Have students make a timeline for their lives, using dividers and noting evidence of each period in sequential order. Use a common scale., (e.g., each year = 3 cm).

Example:



5. Ask students to share their timelines in small groups. Then ask groups to share with the whole class. Chart some of the major periods in their lives and evidence cited.

6. Ask "What kinds of evidence do we have from different periods in the Earth's history?"

7. Compare the scale for a 12 or 13 year timeline vs. a 100 year timeline, vs. a 1,000 year timeline. Tell them that in the next activity, they will be making a 4.5 billion (4,500,000,000) year time scale.

Sample Analogy Graphic Organizer

The analogy graphic organizer provides a visual framework for students to analyze important relationships among concepts and to identify the similarities and differences between a new concept and something with which they are already familiar.

FAMILIAR CONCEPT

My lifetime

NEW CONCEPT

Earth's history

Similarities

- Measurable in years
- Sequential
- Marked by "major events" or identifiable milestones
- Have evidence of different periods

Differences

- I lived it and can recall most of it
- I can visualize 12 years
- Evidence is readily available

- Most happened before any human lived
- It's difficult to comprehend 4.5 billion years
- Evidence is difficult to gather and sometimes debated

Relationship Categories

Time scale
Milestones
Evidence

Analogies and Scale

Analogies help us see how seemingly different things are similar. For example, thinking about the nucleus of a cell as being like your brain helps you understand that the nucleus is the part of the cell that controls what it does and how it operates. Similarly, scale can be used to represent something large (e.g., the state of California) in a small space (on a map) by equating a large distance (1 mile) with a small distance (1 cm). Scale may also be used to divide large periods of time into manageable "chunks."

Complete the questions below, and note the relationship demonstrated.

1. A 48-year old person is telling the story of her life. She has chosen to use a clock's face to represent the events and time periods in her life. At 6:00 on her "clock" she is 24 years old.

   How "old" would she be at 3:00? _____

   How "old" would she be at 9:00? _____

   How "old" would she be at 11:00? _____

   What is the relationship?_____

2. On a map, the distance between New York and Los Angeles (3000 miles) is represented by 30 cm.

   200 miles would be _____

   2,500 miles would be _____

   10,000 miles would be _____

   What is the relationship?_____

3. On a geologic time scale, the dinosaur extinction was 65 million years ago. It is represented by 65 mm.

   17.5 million years would be _____mm

   150 million years would be _____mm

   500 million years would be _____mm

   1 billion years would be _____mm

   What is the relationship?_____

Directions for Constructing a Geologic Time Scale

Part A - Complete the chart

From your knowledge of analogies and proportions, you know that you can represent a given number of years with a given distance. Complete this chart using 1 mm (0.1cm) to represent 1 million years. All measurements should be in metric units. Check your work with at least two other groups before you proceed to part B.

The History of Earth

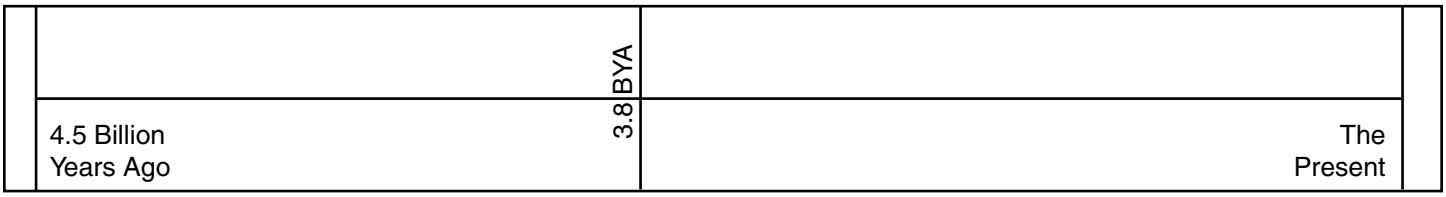
Era	Event	Years Ago (approximate)	Position on Time Scale
Cenozoic	First humans	3 million	
	Grass first appears	20 million	
	Apes appear	35 million	
Mesozoic	Major extinction including dinosaurs	65 million	
	First flowering plants	120 million	
	Early dinosaurs	225 million	
Paleozoic	Trilobites die out	275 million	
	Early reptiles	310 million	
	Amphibians and ferns found on land	350 million	
	Primitive land plants	420 million	
	Jawless fish	480 million	
	Marine invertebrates and trilobites	543 million	
(Pre-Cambrian)	Green algae	1.0 billion	
	Single-celled life abundant	3.0 billion	
	Oldest fossil	3.8 billion	
	Formation of the Earth	4.5 billion	

Part B - Directions for constructing a geologic time scale.

With an accurate chart from Part A, use a 5-meter long paper strip and other materials (meter stick, masking tape, pencil) to create a geologic time scale.

1. Lay the adding machine tape on the floor in a location where it will not disturb another group. Secure the ends of the strip of paper to the floor using making tape.
2. Begin measurement for the time scale with “The Present.” Draw a line across the width of the strip near one end and label it “The Present.”
3. Measure accurately the distance you’ve determined to represent the oldest fossil at 3.8 million years ago. Draw a line across the width of the strip and label it “3,800,000 years ago.”
4. Continue measuring and labeling all 16 points as in step #3.
5. Label every position represented with the corresponding event that occurred. Be prepared to share your time scale with the class.

Sample Timeline:



Scale: 1mm (0.1 cm) = 1 million years

Additional Information and sources:

Analogy Graphic Organizer

Complete the "Analogy Graphic Organizer" as you complete your life timeline and the Earth's geologic time scale. Use the relationship categories listed below in thinking of similarities and differences. You may add additional relationship categories if you wish.

FAMILIAR CONCEPT

My lifetime

NEW CONCEPT

Earth's history

Similarities

Differences

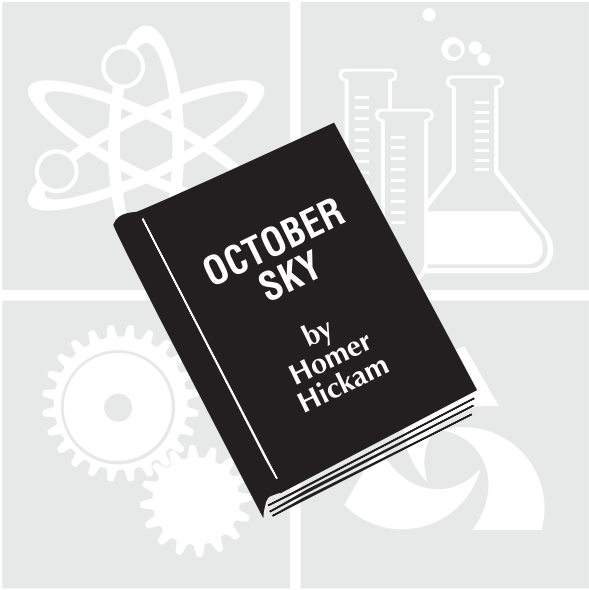
Relationship Categories

Time scale
Milestones
Evidence

Grade

8

Strategic Science Teaching



Title of Lesson:

Chemical Reactions

Essential Question:

How do different substances interact with each other?

Conceptual Statement:

Chemical reactions are processes in which atoms are rearranged into different combinations of molecules.

Conceptual Learning Sequence:

This lesson is part of a conceptual unit on the structure of matter, and how matter undergoes both physical and chemical changes. It is appropriate after students have a general understanding of the structure of matter in terms of atoms, elements, and compounds. This lesson introduces the nature of chemical reactions, and the evidence for determining if a chemical reaction has occurred.

Students Outcomes:

- Students explore the properties of chemical reactions.
- Students investigate features of a chemical reaction, and plan and conduct a scientific investigation to test a hypothesis.
- Students initially encounter information about chemical reactions by reading about rockets in an engaging text.

Lesson Overview:

In this lesson, students use "Questioning the Author" as they read *October Sky*. This strategy helps them engage with the ideas in the text and build their understanding. They explore the chemical reaction between copper chloride and aluminum, and deepen their understanding of chemical reactions.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental difference for students who are English learners.

Literature in the Science Learning Cycle:

The literature selection, *October Sky*, is used in the ENGAGE stage to focus student interest on chemical reactions.

Learning Strategy:

This lesson uses “Questioning the Author” which helps students transform the author's ideas into their own ideas. Students are prompted to judge whether the author has clearly communicated his ideas, and to attempt to re-state the ideas more clearly. (See Appendix pages 174-177.)

Literature Selection

Title: *October Sky* (originally published as *Rocket Boys*)
Author: Hickam, Homer
Publisher: Random House, New York, 1998.
Annotation: This memoir tells the story of a NASA engineer who grew up in West Virginia in the 1950s, when he was interested in the physics of rockets rather than football and mining.
Genre: Autobiography

California Science Content Standards:*

Science: Grade 8, Physical Science

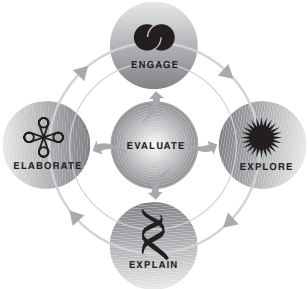
Reactions

5. Chemical reactions are processes in which atoms are rearranged into different combinations of molecules. As a basis for understanding this concept:
   a. Students know reactant atoms and molecules interact to form products with different chemical properties.
   c. Students know chemical reactions usually liberate heat or absorb heat.

7. Investigation and Experimentation

9. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:
   a. Plan and conduct a scientific investigation to test a hypothesis.
   c. Distinguish between variable and controlled parameters in a test.

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Science Thinking Process, Learning Strategy	Suggested Time
ENGAGE	Students engage in a real life example of adolescents conducting science experiments as they read about Homer Hickam's beginning attempts to power a rocket. This reading introduces the concept of chemical reactions. Communicating	50 minutes
EXPLORE	By experimenting with copper chloride and aluminum, students directly experience a chemical reaction that involves heat production, changes in color, formation of a precipitate, and production of a gas. Observing, Communicating, Comparing	50 minutes
EXPLAIN	Students compare the results with the three pieces of aluminum foil, and explain their observations in terms of the chemical reaction between copper chloride and aluminum. Communicating, Comparing, Relating	25 minutes
ELABORATE	Students develop a hypothesis about the copper/aluminum reaction. They experimentally test their hypothesis by changing only one variable. Observing, Communicating, Comparing, Relating	75 minutes
EVALUATE	Students evaluate their understanding by describing their hypothesis, experimental design, experimental results, and conclusions. As a homework assignment, students finish reading the book and relate it to continuing investigation and experimentation. Teacher evaluates student understanding of student outcomes in this activity as well as throughout the lesson. Communicating, Comparing, Relating	50 minutes

Chemical Reactions

Teacher Background:

When two or more materials come into contact and change their composition and properties, we refer to that process as a chemical reaction. These kinds of reactions occur all around us and within our bodies. We can readily observe changes that indicate that a chemical reaction has occurred. These include a change in temperature that is not caused by external heating or cooling; the production of a gas that is not due to boiling; the formation of a solid precipitate from a solution; a change in color that does not result from dilution or mixing colors; and the irreversible disappearance of a solid in a liquid (cannot recover the original solid by evaporating the liquid).

We observe the results of chemical reactions at our macroscopic level. Changes at the level of atoms and molecules are the underlying cause of chemical reactions. During any reaction, the atoms involved are neither gained nor lost, but are only rearranged.

This lesson involves the reaction of cupric chloride (cupric means copper that has a net electrical charge of +2) with aluminum. During this reaction, the aluminum changes from being a solid, neutrally charged metal to the positively charged ionic state where it dissolves as a salt (aluminum chloride). Thus, the solid aluminum is observed to disappear. The copper (initially present dissolved as a positively charged ionic salt and combined with chloride) changes to the neutral, metallic state and appears as a copper-colored precipitate. Positively charged copper in solution is blue while positively charged aluminum has a much paler color. Therefore the color of the liquid in the reaction changes from blue to pale gray as the salt changes from cupric chloride to aluminum chloride.

Chemical changes involve interactions among the electrons of the different atoms and molecules. At the atomic level, copper is gaining electrons from aluminum which is why it goes from having a positive charge to being neutral. The aluminum loses electrons and changes from electrically neutral to positively charged.

Many chemical reactions either release or absorb energy. The reaction between cupric chloride and aluminum releases energy as evidenced by the increase in temperature of the solution. Hydrogen gas is also produced as the result of a side reaction.

Related California Content Standards

Language Arts

Reading

2.0 Reading Comprehension (Focus on Informational Materials)

Students read and understand grade-level appropriate material. They describe and connect the essential ideas, arguments, and perspectives of the text by using their knowledge of text structure, organization, and purpose.

Listening and Speaking

2.2 Deliver oral responses to literature:

a. Interpret a reading and provide insight

b. Connect the students' own responses to the writer's techniques and to specific textual references.

Grouping: Whole group, groups of 4, individual

For hands-on activities, mix the EL with the fluent English speakers. For debriefing, include at least two EL with native to form discussion groups.

Materials:

Per Class

200 ml 0.5M Copper chloride

25 ml or 50 ml Graduated cylinder

Various materials depending on student hypotheses (See Teacher Tips).

Per Group

1 Tray for all the materials
20 ml 0.5M Copper chloride in one 10-ounce clear cup
2 Empty 10-ounce clear plastic cups
3 Pieces of aluminum foil, each 6 cm by 6 cm
2 Pairs of latex gloves
1 Chopstick (wood or plastic)
1 Tweezers
Paper towels
Various materials depending on student hypotheses (See Teacher Tips).

Per Student

1 Copy of *October Sky*
Safety goggles
Student Pages 1.0 and 1.1

Advanced Preparation

1. Purchase or prepare enough 0.5M cupric chloride for the EXPLORE and ELABORATE stages (See Teacher Tips for safety considerations).
2. Cut aluminum foil into 6 cm by 6 cm pieces.
3. Pour 20 ml of 0.5M cupric chloride into one clear 10-ounce cup for each group of students.

Teacher Resources

Science Safety Handbook for California Public Schools, 1999 Edition, CDE Press.
"Chemical Reactions: Teacher's Guide," Great Explorations in Math and Science (GEMS), Lawrence Hall of Science, University of California at Berkeley.

Teacher Tips:

- Post "Lab Safety Rules" so teacher and students can refer to them while doing the experiments.
- Post a chart that lists observable criteria for a chemical reaction.
- Purchase 0.5M cupric chloride solution from a chemical supply source such as Flinn Scientific (www.flinnsci.com). Alternatively, if you have appropriate storage and safety facilities/equipment/experience, you can prepare a stock solution by dissolving 85 grams of the cupric chloride dihydrate in water to make one liter of solution. Use a fume hood or wear a respirator. In addition, wear a lab apron, gloves, and safety glasses. Cupric chloride dihydrate reagent is highly toxic and has a poor shelf life. The prepared solution is much less hazardous and has a long shelf life.
- Demonstrate the proper technique for safely decanting the liquid just before having the students do that step.
- When you are ready to do the experiment, it must be done in a one class period.
- Have the students submit their hypothesis/proposed experiment at least one day before they will actually test their hypothesis. This will give you/them an opportunity to obtain the necessary materials.
- Students often choose these types of variables for their experiment: amount of aluminum or amount of copper chloride; kind of metal to add to copper chloride (e.g., nail galvanized or not, penny, copper wire, brass screw, aluminum wire, wire mesh); cooling (ice). You might want to have these supplies on hand ahead of time. Do not heat the reaction!
- Wear safety goggles and gloves when handling the solutions, precipitates, and when disposing of the waste. Disposal of solids: Filter out the solids (collect the liquid) and wash with water. Place solid residue in a plastic trash container, not in the classroom wastebasket. Disposal of liquid: The cupric chloride reaction liquid may be disposed down the drain with copious amounts of water if-and only if-your school drains are connected to a sanitary sewer system, with a water treatment plant working on the effluent from your drains. Do not use this disposal procedure if your drains empty into groundwater through a septic system or into a storm sewer. The Science Safety Handbook for California Public Schools (1999 Edition) states that you should determine the kind and quantity of nonhazardous chemicals (waste) that may legally be flushed down sink drains, and that school officials should consult with their county health department and regional water quality control board, and obtain approval from the local publicly owned treatment facility.

VOCABULARY

chemical reaction – a chemical change resulting in the transformation of beginning substances (reactants) into changed substances (products)

decant – pour a liquid away from a solid

hypothesis – a testable explanation of observations that relate to a scientific question

precipitate – a solid that deposits from a liquid as a result of a chemical reaction

products – substances formed as a result of a chemical reaction

reactants – substances present before the chemical reaction begins

variable – the one condition of an experimental set-up that is changed when testing a hypothesis

The Science Learning Cycle:

Chemical Reactions

ENGAGE:

1. Introduce students to "Questioning the Author" to help them understand, in their own words and concepts, the content in the text.

2. Model steps 1 and 2 of instructional procedures listed for "Questioning the Author" (See Appendix, page 174). Use the Sputnik example to demonstrate the procedure.

3. Have the students read Chapter 5 of *October Sky*. Ask each student to find at least one paragraph in the chapter that involves a science idea, experiment, or vocabulary word where the student is not certain what the author is saying. Using "Questioning the Author," have students write in their own words what they think the author is trying to say in the selected paragraph.

4. Ask several students to describe the paragraph they chose and the wording they would use to describe what the author is trying to say. In each case, have the class discuss whether the suggested change makes the ideas easier to understand as well as other ways to phrase those ideas.

EXPLORE:

5. Ask students to scan Chapter 5 and look for experiments involving chemical reactions. Chart and discuss their responses.

6. Share what scientists consider as evidence of chemical reactions (e.g., change in temperature, production of a gas, formation of precipitate, change in color, and/or disappearance of a solid) and ask students to categorize their examples from the book.

7. Explain that students are going to experiment with a chemical reaction. Stress the importance of safe laboratory practices, referring to specific actions that must or must not be taken. Inform students that copper chloride is a toxic chemical that should never be put in the mouth, and that harms eyes and skin.

8. Assign students to groups of four and ask them to identify who will assume the following roles: materials manager, investigator, recorder, reporter. Note: have students rotate roles periodically during the experiment.

9. Distribute the instruction and data sheets for Experience a Chemical Reaction (Student Pages 1.0, 1.1). Review the experimental and safety procedures before students commence the activity. Make sure that all students are wearing safety glasses, and that the students handling the chemical solution are wearing latex gloves.

10. Have the materials managers obtain the materials for their group. Instruct the students to follow the procedures and to record their observations with the first piece of foil. After the first piece of aluminum foil has stopped reacting, have the students share their results.

11. Demonstrate the proper procedure for decanting the fluid from the initial reaction cup into an empty cup.

12. Instruct the students to follow the procedure and to record their observations with the second piece of foil. After the second piece of aluminum foil has stopped reacting, have the students decant the fluid into a fresh cup.

EXPLAIN:

13. Have students predict in writing what will happen when they add the third piece of aluminum foil to the fluid. Have them perform the experiment, and record their results.

14. Carefully collect all the solutions and precipitates. Follow appropriate safety procedures in disposing of waste (see Teacher Tips!). Wear safety goggles and gloves when handling the solutions, precipitates, and when disposing of the waste.

15. Have the students whiteboard the results from the three trials of the experiment. Ask students to compare results and explain their evidence that a chemical reaction occurred.

16. Ask students to explain what happened to the third piece of aluminum foil. (Note: there should have been no reaction.) Ask students what they would need to do to continue the reaction with the third piece of aluminum foil and why.

ELABORATE:

17. Ask students to develop a hypothesis about a change they can make to the aluminum-copper chloride reaction and the effect they will observe. Review with students the concepts of experimental variables and controls. Have them design an experiment to test their hypothesis (see Teacher Tips).

18. Have students submit their hypothesis and experimental design to the teacher (Student Page 2.0). Provide the students with feedback about their hypothesis and experimental design. If necessary, help them develop an acceptable hypothesis.

19. Using appropriate safety procedures, have each group conduct their experiment, and record their observations.

EVALUATE:

20. Have each group present their hypothesis, experiment, and results to the class. Ask students to explain their results in terms of chemical reactions (e.g., used half the amount of copper chloride so the amount of aluminum that reacted was reduced; used a metal or form of aluminum that reacted slower or not at all with copper chloride as judged by reduction in color change, gas bubbles, and heat produced). Collect and safely dispose of the waste. (see Teacher Tips).

21. Have the class discuss each group's presentation. Have them describe any changes they would make to the experimental design and/or to critique the group's conclusions.

22. As a homework or continuing classroom assignment, have students finish reading *October Sky*. Ask students to recall events in the book where repeated experimentation resulted in new hypotheses and new learnings.

Teacher Reflection:

1. How does the student work provide evidence that students understand the properties of chemical reactions, and that they know how to plan and conduct a scientific investigation to test a hypothesis?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts and processes?
4. How would you modify instruction to ensure understanding of student outcomes by all students?

Experience a Chemical Reaction

You are going to experiment with a chemical reaction involving copper chloride (blue liquid) and aluminum. Copper chloride is a toxic chemical that should never be put in the mouth, and that harms eyes and skin. Wash any spills (particularly on the body or clothing) with large amounts of water.

Identify who in your group is going to serve as materials manager, recorder, reporter, and investigator. The materials manager should obtain the tray of materials that your group needs. The investigator needs to wear latex gloves.

Add one piece of aluminum foil to the copper chloride. Gently use the chopstick to submerge the aluminum foil. Write down all your observations until no more changes occur.

OBSERVATIONS FIRST PIECE OF ALUMINUM FOIL:

After your teacher demonstrates how to decant (pour off) the liquid, decant the remaining liquid into an empty cup. Add a second piece of aluminum foil. Gently use the chopstick to submerge the aluminum foil. Write down all your observations until no more changes occur.

OBSERVATIONS SECOND PIECE OF ALUMINUM FOIL:

Decant the fluid into an empty cup and predict what will happen when you add the third piece of aluminum foil.

PREDICTIONS FOR THIRD PIECE OF ALUMINUM FOIL:

Add the third piece of aluminum foil. Gently use the chopstick to submerge the aluminum foil. Write down all your observations until no more changes occur.

OBSERVATIONS FOR THIRD PIECE OF ALUMINUM FOIL:

The materials manager should bring all your cups and materials in a tray to the collection area. Each student should answer the following questions.

1. Was there any chemical reaction when you first added aluminum to the copper chloride?

   What evidence supports your answer?

2. Was there any chemical reaction when you added the second piece of aluminum?

   What evidence supports your answer?

3. Was there any chemical reaction when you added the third piece of aluminum?

   What evidence supports your answer?

4. How do you explain what happened or did not happen in the third cup?

Our Hypothesis

As a group, develop a hypothesis about a change that you can make to the experiment with copper chloride and aluminum. The hypothesis must be something you can test by changing only one variable. Describe how you will test your hypothesis.

GROUP NAME: _____

OUR HYPOTHESIS:

HOW WE WILL TEST OUR HYPOTHESIS:

TEACHER APPROVAL _____

OUR OBSERVATIONS/DATA:

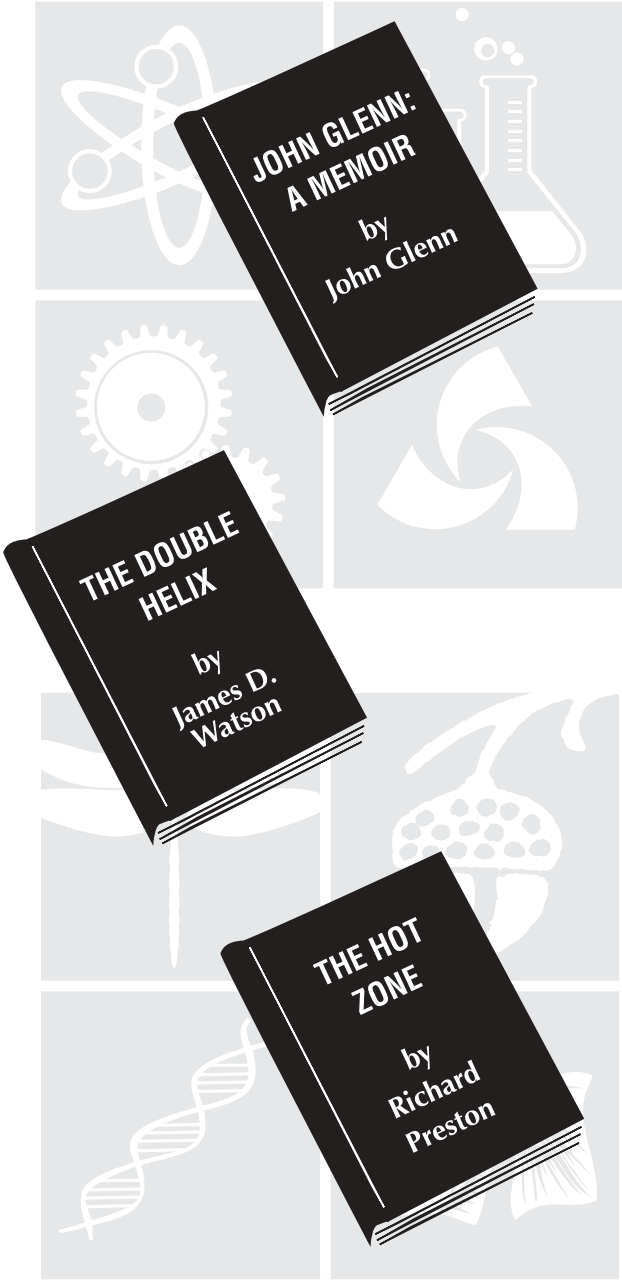
HOW WE EXPLAIN OUR OBSERVATIONS:

WHAT WE CONCLUDE ABOUT OUR HYPOTHESIS:

Grades

9-12

Strategic Science Teaching



Grades 9-12

Grade	Lesson Title	Book Title	Science Standard	Language Arts Standard	Mathematics Standard	English Language Development (ELD) Standard	Learning Strategy	Literature in the Learning Cycle "E"	Science Thinking Process	Pages
9-12	Standing Waves	John Glenn: A Memoir	Physics Waves 4a, b, c Investigation & Experimentation 1d, g	N/A	Algebra 1 15.0 Trigonometry 2.0	Reading Comp.	Reciprocal Teaching	Elaborate	Apply Communicate Compare Observe Order Relate	113-128
9-12	Double Helix	The Double Helix	Organic Chemisry and Biochemistry 10a, e Genetics 5a Investigateion & Experimentation 1d, g, k, l	Reading Comp. Comp. & Analysis 2.4, 2.5	N/A	Reading Comp.	LINK (List, Inquire, Note and Know)	Engage Explain	Apply Communicate Compare Infer Observe Relate	129-136
9-12	Virus Alert	The Hot Zone	Biology/Life Cell Biology 1c Ecology 6b Investigation and Experimentation 1d, g, l	Reading Comp. Comp. & Analysis 2.5, 2.4 Listening & Speaking Organization & Delivery of Oral Communication 1.8, 2.4	N/A	Reading Comp. Listening & Speaking	QAR (Question-Answer Relationship)	Engage Explore Elaborate	Apply Communicate Infer Observe Relate	137-144
9-12	Seeing Stars	Contact	Earth Earth's Place 1d, 2a, b, d Investigation & Experimentation 1g, k	Reading 2.0 Writing 2.1 Written and Oral Conventions 1.0	Geometry 15.0	Written Strategies and Applications Written and Oral Conventions	KWL (Know, Wonder, Learn) Learning Log	Explore	Communicate Compare Observe Order Relate	145-156

Title of Lesson:

Standing Waves

Essential Question:

How does energy move through space?

Conceptual Statement:

Waves carry energy from one place to another, and have characteristic properties by which they can be described.

Conceptual Learning Sequence:

This lesson is part of a conceptual unit on the characteristics of waves. It is appropriate after students know that energy has many forms. This lesson introduces the nature of waves and their characteristics, including that waves carry energy from one place to another.

Student Outcomes:

- Students explore the properties of waves.
- Students investigate waves through simulations and hands-on experiments that lead to under standing wave properties and the usefulness and limitations of models.
- Students use "Reciprocal Teaching" as they read sections of *John Glenn: A Memoir*, and apply it to their experiments and simulations.

Lesson Overview:

In this lesson, students engage in a simulation to introduce the concept of waves as a vibration that travels through space and time, and to pique their interest in wave properties. They investigate additional wave features in experiments using tuning forks. Students use "Reciprocal Teaching" as they read sections of *John Glenn: A Memoir*, and apply their understanding of waves to a new situation presented in the reading.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

The literature selection, *John Glenn: A Memoir*, is used in the ELABORATE stage to help students extend their understanding by applying their knowledge of waves to a new situation.

Learning Strategy:

This lesson uses “Reciprocal Teaching,” where students explore science text and share with others. Students explain to each other how to read and comprehend science materials. This strategy uses four processes: questioning, summarizing, clarifying, and predicting. (See Appendix pages 178-179.)

Literature Selection:

Title: John Glenn: A Memoir
Author: Glenn, John, with Taylor, Nick
Publisher: Bantam Books, New York, 1999.
Annotation: This autobiography describes Glenn's experiences in testing new fighter jets, and gives a behind-the-scenes account of significant events in the U.S. space program.
Genre: Autobiography

California Science Content Standards:*

Science Standard: Grades 9-12 Physics

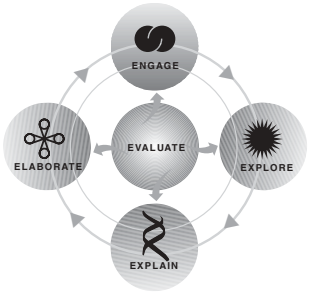
Waves

4. Waves have characteristic properties that do not depend on the type of wave. As a basis for understanding this concept:
   a. Students know waves carry energy from one place to another.
   b. Students know how to identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).
   c. Students know how to solve problems involving wavelength, frequency, and wave speed.

Investigation & Experimentation

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:
   d. Formulate explanations using logic and evidence.
   g. Recognize the usefulness and limitations of models and theories as scientific representations of reality.

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Learning Strategy, Science Process	Suggested Time
ENGAGE	Students engage in a simulation that models how waves transfer energy from one place to another. Observing, Communicating, Comparing, Ordering	50 minutes
EXPLORE	By experimenting with tuning forks, students explore the mathematical relationship between frequency and wavelength. Observing, Communicating, Comparing, Ordering	50 minutes
EXPLAIN	Students explain their results by qualitatively comparing the wavelengths obtained with three different tuning forks. They use their data to calculate the speed of sound, and compare their results with other student groups. Communicating, Comparing, Relating,	50 minutes
ELABORATE	Students use "Reciprocal Teaching" as they apply their understanding of waves to the destructive standing waves that John Glenn experienced in testing jet fighter planes. Communicating, Comparing, Relating, Applying	50 minutes
EVALUATE	Students evaluate their understanding by designing simulations to model different wave properties and phenomena. Teacher evaluates student understanding of student outcomes in this activity as well throughout the lesson. Observing, Communicating, Comparing, Relating, Applying	100 minutes

Standing Waves

Teacher Background:

Waves are vibrations that move through space and time. While we are all familiar with waves, we tend to have the misconception that the material of the wave travels in the direction of the wave propagation. Upon deeper reflection, such as analyzing a wave traveling across a field of tall grass, we come to realize that a wave represents a disturbance or vibration moving across a medium, but that the parts of the medium do not leave their places. This is an example of a longitudinal wave in which the medium vibrates parallel to the direction of wave propagation. In a transverse wave (such as a slinky moving side-to-side), the medium vibrates perpendicular to the direction of wave propagation.

Unlike physical objects, more than one wave can exist in the same time and same space. When waves occupy the same space at the same time, they interact with each other resulting in interference patterns that depend on whether they are in phase with one another, and also depending on their frequencies and amplitudes.

A standing wave is a particularly dramatic interference pattern. It has locations that do not change position (nodes), and locations that alternate rapidly between being displaced maximally to one side and then maximally to the opposite side. The name "standing wave" may sound calm, as if the wave stays in one position. This is true only at the nodes. The maximum positions rapidly alternate between being stretched to the maximum in opposite directions, resulting in the potential of standing waves to cause dramatic damage or produce dramatic results.

Scientists use models, mental and/or physical, to help them understand phenomena. Since a model is a representation, it has features that more or less accurately represent the phenomenon, and other features that do not.

Related California Content Standards

Mathematics: Grades 9-12

Algebra 1

15.0 Students apply algebraic techniques to solve rate problems, work problems, and percent mixture problems.

Trigonometry

2.0 Students know the definition of sine and cosine as y-and x-coordinates of points on the unit circle and are familiar with the graphs of the sine and cosine functions.

Grouping: Whole group, groups of 4, individual

For simulations and hands-on activities, mix the EL with the native speakers. For debriefing, include at least two EL with native speakers to form discussion groups.

Materials:

Per Class

1 Heavy duty 25 ft coiled phone cord
1 Short piece of strong string to tie one end of the phone cord
Chart showing the positions for Human Wave Model #2 (Teacher Page 1.0)
Chart showing the positions for Human Standing Wave Model (Teacher Page 2.0)

Per Group

3 Tuning forks (frequencies of 256-C, 320-E, 384-G)
1 Meter stick
1 500 ml or 1 liter Graduated cylinder
1 Clear plastic tube about 3 cm in diameter and 40 cm long

Per Student

1 Copy of *John Glenn: A Memoir*
Student Pages 1.0 and 2.0

Advance Preparation:

1. Cut the clear plastic pipe into lengths of 40 cm.
2. Find a good location to tie one end of the 25 foot coiled phone cord where you can stand about 2 meters away from where it is tied and where students can observe waves in the cord when you vibrate it side-to-side.
3. Create a chart illustrating the five positions in the Wave Model #2 simulation (Teacher Page 1.0).
4. Create a chart of the 9 locations in the Human Standing Wave Model simulation but do not fill in the Start or Alternate Positions (Teacher Page 2.0).
5. Have a strip of paper for each location of the Human Standing Wave Model (e.g., student at location 3 switches between +2 and -2 position).

Teacher Resources:

Tuning forks available from Carolina (www.carolina.com item WW-75-4218) or from Flinn Scientific, Inc (www.flinnsci.com item AP9032).

The Exploratorium website (www.exploratorium.edu) and Paul Doherty's wave lessons (http://www.exo.net/~pauld/summer_institute/summer_day10waves/day10_waves.html).

Teacher Tips:

- Do not stretch the phone cord. Get the heavy duty type, and have a backup phone cord available. Practice getting 1/2, 1, 2 or more waves by moving your hand side-to-side. Use flicks of the wrist and minimize arm motion.
- You can substitute a slinky for the phone cord but it works best on the floor or a tabletop.
- Obtain clear plastic tubing from an aquarium supply store.
- As an alternative to Step 7 in the ENGAGE stage, have students design their own Human Wave Model #2 (Teacher Page 1.0) rather than following teacher directions. Plan additional time if you select this alternative. Have students work in groups of four to brainstorm, share, and critique their models. If necessary, correct misconceptions and incorporate features into the student presentations so they are as accurate as Human Wave Model #2.
- You can model changing the frequency (EVALUATE stage, step 34) in two ways. In the first way, simply increase the speed of the beats. In this case, the wavelength remains the same (it is still spread over 9 students), and you have modeled the direct relationship between wave speed and frequency (speed of wave = frequency times wavelength). In the second way, keep the original beat but decrease the wavelength by eliminating the +1 and -1 positions. In this second case, you have modeled an increased frequency due to a decreased wavelength. With wave speed being constant, frequency and wavelength are inversely related to each other (frequency equals speed of wave divided by wavelength).

VOCABULARY

amplitude - the maximum displacement of the medium from its resting position

frequency - the number of waves that pass through a point per unit time

longitudinal wave - a wave that vibrates parallel to the direction of wave propagation (e.g., sound waves)

medium - the material though which the wave is moving

node - a location in the wave that does not move (no displacement of the medium from its resting position)

propagation - direction in which the wave moves through the medium

standing wave - a wave pattern that features stable nodes and locations that rapidly change position

transverse wave - a wave that vibrates perpendicular to the direction of wave propagation (e.g., water waves and light)

wavelength - the distance from any point on a wave to the next adjacent equivalent point (e.g., peak to peak)

wave speed - the speed with which the wave moves through a medium, either measured directly or calculated by multiplying wavelength times frequency

The Science Learning Cycle:

Standing Waves

ENGAGE:

1. Inform students that they will be exploring the nature of waves. Securely tie one end of a 25 ft length of heavy duty coiled telephone cord to a secure location. Fasten a piece of tape at one spot about halfway along the cord. Hold the cord horizontally about 2 meters away from the attachment location. Rapidly flick your wrist side-to-side just once.

2. Have the students describe what happens as a result of that single motion. (A disturbance moves along the length of the wire from you to the attachment point and back again. This happens several times with the amount of motion decreasing each time.)

3. Have the students focus on the piece of tape. Flick the cord again. Ask them what direction the disturbance is moving (along the length of the wire). Ask them to compare how each individual part of the wire is moving relative to the direction that the disturbance is moving (the parts of the wire are moving back and forth, perpendicular to the direction that the disturbance is moving down the length of the wire). Repeat the disturbance so students can confirm these observations.

4. Stand as before, but now move your hand side to side rapidly enough so that a full wavelength of motion is readily observed. Make sure students can observe the full wavelength. Compare again the motion of the wave (along the length of the wire) to the motion of the sections of the wire (back and forth, perpendicular to the direction of wave propagation).

5. Have students conduct the simulation that shows Human Wave Model #1 (Teacher Page 1.0).

6. Ask students to read the description of transverse waves (Student Page 1.0). Ask them how Human Wave Model #1 accurately represents transverse waves. In what ways, does Human Wave Model #1 inaccurately represent transverse waves? Chart the main discussion points.

7. Have students conduct the simulation that shows Human Wave Model #2 (Teacher Page 1.0). Alternatively, you can have them engage in this simulation in an open-inquiry mode (see Teacher Tips).

8. Ask students to discuss whether Human Wave Model #2 more accurately represents transverse waves than Human Wave Model #1. Refer to the discussion about the accuracy and inaccuracy of Human Wave Model #1.

EXPLORE:

9. Introduce the concepts of wavelength, frequency, and amplitude with the following demonstration. Securely tie one end of the 25 foot heavy duty coiled telephone cord as in Step 1 above. Show how a side-to-side motion can generate a wave whose wavelength is equal to the length of the coil. Decrease the frequency and demonstrate that the wavelength is now equal to twice the length of the coil (only see half a wave on the coil). Demonstrate that faster side-to-side vibrations (higher frequencies) result in shorter wavelengths (more than one full wave in the same length of coiled wire). Have students note the amplitude of the waves.

10. Explain to the students that they are going to experiment with sound, which is another wave phenomenon. Assign students to groups of four and ask them to identify who will assume the following roles: 3 investigators, 1 recorder/reporter. Note: have students rotate roles periodically during the experiment.

11. Have one investigator from each group obtain the materials for their group. Distribute Student Page 2.0.

12. Instruct the students to follow the procedures, and to record their observations with all 3 tuning forks. Remind them to only use a soft object to strike the tuning fork (e.g., piece of rubber, heel of shoe, not the graduated cylinder or the lab bench!). Ask the recorder to write observations and measured distance of maximum sound. Remind groups to predict the distance for the second and third tuning forks. Have all students record measurements and predictions in a student-made data table.

13. When the investigation is completed, have the students return the materials to the collection center.

EXPLAIN:

14. Have the recorder/reporter from each group whiteboard their group's results. Have the group describe their observations and the relationship between frequency and the distances they measured (inversely related).

15. Ask the recorder/reporter to share their results, and have the class discuss agreements and discrepancies among the results.

16. Introduce the equation that wave speed = wavelength times frequency. The frequency is in Hertz which is a "per second" unit.

17. Have students use their group data to calculate the wavelength in meters for each tuning fork (Student Page 3.0, Part 1). Remind them that the distances they measured of maximum sound were locations equal to one-quarter of the respective wavelengths. Ask several students to share their answers to the two questions in Part 1.

18. Ask students to complete Part 2 of Student Page 3.0, calculating the speed of sound for each tuning fork. Have them whiteboard their calculations and ask groups to share their data with each other. Discuss the range of values obtained.

19. Have the students compare their results with the accepted value for the speed of sound (approximately 345 meters per second in dry air at 20 degrees Celsius). Discuss the range of values and possible sources of experimental variation.

ELABORATE:

20. Have students read the beginning of Chapter 11 of *John Glenn: A Memoir* (pages 203-212) as homework, and/or describe John Glenn's role as a test pilot for fighter jet planes.

21. Tell students that they will be using "Reciprocal Teaching" as a way to help them understand what they are reading. Write the words QUESTIONING, SUMMARIZING, CLARIFYING, and PREDICTING on the board or on chart paper. Discuss the meaning of those words (as described in Appendix, pages 178-179) with students, and explain that they will be practicing those processes using readings from *John Glenn: A Memoir*.

22. Preface the following reading by telling students that it involves John Glenn testing the F7U Cutlass fighter jet designed and made by the Chance Vought Company. Have students read four paragraphs beginning with the words "The low-altitude armaments . . . " (page 213) and continuing through ". . . operation of the fuel control-flameout" (page 214).

23. In the next few steps, model "Reciprocal Teaching" as if you are the reader/discussion leader. Model "Questioning" by asking the students, "What caused the engines to quit at high altitude?" (air is thin at that altitude and firing the canons caused a standing wave that interfered with the airflow and operation of the fuel control).

24. Model "Summarizing" for the four paragraphs by restating in your own words what happened in the four paragraphs.

25. Model "Clarifying" by focusing on the last paragraph as being a difficult paragraph. Note that John Glenn compared the standing wave to the sound wave resonating in an organ pipe. Tell them that these are both phenomena that occur when waves interact with each other.

26. Model "Predicting" by asking students what they think will happen next.

27. Assign students to groups of 3 and ask them to choose a discussion leader for each group. Ask the students to read the next three paragraphs in the book, and use "Reciprocal Teaching" to discuss the paragraphs. Have the group discussion leaders in each group first ask a question to their group about the reading, and then summarize and clarify. Have them conclude their role as discussion leader by asking the group to predict based on the reading.

28. Tell the students that the military abandoned the Cutlass because of other problems. John Glenn then tested the F8U Crusader. On one flight he had problems controlling the plane after he tested its cannons. The next reading describes what happened after he landed. Have students read 5 paragraphs beginning "After I landed . . ." (page 218) through"… like a bullwhip and just flicked it off (page 219). Have a different student in each group serve as the discussion leader and follow "Reciprocal Teaching" to debrief these paragraphs.

29. Ask students to read the next 2 paragraphs (pages 219-220). Using "Reciprocal Teaching," have a different student in each group play the role of discussion leader.

30. Have the students share their experience using "Reciprocal Teaching," and how it helped make the text more understandable.

EVALUATE:

31. Have students in groups of 4 take a piece of chart paper and divide into four sections. Label the sections: Telephone Cord; Human Wave Models; Tuning Forks; John Glenn reading. Have them list in each section the characteristics of waves they learned.

32. Have students from several groups share their learnings and discuss as a whole class (wavelength, frequency, amplitude, wave equation, medium moving perpendicular to direction of wave propagation, waves interacting with each other to make loud sounds or cause structural damage).

33. Review the terms wavelength, amplitude, and frequency by revisiting Human Wave Model #2. Divide the following three tasks among the groups (several groups will have the same task). Each group will use Human Wave Model #2 as the basis for their demonstration. Each group will propagate a wave based on their given task:
    - Task #1 is to demonstrate what wavelength is (the length of the wave shown by all 9 students at any point in time), and model a wave with twice the wavelength.
    - Task #2 is to demonstrate what amplitude is (distance from sitting to standing with arms raised, or from sitting to squatting with hands on floor), and model a wave with twice the amplitude.
    - Task #3 is to demonstrate what frequency is (how many complete waves pass through any point per second) and model a wave with twice the frequency (see Teacher Tips).

34. Remind students about the standing waves that caused damage to John Glenn's plane. Follow the directions on Teacher Page 2.0 to have students model, observe, and analyze a standing wave.

35. Have students work in groups of 4 to discuss how a standing wave could cause serious damage to the wing of John Glenn's plane. Ask each group to make a drawing that illustrates how the standing wave caused the damage (parts of the wing had to swing from one extreme position to another while other parts of the wing did not move at all). Ask students to label node, amplitude, and wavelength on their drawing.

35. Have the groups share and critique their drawings and explanations.

37. Jiggle the coiled telephone wire so that it displays one full wavelength. Have students observe the wire and individually write what is happening (it is a standing wave).

Teacher Reflection:

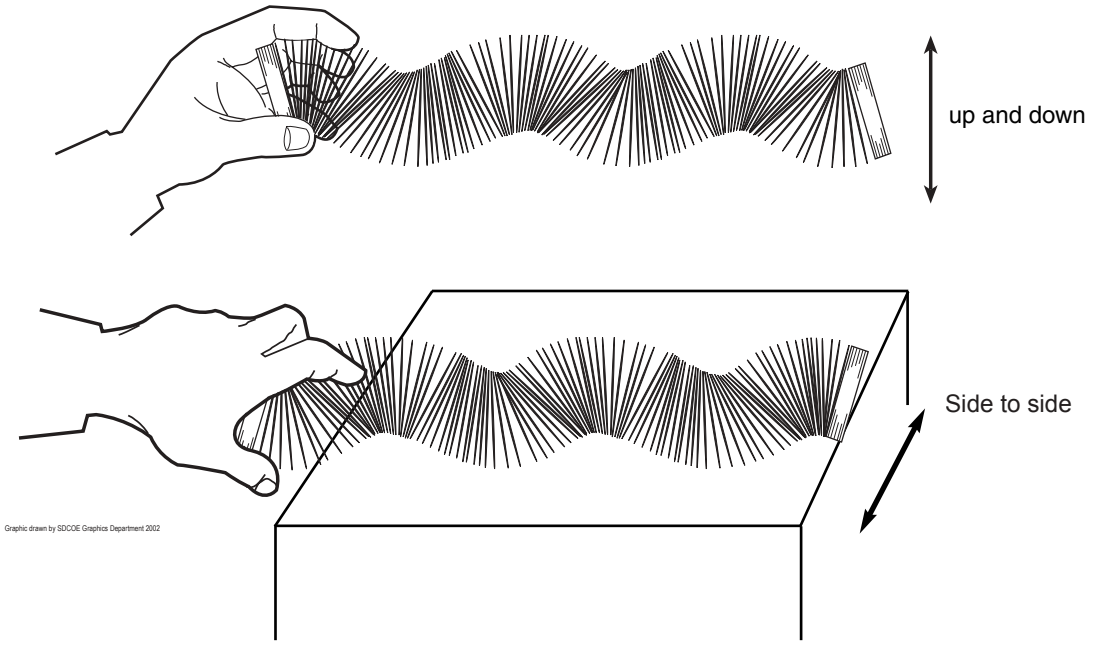
1. How does the student work provide evidence that they learned the properties of waves, and that they recognize the limitations and usefulness of models?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts and processes?
4. How would you modify instruction to ensure understanding of student outcomes by all students?

Transverse Waves

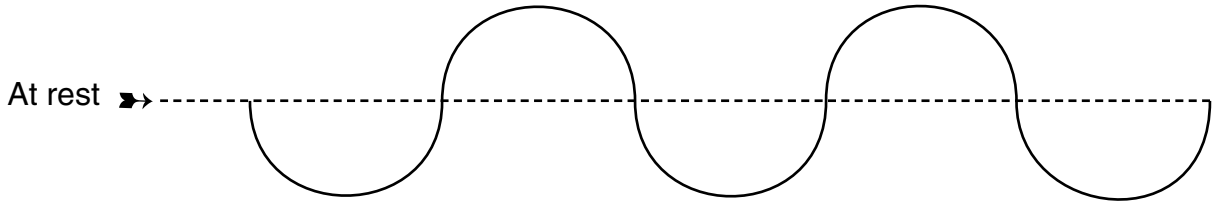
Waves transfer energy from one place to another without transferring matter between the two points. When you vibrate a rope or wire, you can see a wave travel down the length of the wire. The parts of wire itself are moving perpendicular to the direction that the wave moves. The same kind of thing happens with a water wave traveling across the ocean. The water in any one place is moving vertically up and down while the wave itself moves horizontally across the ocean.

The material through which the wave is moving is called the medium. In the case of the stretched wire, the wire is the medium. In the case of the water wave, the ocean is the medium.

These are examples of transverse waves. With a transverse wave, the pieces of the medium move up and down (or side to side) while the wave itself moves perpendicular to that direction. The pieces of the medium do not travel with the wave. In this way, the wave transfers energy from one point to another without transferring matter.



A wave is spread out over space and time. It is not located in any one definite place. When we graph the shape of a wave, it looks like:

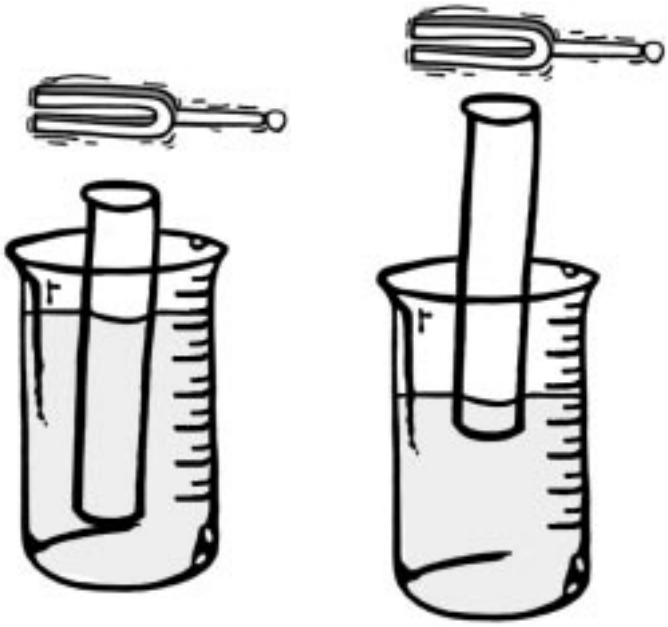


Note that each piece of the wave can have many different possible positions. The center line represents its rest position. Any point in the wave can vary from being at rest to moving up to a maximum distance above or below its rest position.

Tuning Forks

You are going to experiment with tuning forks to investigate the relationship between wavelength and frequency. In your group of 4, assign one person as the recorder/reporter. The other three are investigators. Have one of the investigators get the materials for the experiment.

Fill the graduated cylinder near the top with water. Assign one investigator to strike and hold the tuning fork. Assign another investigator to hold and move the plastic tube slowly upwards. Assign the third investigator to measure the length of the column of air when there is the maximum sound. Look at the figure below to see how you need to synchronize the movement of the tube and the tuning fork.



C (256 Hertz)
Strike the C (265 Hertz) tuning fork against a soft object (for example, a piece of rubber or rubber heel of a shoe; NOT the graduated cylinder or any hard object such as the lab bench). Hold the tuning fork about 1 cm above the tube. Slowly and continuously raise the tuning fork and the tube (synchronized with each other) until you find the first place of loud sound. Hold the tuning fork and tube at this place of maximum sound. Have the third investigator then measure the distance from the top of the water to the bottom of the tuning fork. Record your measurement. Repeat at least two or more times until you are comfortable with accuracy of the measurement.

Enter your results in a data table.

G (384 Hertz)
Repeat the experiment with the G (384 Hertz) tuning fork. Predict what distance you will measure for the place of maximum sound and record that predication in your data table.

Enter your measured results in the data table.

E (329 Hertz)
Repeat the experiment with the E (320 Hertz) tuning fork. Predict what distance you will measure for the place of maximum sound and record that prediction in your data table.

Enter your measured results in the data table.

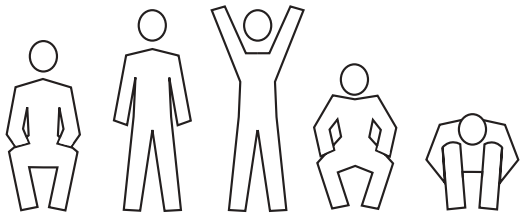
Do the Wave

Human Wave Model #1: Place 9 chairs in the front of the room facing the rest of the class. Have a student sit in each chair and ask them to “do the wave” going from their left to their right. When the wave reaches the end person, have the person on the other end begin again.

Distribute the reading about transverse waves (Student page 1.0). In groups of four, have the students discuss how Human Wave Model #1 does and does not accurately represent the nature of a transverse wave. (Accurately - it is a disturbance in the medium that moves through the medium; the particles of the medium move perpendicular to the motion of the wave; the particles of the medium do not travel with the wave; waves involve a transfer of energy between two points without being a transfer of matter. Inaccurately - at any moment, a wave is spread out continuously in space and time; any location in the wave has more than two possible positions; there are “below the line” positions in addition to “above the line” positions in the wave.)

Human Wave Model #2: Invite a different group of 9 students to sit in front of the room facing the rest of the class. Tell them they are going to demonstrate Human Wave Model #2, that you think may be a more accurate representation of a transverse wave. On a large piece of chart paper, indicate the movements that they will make as below:

0 = seated
+1 = standing, arms at side
+2 = standing, hands over head
-1 = squatting arms at side
-2 = squatting, hands on floor



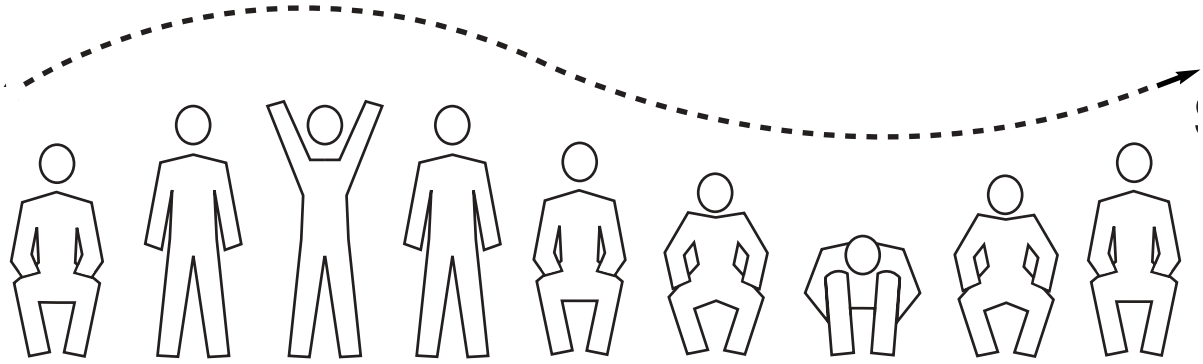
Have the students take their START positions and notice from the chart (reading horizontally) the sequence of their positions. For each beat, they will move one position to the right.

HUMAN WAVE MODEL #2								
Location	START	NEXT	NEXT	NEXT	NEXT	NEXT	NEXT	NEXT
1	0	+1	+2	+1	0	-1	-2	-1
2	+1	+2	+1	0	-1	-2	-1	0
3	+2	+1	0	-1	-2	-1	0	+1
4	+1	0	-1	-2	-1	0	+1	+2
5	0	-1	-2	-1	0	+1	+2	+1
6	-1	-2	-1	0	+1	+2	+1	0
7	-2	-1	0	+1	+2	+1	0	-1
8	-1	0	+1	+2	+1	0	-1	-2
9	0	+1	+2	+1	0	-1	-2	-1

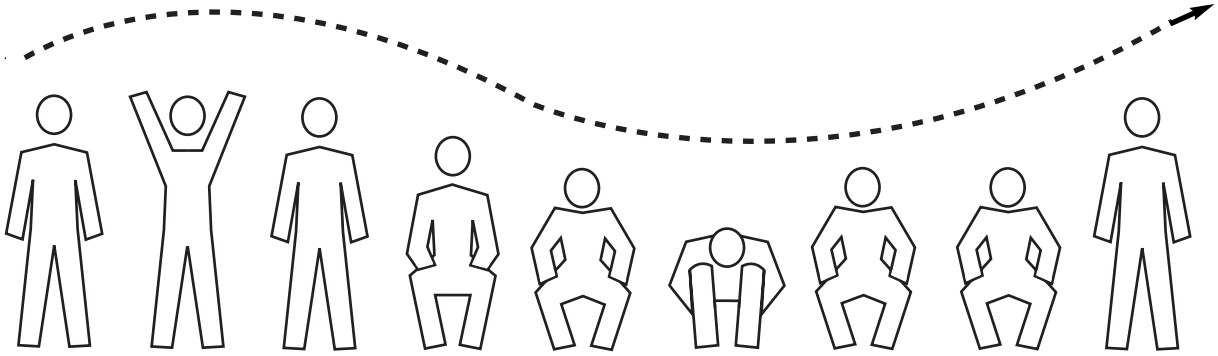
Use a steady beat to have the students model at least one full round of 9 beats. Also stop the beat at least three times during the demonstration and have students note the position of each location in the wave (in other words, what the wave looks like at a particular instant in time). Repeat with at least one other group of 9 students.

Transverse Wave

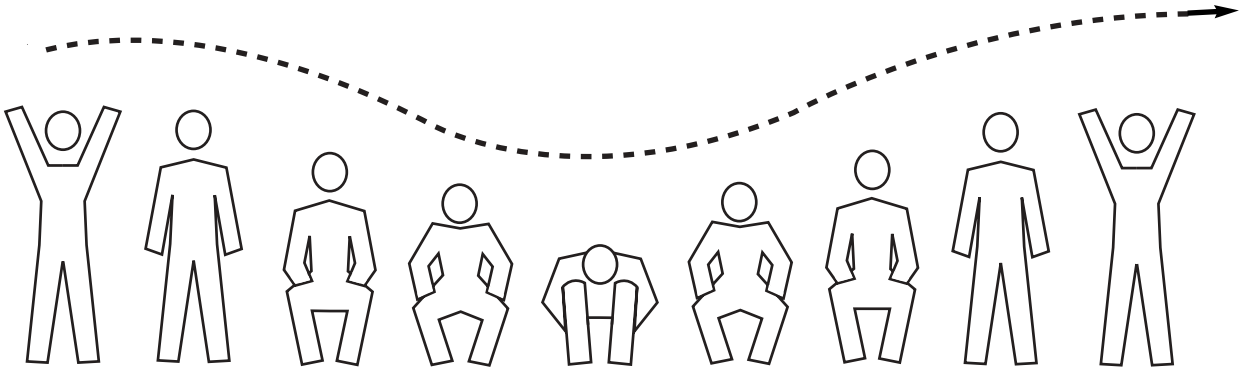
START



BEAT 1



BEAT 2

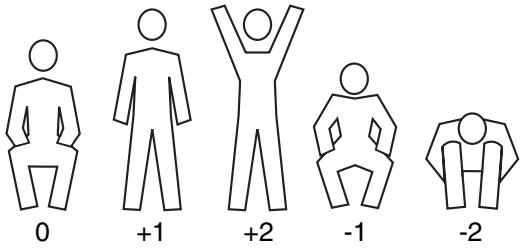


Note the wave propogates right to left and that medium motion is up and down.

Human Standing Wave Model

Place 9 chairs in the front of the room facing the rest of the class. Invite 9 students to sit on the chairs facing the class.

0 = seated
+1 = standing, arms at side
+2 = standing, hands over head
-1 = squatting arms at side
-2 = squatting, hands on floor



Place a chart on the board of the Human Standing Wave Model indicating the 9 student locations but not the start or alternate positions. Assign at least one student in the class to observe each of the 9 students. Give each of the 9 seated students a piece of paper indicating the two positions that they should take in modeling a standing wave.

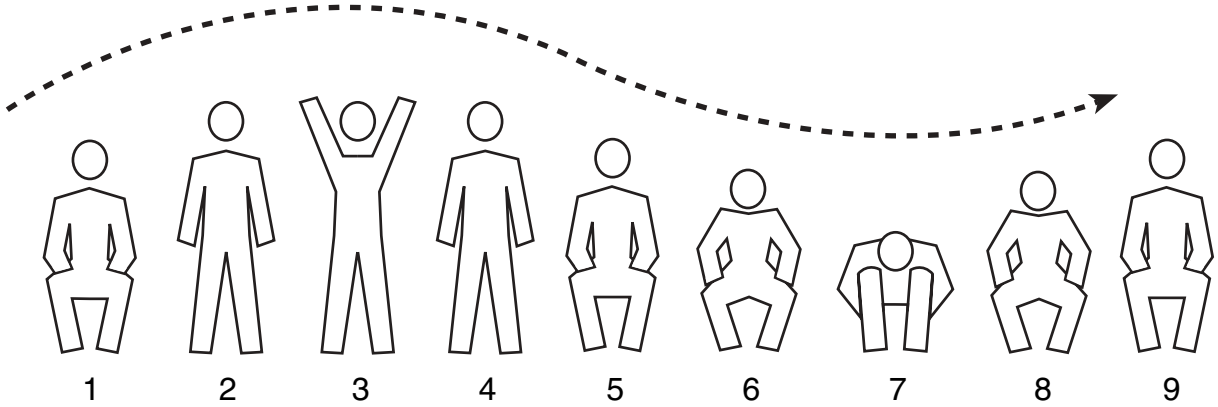
Use a steady beat (drum, bell or other device) to indicate when the students switch from one position to the other. After several rounds, have the observing students fill in the chart noting the two positions for the student they observed. A correctly completed chart looks like the one below.

HUMAN STANDING WAVE MODEL		
Student Location	Start Position	Alternate Position
1	0	0
2	+1	-1
3	+2	-2
4	+1	-1
5	0	0
6	-1	+1
7	-2	+2
8	-1	+1
9	0	0

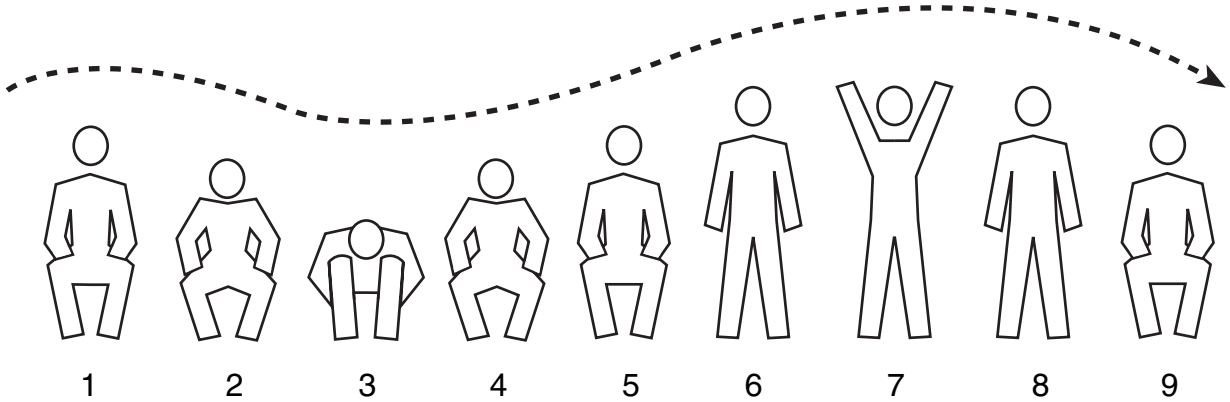
Invite another group of 9 students to sit in front of the class. Without giving them the piece of paper for their location, have them model a standing wave. Have the class critique their demonstration.

Standing Wave

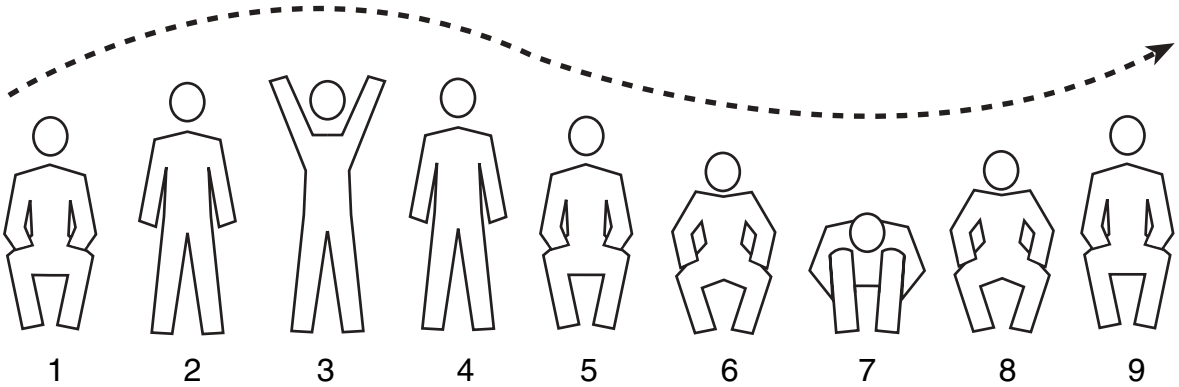
Start



Next



Next



1, 5 and 9 are seated the whole time.
Maximum fluctuations at positions 3 and 7.

Grades

9-12

Strategic Science Teaching

Title of Lesson:

Double Helix

Conceptual Statement:

DNA is a very large biochemical molecule. Its chemical structure enables DNA to carry out the heredity function of accurately passing information from generation to generation.

Conceptual Learning Sequence:

This lesson would serve as an introductory lesson in a unit exploring the chemistry of living things.

Student Outcomes:

- Students describe the chemical structure of the DNA molecule.
- Students build a model of the DNA molecule based on available information, and appreciate the advantages and limitations of models.
- Students use "LINK" to extract information from text about DNA and its discovery.

Essential Question:

What is the chemistry of heredity?

Lesson Overview:

In this lesson students learn the context for the discovery of the DNA molecule by jigsawing the opening chapters of The Double Helix. Students use "LINK" (List, Inquire, Note and Know) to access their prior knowledge about this context and to prepare for the reading. Students build several models of DNA, refining the models as they receive more information. Students read a section in The Double Helix to better understand how interpretations of data led to the discovery of the structure of DNA. They apply their understanding of the structure by building a model that incorporates information from the text and from their previous models.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

Several selections from The Double Helix are used in the ENGAGE stage to assist students in understanding the context (people/places) of the scientific work that surrounded the discovery of DNA's structure. In the EXPLAIN stage, students use a reading from the book to gather information about the structure of DNA, compare the information to their models, and understand the complexities of scientific discovery.

Learning Strategy:

This lesson uses "LINK" which prompts students to brainstorm what they will encounter in a reading selection, and to direct their discussion of what they already know about a topic. (See Appendix pages 186-187.)

Literature Selection:

Title: The Double Helix
Author: Watson, James D.
Publisher: Mentor Books, 1968 ISBN: 0451627873
Annotation: James Watson, Francis Crick and Maurice Wilkins were awarded the Nobel Prize in 1962 for determining the molecular structure of DNA. This book is the personal story of Watson's involvement with the discovery and documents both his interpersonal and scientific thinking. The book provides a behind-the-scenes look at the very human side of scientific discovery.
Genre: Narrative Nonfiction

California Content Standards:*

Science Standard: Grades 9-12

Organic Chemistry and Biochemistry

10. The bonding characteristics of carbon allow the formation of many different organic molecules of varied sizes, shapes, and chemical properties and provide the biochemical basis of life. As a basis of understanding this concept:
    a. Students know large molecules (polymers) such as proteins, nucleic acids, and starch, are formed by repetitive combinations of simple subunits.
    e. Students know how to identify the functional groups that form the basis of alcohols, ketones, ethers, amines, esters, aldehydes, and organic acids.

Biology/Life Science: Grades 9-12

Genetics

5. The genetic composition of cells can be altered by incorporation of exogenous DNA into the cells. As a basis for understanding this concept:
    a. Students know the general structures and functions of DNA, RNA, and protein.

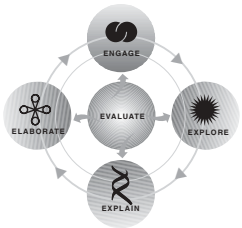
1. Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:

d. Formulate explanations by using logic and evidence.
g. Recognize the usefulness and limitations of models and theories as scientific representations of reality.
k. Recognize the cumulative nature of scientific evidence.
l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

*Specific standards addressed in this lesson.

Lesson at a Glance

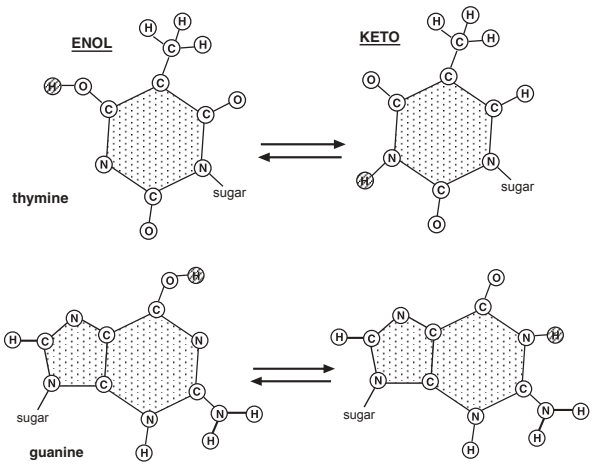


Science Learning Cycle	Objective Learning Strategy, Science Process	Suggested Time
ENGAGE	Students use "LINK" to make a conceptual map about the context surrounding the discovery of DNA. They engage with the text to complete this concept map. Communicating	50 minutes
EXPLORE	Through a series of activities, students explore how to use information to build and refine models. Students recognize the strengths and limitations of models to understand phenomena. Communicating, Infering, Observing, Ordering	50-100 minutes
EXPLAIN	Students read a selection from The Double Helix to help them explain the structure of DNA. Using information from the book and their models from the EXPLORE stage, students refine their models to account for DNA's functions. Communicating, Comparing, Inferring	50 minutes
ELABORATE	Students demonstrate and extend their understanding of the structure of DNA by building a paper model of DNA that reflects certain criteria. This stage incorporates the EVALUATE stage. Communicating, Comparing, Inferring, Applying	50 minutes
EVALUATE	Students evaluate their understanding by constructing a paper model of DNA in the ELABORATE state. Teacher evaluates student understanding of student outcomes in this activity as well throughout the lesson. Applying	Part of the ELABORATE stage

Double Helix

Teacher Background:

Scientists knew that DNA was the molecule that enabled heredity, but it was not clear if the science of the day could reveal the structure of a molecule a million times bigger than a water molecule. The research evidence about its chemical makeup and structure was in a messy stage. Rosalind Franklin's new X-rays of DNA crystals indicated a helical structure, but even she had strong doubts about that conclusion. Chargaff had evidence that the number of adenines roughly equaled the number of thymidines (A=T) and that guanines also equaled cytosines (G=C). Nobody knew what this meant, or even whether it was true or important. The repeating phosphate-sugar backbone could be placed on the outside or the inside of the structure.



Watson and Crick combined model-building with the X-ray data and the chemistry of the bases to eventually find the solution. When Watson used the keto instead of the enol structures of the bases, he found that the hydrogen bonded A+T base pairs have the exact same shape as the hydrogen bonded G+C base pairs. Enol and keto are two different ways that the same atoms can bond with each other. The differences in hydrogen position and oxygen bonding result in very different patterns of hydrogen bonding.

Watson's model-building showed that the atoms would fit properly only if the sugar phosphate backbone was on the outside. His "like-with-like" model did not work because the bigger purine-purine base pairs take up more space than the smaller pyrimidine-pyrimidine base pairs (especially using the keto forms). In contrast, the A-T and G-C base pairs (both being purine-pyrimidine combinations) have exactly the same size and shape, so they can fit uniformly within the sugar-phosphate backbone.

Note a possible teacher/student misconception: The book emphasizes the nucleotide bases. Yet, DNA is an acid. DNA has both acidic groups (the phosphate backbone) and basic groups (the nucleotide bases). The acidic groups are stronger, so over-all it is an acid.

Related Standards:

English-Language Arts: 9th and 10th Grade

Reading Comprehension (Focus on Informational Materials)

Students read and understand grade-level-appropriate material. They analyze the organizational patterns, arguments, and positions advanced.

Comprehension and Analysis of Grade-Level-Appropriate Text

2.5 Extend ideas presented in primary or secondary sources through original analysis, evaluation, and elaboration.

Reading: 11th and 12 Grade

Comprehension and Analysis of Grade-Level-Appropriate Text

2.4. Make warranted and reasonable assertions about the author's arguments by using elements of the text to defend and clarify interpretations.

English Language Development Standards

9-12 Reading Comprehension

Recognize a few specific facts in familiar expository texts such as consumer and workplace documents and content area texts.

Read and orally identify a few specific facts in simple expository text such as consumer and workplace documents and content area texts.

Orally identify main ideas and some details of familiar literature and informational materials/public documents (e.g., newspapers, brochures, etc.) using key words or phrases.

Apply knowledge of language to achieve meaning/comprehension from informational materials, literary texts, and texts in content areas.

Grouping:

Whole group, groups of 4, individual

For hands-on activities, mix the EL with the native speakers. For debriefing, include at least two EL with native speakers to form discussion groups.

Materials:

Per Class
Video- *Race for the Double Helix* (optional)

Per Group
45 Pop-it beads or paper clips of 4 different colors (e.g., red, green, black and white)
Assortment of fastening materials (e.g., twist ties, wire, rubber bands, yarn/string)
8 Copies of Student Page 2.0
Scissors
Scotch tape, Masking tape

Per Student
Tray with rim (e.g., Styrofoam meat tray)
Model #1, #2, and #3 cards from Student Page 1.0
Student page 2.0
Colored pencils (optional)
The Double Helix

Advance Preparation:

1. Duplicate enough Student Page 1.0 for each student. Cut the model cards apart.
2. Assemble pictures or realia of a zipper, spiral staircase, slinky, and double helix.
3. Using card stock, duplicate 8 copies of Student Page 2.0 for each group.

Teacher Resources:

Race for the Double Helix video, Salk Institute, La Jolla, CA 18 minutes, 1992.

Teacher Tips:

- If pop-it beads are not available, or if you think your students will not respond favorably to their use, use paper clips instead.
- For durability, laminate the model cards.
- Models 1-3 are exploratory; as students begin to make their models watch for patterns in the way they set up the pop-it beads or paper clips. These patterns provide evidence of student understanding.
- Remind students to build their models based on the information given to them.
- If you think students need more familiarity with the puzzle pieces (names and shapes), have students color the individual piece to indicate what they are.
- Provide two colors of tape so that students can indicate hydrogen and covalent bonding on their paper model.
- Open the ELABORATE/EVALUATE stage by having students design their own paper model rather than using Student Page 2.0
- Use the book to help students understand that interpersonal competitions and conflicts are often part of a scientific endeavor. The examples in the book provide fodder for rich discussions.

Related Student Resources:

Access Excellence http://www.accessexcellence.org/RC/index.html#students

Asimov, Isaac. *El Codigno Genetico*, 1986

Human Genome Project http://www.nhgri.nih.gov/HGP

Molecular Biology On-Line http://www.iacr.bbsrc.ac.uk/notebook/courses/guide/dnast.htm

Lesson Credits:

Adapted from Biological Science Curriculum Studies, Biology, A Human Approach, Chapter 12.

VOCABULARY

amino acids – organic acids with the amino group NH_2; the main components of proteins

covalent bonding – strong chemical bonds that connect atoms; in DNA, the bonding within a strand (e.g., sugar-phosphate bond)

DNA – deoxyribonucleic acid, a nucleic acid formed from a repetition of simple building blocks called nucleotides

gene – a specific sequence of nucleotides in DNA or RNA

helix – a spiral or coiled shape; the shape of the DNA molecule

hydrogen bonding – the type of weak bonding between strands of DNA (e.g., between adenine and thymine)

nucleotides – base constituents of all genes (adenine, cytosine, guanine, and thymine)

The Science Learning Cycle:

Double Helix

ENGAGE:

1. Use "LINK"(List, Inquire, Note, Know) to prepare the students to read the first selection in *The Double Helix*. Create a concept map on the board with the words "Discovery of DNA" in a center circle; make three circles from this center circle and label one "people", another "places," another "type of research." Ask students to list, on their own paper, words that they associate with any of the circle concepts.

2. Ask several students to share their ideas and chart them in appropriate places on the concept map. In small groups, ask students to share and elaborate on the ideas on the board and on their own list.

3. Show *The Double Helix* book cover to the class. Based on their conversations in Step 1 and 2, ask students to write a statement about the concepts that they might find in this reading. This step is optional.

4. Divide the class into groups of three; have student count-off 1, 2 or 3. Ask all number 1's to read chapter one; number 2's to read chapter 2, and number 3's to read the first four paragraphs of chapter 3.

5. After the students have completed their reading, ask student to identify some of the major characters (e.g., James Watson, Francis Crick, Maurice Wilkins, Rosalind Franklin, Linus Pauling, Sir Lawrence Bragg), where they worked (e.g., Cambridge, Cal Tech), and how they contributed to the field knowledge about DNA (e.g., X-ray diffraction; genes composed of DNA; work on proteins; work on viruses). Add their information to the class concept map.

EXPLORE:

6. Briefly summarize that while there were many people doing research at the time, and much data had been gathered, it remained unclear just what DNA looked like. The scientists were involved in using pieces of information, gathered from several places, to make models that might be the structure of DNA. To them, "DNA was the most golden of all molecules."

7. Ask students to imagine themselves as part of a team of research scientists involved in an effort to describe the DNA structure. Explain that their task is to build a model based on available information, and to then change the model, as new information becomes available.

8. Distribute a Model #1 Card to each student, and the materials to groups of four students. Explain that although they will work as team, each student will build their own model to compare with other students. Provide time for students to build the model, then ask them to share with each other.

9. Ask students to analyze their model. What features represent the properties of DNA as described on the Model #1 card? How might this structure allow DNA to store information, in general, and to store different information along its length? If necessary, prompt the discussion by asking why they placed the colored beads (paper clips) in the order they did.

10. Distribute a Model #2 Card to each student, and ask students to modify their original model based on the information on this card. Provide time for students to build the model, and then ask them to share with each other.

11. Help students critique the usefulness of their model in representing the "clues" from the Model #1 Card and the Model #2 Card. If there is no modeling of the bonding between the strands, ask what materials the students might use to indicate the weak hydrogen bonds (fasteners). Note: base complementarity is not necessary at this point.

12. Display a picture or realia of a zipper, spiral staircase, slinky, and double helix. Have students compare the structure of their DNA model with these items. Remind students that models are useful, but that they do not portray all the nuances of the real thing!

13. Distribute a Model #3 Card to each student and ask students to modify their original model based on the information on this card. Provide time for students to build the model, and then ask them to share with each other.

14. Ask students: "What is the relationship between subunits bonded to each other on opposite strands of the DNA double helix?" (depending on their model, it will be "like-to-like" or two different colors always opposite each other).

The Science Learning Cycle: Double Helix

EXPLAIN:

15. Ask students to use "LINK" to prepare for their next reading. Have them List what they know about the DNA molecule to this point. Ask them to Inquire of each other what the other person knows.

16. Ask students to read Chapter 25 and 26 and the illustration in Chapter 27 in *The Double Helix*. Write these questions on the board and ask students to answer them (take Notes) from information in the reading:
    - What are the subunits of DNA?
    - What is Chargaff's rule?
    - What does the diameter of the DNA model have to do with its structure?
    - How did choosing the keto instead of the enol forms of the bases contribute to the model?
    - What are the interactions between the subunits on each strand?
    - How does the sequence of subunits on one strand provide a template for the sequence of the subunits on the other strand?

17. Ask students to share what they know about the structure of DNA from their reading.

ELABORATE/EVALUATE:

18. Have students discuss how they would modify their third model based on the information they learned from the reading. How does the structure reflect the functions of information storage and transmission of genetic material?

19. Divide students in groups of four. Provide 8 copies of Student Page 2.0 to each group. Ask them to synthesize their understanding about the structure of DNA by constructing, as a group, one paper model. Ask students to use the two types of tape to denote covalent and hydrogen bonding. Note: as an alternative, have students design their own paper model template. In either case, critique their model for the following:
    - sugar-phosphate "backbone"
    - two strands with 12 base-pairs
    - identified bases: adenine, thymine, guanine, cytosine
    - purines (adenine, guanine) are the large base pieces; pyrimidines (thymine, cytosine) are the small base pieces
    - complementarity of bases
    - recognition that the diameter of the molecule should be the same
    - double helix structure
    - identification of hydrogen bonding between strands
    - identification of covalent bonding within strands

20. Students submit a definition of the chemical structure of DNA that is a refinement of their original "LINK" definition.

Teacher Reflection:

1. How does the student work provide evidence that they understand the structure of DNA, and appreciate the advantages and limitations of models?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts?
4. How would you modify instruction to ensure understanding of student outcomes by all students?

Model #1 Card

Observations about the Structure of DNA

✓ DNA is a polymer: a very long, chainlike molecule composed of small subunit molecules. Covalent bonds attach the subunits, like links on a chain.

✓ Four different types of subunit molecules exist.

Model #2 Card

Observations about the Structure of DNA

✓ DNA has two long chains of subunits twisted around each other to form a double helix.

✓ The two helical chains (strands) are bonded together weakly, with subunits on one strand bonding to subunits on the other strand

✓ The diameter of the DNA molecule is uniform along its length.

Model #3 Card

Observations about the Structure of DNA

✓ The order of subunits in one strand of DNA determines the order of subnunits in the other strand.

✓ As you try to solve this portion of the model, consider that the aspect of DNA's structure that you now are modeling provides clues for the patterns of DNA replication.

Grades

9-12

Strategic Science Teaching

Title of Lesson:

Virus Alert

Essential Question:

What are various types of pathogens and how do they affect organisms?

Conceptual Statement:

Viruses differ from prokaryotic and eukaryotic cells in complexity and general structure. The threats they pose are related to the nature of virus reproduction, human behavior and human defense systems.

Conceptual Learning Sequence:

This lesson is part of a conceptual unit on pathogens and their affects on organisms. It is appropriate after students have a general understanding of disease, human defenses (e.g., antigens/antibodies), and disease-causing agents including bacteria.

Student Outcomes:

- Students describe the structure and reproductive requirement of viruses.
- Students participate in a simulation to explore the relationship of human behavior to the spread of viruses.
- Students extract information about viruses from expository text.

Lesson Overview:

In this lesson, students participate in an activity that models the invisible and rapid spread of viruses. The students read and analyze sections of *The Hot Zone* using the learning strategy "Question-Answer Relationships" (QAR) to access information about the nature and reproductive requirements of viruses, and to better understand the human role in the spread of viruses. "QAR" helps students identify different kinds of questions and create strategies for finding the answers.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental difference for students who are English learners.

Literature in the Science Learning Cycle:

The literature selection, *The Hot Zone*, is used in the ENGAGE stage to create a graphic picture of the spread and the effects of a virus on humans. The literature is also used in the EXPLORE and ELABORATE stages to build understanding about the structure and reproductive requirements of viruses, and the relationship of human behavior to the spread of the viruses.

Learning Strategy:

This lesson uses the "Question-Answer Relationship" ("QAR") learning strategy which is based on the four-part system for classifying questions: Right There; Think and Search; Author and You; and On Your Own. (See Appendix pages 171-173.)

Literature Selection:

Title: *The Hot Zone*
Author: Preston, Richard
Publisher: Anchor Books, 1998 ISBN: 0385479565; (small format paper-back 4 1/4 inches x 6 1/2 inches)
Annotation: This is a dramatic, true account of the appearance of lethal viruses into the human population and the battle to contain them. The book is very graphic and fast-paced.
Genre: Narrative Nonfiction

California Science Content Standards:*

Biology/Life Science; Grades 9-12

Cell Biology

1. The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells. As a basis for understanding this concept:
   c. Students know how prokaryotic cell, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure.

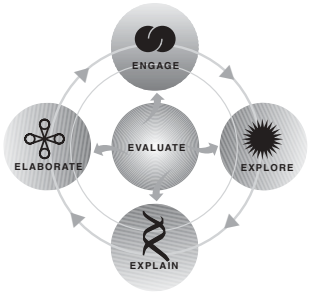
Ecology

6. Stability in an ecosystem is a balance between competing effects. As a basis for understanding this concept:
   b. Students know how to analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of nonnative species, or changes in population size.

Investigation Experimentation

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for under standing this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:
   d. Formulate explanations by using logic and evidence.
   g. Recognize the usefulness and limitations of models and theories as scientific representations of reality.
   l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

*Specific standards addressed in this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Learning Strategy, Science Process	Suggested Time
ENGAGE	Students engage in connecting their current understanding of viruses to new situations. By reading a powerful section of *The Hot Zone* and by using the "QAR" strategy to answer questions and generate their own, students prepare for the simulation. Communicating	50 minutes (one class period)
EXPLORE	Through a simulation, students explore how quickly a virus spreads. Students continue building and answering their questions by visiting appropriate web sites, using text material and doing further reading in *The Hot Zone*. Observing, Communicating, Ordering, Inferring	50-100 minutes (one to two class periods)
EXPLAIN	Students explain the content of the questions they investigate. The teacher facilitates the discussion to connect the aspects of engagement and exploration activities to student understanding of the content. Communicating, Comparing, Inferring	50 minutes (one class period)
ELABORATE	Through further reading and use of the "QAR" strategy, students expand and generalize their understanding of how filoviruses spread. Communicating, Comparing, Inferring, Applying	50 minutes (one class period)
EVALUATE	Students evaluate their understanding by constructing a poster that informs how to prevent the spread of viruses. Teacher evaluates student understanding of student outcomes in this activity as well throughout the lesson. Applying	50 minutes (one class period)

Virus Alert

Teacher Background:

Viruses consist of genetic material, either DNA or RNA, surrounded by a protein coat. Some viruses appear to be harmless to humans, while others cause important infectious diseases.

There is on-going controversy over whether or not viruses are living. Viruses depend on a host's cell for the virus's metabolic and reproductive needs. Viruses are typically transmitted through air or fluid, and do not respond to antibiotics.

The Ebola virus cited in *The Hot Zone* belongs to a family of viruses called filovirus. These viruses look like a strand of thread that may tangle or roll into loops. Some or all filoviruses are particularly contagious and lethal.

Related Standards:

English-Language Arts: Grades 9-10

Reading Comprehension (Focus on Informational Materials)

Students read and understand grade-level-appropriate material. They analyze the organizational patterns, arguments, and positions advanced.

Comprehension and Analysis of Grade-Level-Appropriate Text

2.5 Extend ideas presented in primary or secondary sources through original analysis, evaluation, and elaboration.

Listening and Speaking

Students formulate adroit judgments about oral communication They deliver focused and coherent presentations of their own that convey clear and distinct perspectives and solid reasoning. They use gestures, tone, and vocabulary tailored to the audience and purpose.

Organization and Delivery of Oral Communication

1.8 Produce concise notes for extemporaneous delivery.

2.4 Deliver oral responses to literature:

Advance a judgment demonstrating comprehensive grasp of the significant ideas of works or passages (i.e., make and support warranted assertions about the text.)

Support important ideas and viewpoints through accurate and detailed references to the text or to other works.

Reading: Grades 11-12

Comprehension and Analysis of Grade-Level-Appropriate Text

2.4. Make warranted and reasonable assertions about the author's arguments by using elements of the text to defend and clarify interpretations.

English Language Development Standards

Reading Comprehension

Recognize a few specific facts in familiar expository texts such as consumer and workplace documents and content area texts.

Read and orally identify a few specific facts in simple expository text such as consumer and workplace documents and content area texts.

Orally identify main ideas and some details of familiar literature and informational materials/public documents (e.g., newspapers, brochures, etc.) using key words or phrases.

Apply knowledge of language to achieve meaning/comprehension from informational materials, literary texts, and texts in content areas.

Listening and Speaking

Actively participate and initiate more extended social conversations with peers and adults on unfamiliar topics by asking and answering questions and soliciting information.

Prepare and deliver short presentation on ideas, premises, or images from a variety of common sources.

Grouping:

Whole group, groups of 4, individual

For hands-on activities, mix the EL with the native speakers. For debriefing, include at least two EL with native speakers to form discussion groups.

Materials:

Per Class

Clear base indicator (phenolphthalein) in a dropper bottle or with a pipette

Base solution, 10 ml of 0.1 M NaOH or 20% solution of Liquid Drano™ for one student (see advanced preparation)

Per Student

Small clear cup, test tube or beaker (20 ml or more)

Dropper, or pipette

Water, 10 ml

Post-its™

Advanced Preparation:

1. Prepare the base solution of NaOH by placing 0.4 grams of NaOH dissolved in enough water to make 100 ml of solution OR place 20 ml of Drano in 80ml of water.

Glove and Safety glasses required.

2. Put 10 ml of water in all of the students' cups but one; put 10 ml of the base solution in this one cup. There should be one student "infected" with the base solution for every 24 students participating.

Teacher Resources:

Centers for Disease Control (U.S. Department of Health and Human Services)
http://www.cdc.gov/

The Biology Project (University of Arizona)
http://www.biology.arizona.edu/cell_bio/tutorials/pev/problems.html

Teacher Tips:

- Teach the "QAR" methodology to students before doing this lesson.
- Obtain a commercial kit that models the rapid spread of viruses (See Lab Quest) instead of doing your own preparation.
- Do not let the students know that one student has a different solution; the "infection" needs to be invisible.
- Make sure that the student-generated questions used in the class chart reflect the content that needs to be addressed in this lesson. If they do not, add the appropriate questions.
- In Step 10 and 11, decide how direct to be with the activity directions. For example, provide an overhead with the directions on it, or model the first exchange before having the class complete their exchanges.
- The page numbers in this lesson correspond with the small format (4 1/4 inches x 6 1/2 inches) paper-back version of *The Hot Zone*.

Related Student Resources:

Cook, Robin. *Outbreak*. Berkeley,1991.

Garrett Laurie. *The Coming Plague*. Viking, 1995.

Horowitz, Leonard G. and Martin, W. John. *Emerging Viruses: AIDS and Ebola, Accident or Intentional*. Tetrahedron,1996.

Roca, Núria Bosch and Serrano, Marta. *La Célula, El Origen do la Vida*. Norma SA, 1995.

VOCABULARY

eukaryotic – cells which contain a visibly evident nucleus and organelles. Eukaryotic cell structure is characteristic of all organisms except bacteria and blue-green algae

filovirus – a virus with an unusual thread or strand shape, very contagious and dangerous, e.g., Marburg and Ebola

pathogens – disease-causing agent, e.g., some viruses, bacteria, fungi

prokaryotic – cells which do not have a distinct nucleus. Procaryotic cell structure is characteristic of organisms such as bacteria or blue-green algae (cyanobacteria)

virus – a microorganism that consists of a protein covering and either DNA or RNA inside the covering. Viruses reproduce only within the cells of their host

The Science Learning Cycle:

Virus Alert

ENGAGE:

1. Use a think-pair-share strategy to help students make connections between their current knowledge of viruses and what they will learn in this lesson. Ask students to think about what they already know about viruses. Allow one minute for thinking. Have students share what they know about viruses with a partner. Have partner groups share with the class. Record class responses about viruses.

2. Explain to students that they are going to read selections from *The Hot Zone* to add to their understanding of viruses.

3. Preview the book with the students: have students relate the picture on the cover to what they know about viruses; ask students to predict what the title might mean; have students read the table of contents to get an overview of the book; note the list of main characters and glossary found at the end of the book; have students look at the map to determine the setting for the story.

4. Have students read the first seven pages, beginning with "Infectious Area No Unauthorized Entry" to "Caution Biohazard." Ask students to discuss what the author's purpose is in beginning a book with these warning messages.

5. Using the "QAR" strategy, provide the students with the following four questions to answer as they read *The Hot Zone*, pages 14 -24. Partner EL students with native speakers for Step 5 and 6.

6. Right There: What is vomito Negro?
   Think and Search: What is the pattern of the virus's effect on the human body?
   Author and You: How does Monet's experience in the emergency room relate to your own experiences in an emergency room or some other time when you needed swift attention?
   On Your Own: If you were seated next to a passenger with these symptoms, what would you do?

7. While reading, ask students to write on post-its additional questions elicited by the reading on pages 14-24.

8. In groups of four, have students share their answers to the four questions and share their newly generated questions that were elicited by reading the text.

9. Ask students to set aside these questions as they prepare to participate in a simulation about the transmission of viruses. Explain that this activity might answer some of their questions.

EXPLORE:

Part A

10. Remind students to put on safety goggles and gloves. For every 24 students, give 23 a container with water and give one student a container with the base solution. Give one student 10 ml of base solution instead of the water. (All the students think that everyone's liquid is the same.)

11. Have students walk around the classroom, find another student and ask that student to define a virus. After they exchange definitions, ask the students to exchange a small amount of liquid by inserting their own dropper into their own liquid and dropping the liquid into the other student's container. Have students record the name of the person with whom they exchanged the fluid.

12. Ask students to repeat step 10 with two other students and then return to their seats.

13. Inform the students that one (or more) of their classmates was carrying a very contagious virus, a filovirus, like the one described in *The Hot Zone* reading. Identify the original carrier(s) by putting the indicator solution in that student's container.

14. Ask the students to review the list of students with whom they exchanged fluid. Ask, "Who thinks they may have been infected by the carrier?" Test their solution with the indicator. Continue using the indicator until all students have been tested.

15. Lead a discussion of the observations that the students made during this simulation. For example, some students may not have been directly infected by the identified carrier but were infected secondarily by someone who was infected by the carrier. Some students may have exchanged fluid with someone who was infected by the carrier, but before the infection. If there is more than one student with the base solution at the beginning of the activity, the students are able to see the complications in determining the "chain of infection."

16. Ask students to return to their list of questions that they originally generated in the reading. Ask them if this activity helped to answer any of the questions. If so, have the students remove those questions from their list.

17. Ask students to generate, on post-its, new questions from the simulation.

Part B

18. In groups of four, have the students share their unanswered questions from the initial reading and the "infection" simulation. Ask them to use the "QAR" strategy to classify their questions into the four types.

19. Create a class question chart by having each group post their questions under the appropriate categories: (Right There; Think and Search; Author and You; and On Your Own). Scan the questions and clump in each category those that are similar.

20. Divide the questions among the groups so that all groups have some questions in common and some unique questions. Make sure that the following questions are among those to be answered: In Latin, what does "filovirus" mean? What do they look like? How are Ebola and Marburg viruses similar? How are they different? How do viruses like Ebola spread and die out? What can be done to prevent the spread of viruses?

21. Direct the students to find answers to their questions by using their textbook, *The Hot Zone* (pages 37-38; 62-67; 83-86; 98-100; 105-109; 117-118, and 197-198) and the internet. Search viruses, filoviruses, Ebola in addition to these sites:
http://www.cdc.gov/ncidod/spb/mnpages/ebola.htm
http://www.biology.arizona.edu/cell-bio/tutorials/pev/problems.html

EXPLAIN:

22. Facilitate student explanation of the content (i.e., the structure and reproductive requirements of viruses, and the relationship between human behavior and the spread of viruses) by having groups share their answers to the questions. For the questions that the groups had in common, are their explanations similar? What can each group learn from the questions they did not have to answer?

ELABORATE:

23. Have students respond to the prompt "What are some other ways filoviruses spread?" as they read *The Hot Zone* (pages 215 – 217, 360 – 371). Ask students to discuss the relationship between human behavior and the spread of viruses. Ask students what questions they still have and how they might research answers to those questions.

EVALUATE:

24. Have students select one question for each "QAR" category. The questions may be selected from their own question list or the class question list. Direct students to design a poster to prevent the spread of viruses. Have students use the *The Hot Zone* "QAR" questions as an outline for the poster. The poster should indicate student understanding of: 1) the structure and reproductive requirements of viruses, 2) the relationship between human behavior and the spread of viruses, and 3) the "QAR" strategy.

Teacher Reflection:

1. How does the student work provide evidence that they learned the structure and reproductive requirements of viruses, and the relationship of human behavior to the spread of the viruses?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts?
4. How would you modify instruction to ensure understanding of student outcomes by all students?

Grades

9-12

Strategic Science Teaching

Title of Lesson:

Seeing Stars

Essential Question:

How can observations from Earth give us information that explains the structure of galaxies and the universe?

Conceptual Statement:

Galaxies are the primary structure of the universe. They are made up of a variety of objects themselves, mostly stars.

Student Outcomes:

- Students describe the structure and scaleof objects in the universe.
- Students develop models of a starfield representing common properties of stars.
- Students use “Learing Log and KWL Plus” to orgnaize information from text about structures of the universe.

Conceptual Learning Sequence:

This is an introductory lesson for a conceptual unit about the structure and scale of stars, galaxies, and the universe.

Lesson Overview:

Students use the learning strategy, “KWL Plus” to organize prior knowledge and new information about galactic objects from the book *Contact,* the investigation, and reference sources. Students also use the learning strategy, “Learning Log”, with a reading selection from the book *Contact*, to record information about objects in a galaxy. Students will observe a demonstration of a two-dimensional star field then use their observations, research, and data to build a three-dimensional model of a star field that more accurately represents the structure of an actual galaxy.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

The book *Contact*, chapter 19, is used as the EXPLORE phase in the instructional model. It provides observational data, in a narrative form, to simulate actual travel to distant objects in the Milky Way. Students record this data in the “Learning Log”. This provides information about galactic structures for the KWL and set a context for the construction of a three-dimensional star field model.

Learning Strategy:

This lesson uses “Learning Log” to have students record gathered information from text and resources as needed to complete a KWL. “KWL Plus “ is utilized to organize information and demonstrate knowledge. (See Appendix pages 167-170.)

Literature Selection:

Title: *Contact.*

Author: Sagan, Carl.

Carl Sagan was an award-winning writer and Professor of Astronomy and Space Sciences at Cornell University. He popularized science, reaching millions of people through newspapers, magazines and television broadcasts including the PBS series Cosmos, which became the most watched series in public television history.

Publisher, Year: Simon and Schuster, New York, 1985.

Annotation: In this science fiction story, Eleanor Arroway is a brilliant physicist who heads the team listening for a signal from an outer space project. When the message arrives, scientists mobilize their efforts to decode and respond to this message.

Genre: Science Fiction.

California Content Standards:*

Science: Grades 9 -12, Strand Earth Sciences, Sub-Strand Earth's Place in the Universe

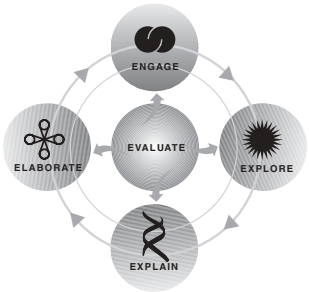
1. Astronomy and planetary exploration reveal the solar system's structure, scale, and change over time. As a basis for understanding this concept:
   d. Students know the evidence indicating that the planets are much closer to Earth than the stars are.

2. Earth-based and space-based astronomy reveal the structure, scale, and changes in stars, galaxies, and the universe over time. As a basis for understanding this concept:
   a. Students know the solar system is located in an outer edge of the disc-shaped Milky Way galaxy, which spans 100,000 light years.
   b. Students know galaxies are made of billions of stars and comprise most of the visible mass of the universe.
   d. Students know that stars differ in their life cycles and that visual, radio, and X-ray telescopes may be used to collect data that reveal those differences.

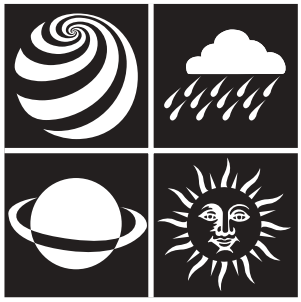
1. Investigation and Experimentation

g. Recognize the usefulness and limitations of models and theories as scientific representations of reality.
i. Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena.
k. Recognize the cumulative nature of scientific evidence.

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Science Thinking Process	Suggested Time
ENGAGE	Students record prior knowledge of “Galactic Structures” in a KWL. Students observe demonstration. Communicating, Observing	1 hour
EXPLORE	Students read chapter 19 of *Contact*, Students begin “Learning Log” of the galactic observations, targeting KWL. Observing, Communicating, Comparing, Ordering	will vary
EXPLAIN	Students complete star models and investigation record sheet and present to class. Students organize KWL into categories using reference sources as needed. Comparing, Ordering, Categorizing, Relating	1 or 2 hours
ELABORATE	Elaborate research into EM spectra, singularities, and space travel.	As Needed
EVALUATE	Students complete “KWL Plus” concept map. Students produce an accurate account of objects in a galaxy.	2 or 3 hours



Seeing Stars

Teacher Background:

When astronomers first observed the sky, they imagined the stars were on the single surface of a giant "crystalline sphere" that encompassed the Earth and the sun. They believed that the planets were on a smaller sphere inside the one on which the stars moved.

We now recognize stars as diverse structures that make up galaxies and the galaxies as the basic units of the universe. However astronomers now talk of strings and superstructures in the galaxy, reflecting a possible change in our understanding of these structures.

Over time astronomers realized that as the Earth moved around the sun, some stars shifted in position relative to the background of others. They realized that this shifting occurred because of a parallax effect when the Earth was on opposite sides of the Sun.

Further observation of stars using telescopes that collect visible light, radio waves and x-ray energy allowed astronomers to understand the structure and properties of many types of stars.

Any discussion of scale and structure would relate to this lesson.

Related California Content Standards

Science: Grades 9 -12, Strand Physics, Sub-Strand Waves

4. Waves have characteristic properties that do not depend on the type of wave. As a basis for understanding this concept:
   a. Students know waves carry energy from one place to another.
   e. Students know radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 3 x 108 m/s (186,000 miles/second).
   f. Students know how to identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.

Science: Grades 9 -12, Strand Physics, Sub-Strand Electric and Magnetic Phenomena

5. Electric and magnetic phenomena are related and have many practical applications. As a basis for understanding this concept:
   i. Students know plasmas, the fourth state of matter, contain ions or free electrons or both and conduct electricity.

Science: Grades 9 -12, Strand Chemistry, Sub-Strand Atomic and Molecular Structure

1. The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure. As a basis for understanding this concept:
   j. Students know that spectral lines are the result of transitions of electrons between energy levels and that these lines correspond to photons with a frequency related to the energy spacing between levels by using Plank's relationship (E = hv).

Science: Grades 9 -12, Strand Chemistry, Sub-Strand Nuclear Processes

11. Nuclear process are those in which an atomic nucleus changes, including radioactive decay of naturally occurring and human-made isotopes, nuclear fission, and nuclear fusion. As a basis for understanding this concept:
   b. Students know the energy release per gram of material is much larger in nuclear fusion or fission reactions than in chemical reactions. The change in mass (calculated by E = mc2) is small but significant in nuclear reactions.
   e. Students know alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations.

Math: Grades 9 - 12

Geometry 15.0 Students use the Pythagorean theorem to determine distance and find missing lengths of sides of right triangles.

Language Arts: Grades 9 -10

Reading 2.0 Students read and understand grade-level appropriate material. They analyze structural patterns, arguments and positions advanced.
Writing 2.1 Write biographical or autobiographical narratives or short stories:
   a. Relate a sequence of events and communicate the significance of the events to the audience.
   e. Make effective use of descriptions of appearance, images, shifting perspectives, and sensory details.

English Language Development Standards

Written and Oral Conventions
1.0 Students write and speak with a command of standards English conventions.

English Language Development: Grades 9-12

Writing Strategies and Applications
Present a brief report while clarifying facts presented in two to three forms of expository text.
Write expository compositions such as descriptions, compare/contrast, and problem/solution that include a main idea and some details using simple sentences.

English Language Development: Grades 9-12

Written and Oral Conventions
Narrate a sequence of events and communicate their significance to the audience.

Grouping: Varies throughout the learning cycle

Students will work independently for the demonstration.
Students will work in groups of 3-4 for the investigation.

Group EL with native speakers during the demonstration. Group EL with like language as well as with native speakers during the investigation

Materials:

Per Class

Overhead projector
black construction paper
Single hole punch, pencil and pin
Large (projection screen size) black sheet or paper
Video *Contact*, produced and directed by Robert Zemeckus, 150 minutes, Warner Brothers Films, 1997.

Per Student

One string/group, cut in 2 meter lengths
One-inch Styrofoam™ balls
Paint, markers and other art supplies
Thumbtacks
Tape, as needed
Step ladder or foot stool to reach ceiling

Advanced Preparation:

For Demonstration

Punch holes in a variety of sizes in the black paper.
Position the overhead as far back in the room as possible to project a large star field.
Tape black paper to flat glass surface of the overhead to keep the star field projection constant.
Post a large black sheet or black bulletin board paper across the wall to fit the projected star field.

For Investigation

Determine the number of Styrofoam™ balls needed to provide one per group for each student group.
Measure and cut string.
Provide a recording sheet for each student. See Student Pages 1.0, 1.1

VOCABULARY

galaxy – a group of billions of stars and their planets, gas and dust that extends over many thousands of light years and forms a unit within the universe

parallax – the angle between two imaginary lines from two different observation points meeting at a star or celestial body that is used to measure the distance from the Earth

properties – the characteristic qualities or distinctive features of something

star – a gaseous object in space such as the sun, ranging in size from that of a planet to larger than the Earth's orbit, which generates energy by thermonuclear reactions

universe – all matter and space that exists, considered as a whole; the cosmos

Provide still and video images to support understanding of new vocabulary

Teacher Resources:

California Science Content Standards. California Department of Education, 1998.

The California Science Framework. California Department of Education, expected 2002.

California Science Framework. California Department of Education, 1990.

Strategic Teaching and Learning; Standards-Based Instruction to Promote Content Literacy in Grade Four Through Twelve. California Department of Education, 2000.

Conceptual Physical Science. Second Ed., Hewitt, Suchocki and Hewitt, Addison Wesley Longman, 1999.

Space Mathematics. NASA / NCTM, 1985. Math of parallax pgs 23-24, planets pgs 20-23 and light years p 24.

Integrated Science Curriculum. Pages 692-722. Total Reading, 1987.

Once Upon a GEMS Guide. Pages 81-93. Lawrence Hall of Science. The Regents of the University of California, 1994.

Astronomy Village: Investigating the Universe. CD version 1.0. Wheeling Jesuit College/NASA Classroom of the Future. 1995.

Astronomy web sites:

PBS Teacher Source http://www.pbs.org/teachersource/science_tech/high_galaxy.shtm

Star Distance www.pbs.org/deepspace/classroom/activity3.html

Black Holes www.pbs.org/deepspace/classroom/activity4.html

Stars and other objects: http://www.cnde.iastate.edu/staff/jroeger/stars.html

Teacher Tips:

- Plan a trip to a planetarium for a show on galaxies or the structure of the universe.
- A "Word Wall" is a vocabulary reference source kept visible during an entire instructional unit. Usually a bulletin board format.
- Allow students revision time to avoid any misunderstandings.
- Prior knowledge of Grade 8 California Science standards 4.0 is assumed for this lesson.
- The movie *Contact* may be used, with discretion, as a culminating event. Note that it is significantly different from the book, without much of the challenging thinking.
- This lesson can easily be followed by a lesson on parallax.

Related Student Resources:

Krauss, Lawrence M.. *Physics of Star Trek*. BasicBooks, a division of Harper Collins, 1995.

Mitton, Simon and Mitton, Jaqueline. *Astronomía (The Young Oxford Book of Astronomy)*. Edebé, 1995.

Henbest, Nigel. *El universo: Un viaje a través del espacio y del tiempo (The Universe)*. Folio, 1995.

Lesson Credits:

The contributions and support of Don Scott, NASA educator, are appreciated.

ENGAGE
EXPLORE
EXPLAIN
ELABORATE
EVALUATE

The Science Learning Cycle:

Seeing Stars

ENGAGE:

1. Students will begin with a KWL brainstorm session. Title the KWL 'Galactic Structures" Encourage students to list all they Know and Wonder about this topic.
2. Use the star field demonstration to illustrate the limits we encounter when observing the sky with the naked eye. Ask students: What objects do we see and what can we tell about them?
3. Have students do #1 on the Reporting Sheet
4. Have students begin a “Learning Log” to record their observations of the star field demonstration and prepare to record information about the objects that make up a common galaxy.
5. Direct them to organize the “Learning Log” into sections that record:
   What I Read/Observed
   How I Understood
   What I Learned
6. Ask students to add to their “KWL Plus” if anything has come to mind.

EXPLORE:

7. Read chapter 19 (15 pgs) in *Contact*.
   Have students use their “Learning Log”s to record the names and descriptions of galactic structures.
   Ask them to record the properties that distinguish types of stars.
   Provide 5-15 minutes of writing time after each reading session required.
8. Direct students to take their “Learning Log” information and categorize it in the three KWL columns.
9. Ask them to look for corrected misunderstandings or something new they learned, something they wanted to know, or new questions they generated.
10. Are there any items on the KWL that need to be researched further? If so provide access to resources, as needed.
11. Have students determine large concepts (group the topics) that are now apparent on the KWL. Explain that these will be used to organize their information about galactic structures.

EXPLAIN:

12. Working as a whole class have the students use their “Learning Logs” to contribute to the revision and categorization of the “KWL Plus”.
13. Keep a "Word Wall" to facilitate vocabulary for students. This lesson component works well for English Language Learners.
14. Have students construct their own Concept Maps based on the “KWL Plus”.
15. Encourage students with questions to use the KWL method on their own to seek out the things they still wonder about.
16. Students will select one of the structures they have learned about to be their model.

17. In groups students will:
    a. identify the characteristics of the star, or other object selected.
    b. find a visual way to "design" their model.
    c. prepare a short presentation for the rest of the class using the reporting sheet as their outline.
    d. hang the model from the ceiling so that a beam of light from the overhead projector (making the star field) will illuminate it.

18. Have students do # 2-4 on the Reporting Sheet.

ELABORATE

19. Some students may want to investigate how to use the classroom star field for a parallax investigation.

20. Those ready to work on further topics may pursue EM spectra, space travel, life cycles of stars, or singularities.

21. Compare the film *Contact* to the book.

EVALUATION

22. Have students confirm correct understanding of the objects presented by the class using the “KWL Plus”.

23. Have students do # 5-9 on the Reporting Sheet.

24. Have students use the “KWL Plus” categories, agreed upon by the whole class, to construct their final Concept Maps titled "Galactic Structures".

25. Accurate Concept Maps can then be used to compose a structured “Learning Log” (journal-like) about a journey to a common galactic object. (Use travel promotions, hyper-studio or Power Point slide shows, or other evaluation options). The criteria for a complete journal will include:

    a) accurate properties (at least 3);
    b) information on the energy emitted and how it is detected;
    c) a reasonable description of the object's general location in the galaxy;
    d) how rare or common an object it is.

Teacher Reflection:

1. How dose the student work provide evidence that they learned the scle and structure of galazies in the universe?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts?
4. How would you modify instruction to ensure understanding of student outcomes by all students?

Seeing Stars - Reporting Sheet

Name: _____ Date: _____

1. Describe the star field as you first see it. How is it similar to the way we observe the sky from Earth?

   a. What can we tell about stars this way?

   b. Is the size we observe accurate?

   c. The distance?

2. Name the "Galactic Object" your group will be modeling.

   a. How is its location described in *Contact*?

   b. What are the characteristics that identify this object to astronomers like Ellie Arroway? Give at least three.

   c. How do astronomers detect/observe your object?

      What tool is used to detect it?

      What energy is observed?

3. Assume the overhead projector is our sun and the black wall screen is the center of the Milky Way. Estimate where in that distance your model should be hung from the ceiling. (Half way, one-fourth, etc.)

Seeing Stars - Reporting Sheet

4. Prepare a 5-10 minute presentation based on your investigation. Inform the class about the object you are modeling. This Reporting Sheet will work as your outline.

a. Describe the star field as it appears with the models.

b. How can models help someone understand something like stars?

c. Review your answers to question #1. How would you answer now?
Write about any new ideas or information you have.

d. What is the relationship between stars and galaxies?

e. What generalizations could you support with observational data about the structure of the universe?
Make some generalizations about the structure of the universe. Use observational data to support your statement.

Bibliography

Asimov, Isaac. *Nuestra luna (The Earth's Moon)*. SM, 1989.

Astronomy Village: Investigating the Universe. CD version 1.0. Wheeling Jesuit College/NASA Classroom of the Future. 1995.

California Department of Education. *Science Framework for California Public Schools Kindergarten through Grade Twelve*, California Department of Education, Sacramento, CA 1990.

California Department of Education: *California Science Content Standards*,1998.

California Department of Education: *Strategic Teaching and Learning,Standards-Based Instruction to Promote Content Literacy in Grades FourThrough Twelve*, 2000.

California Department of Education: *The California Science Framework*, expected 2002.

California Journal of Science Education, *Controversy in the Classroom II: Evolution*, Volume 1, Issue 2, Spring 2001.

Classroom Instruction that Works, Research-Based Strategies for Increasing Student Achievement, 2001, Marzano, Robert J., Pickering, Debra J., Pollock, Jane E., ASCD, Alexandria, VA.

Cole, Joanna. *The Magic School Bus Lost in the Solar System*. Scholastic,1990.

Cook, Robin. *Outbreak*. Berkley Publishing Group, New York, 1991.

Evolution and the Fossil Record, John Pojeta, Jr., and Dale A. Springer, American Geologic Institute, The Paleontological Society, 2001. http://www.agiweb.org. ISBN 0-922152-57-8.

Feyman, Richard. *Six Easy Pieces: Essentials of Physics Explained*. Addison Wesley, 1995.

Feyman, Richard. *The Character of Physical Law*. MIT Press, 1994.

Foster, Gerald Wm. *"Look to the Moon", Science and Children* (November/December), 30-33. 1996.

Garrett, Laurie. *The Coming Plague*. Penguin Press, New York, 1995.

Henbest, Nigel. *El universo: Un viaje a través del espacio y del tiempo (The Universe)*. Folio, 1995.

Hewitt, Paul, John Suchocki, and Leslie Hewitt. *Conceptual Physics*, 2nd ed., Addison Wesley Longman, Inc. Menlo Park, CA, 1999.

Hewitt, Suchocki and Hewitt: *Conceptual Physical Science*. Second Ed., Addison Wesley Longman, 1999.

Horowitz, Leonard G. and W. John Martin. *Emerging Viruses: AIDS and Ebola, Accident or Intentional*, Tetrahedron Press, 1996.

Integrated Science Curriculum. Pages 692-722. Total Reading, 1987.

Krauss, Lawrence M. *Physics of Star Trek*. BasicBooks, a division of Harper Collins, 1995.

Matter Can Be Changed in Many Ways, K-12 Alliance, 2000.

Mitton, Simon and Jaqueline. *Astronomía (The Young Oxford Book of Astronomy)*. Edebé, 1995.

Preston, Richard. *The Hot Zone*. Anchor Books, New York, 1998.

Regents of the University of California: *Once Upon a GEMS Guide*. Pages 81-93. Lawrence Hall of Science, 1994.

Rey, H. A. *Find The Constellations*. Houghton Mifflin, 1976.

Sagan, Carl. *Contact*. Simon and Schuster, New York, 1985.

Bibliography

Silver, Donald M. *The Night Sky (One Small Square)*. McGraw Hill, 1998.

Space Mathematics. NASA / NCTM, 1985.

Math of parallax pgs 23-24, planets pgs 20-23 and light years p 24. *Teaching About Evolution and the Nature of Science*, National Academy of Sciences, National Academy Press, Washington, DC, 1998. (Also available on-line at http://www.nap.edu/readingroom/books/evolution98)

Understanding Geologic Time http://www.ucmp.berkeley.edu/geotime

Watson, James D. *The Double Helix*. Mentor Books, New York, 1968.

Willis, Shirley. *Dime porqué cambia de forma la luna (Tell Me Why the Moon Changes Shape)*. Watts, Franklin, 1999.

Grouping Strategies for English Learners

Proficiency Level	Suggested Grouping	When most appropriate
Beginning	Mixed with fluent English speakers	For hands-on, concrete activities that are not conceptually demanding
Early Intermediate	With one or more students from the same native language background (e.g., pairing two Vietnamese students together) Preview-review: 1. Preview: Bilingual teacher, instructional assistant or peer tutor previews essential questions, concepts and vocabulary in native language with small group of students. 2. Lesson is conducted in English for the entire class, using SDAIE strategies. 3. Review: Bilingual teacher, instructional assistant or peer tutor reviews and checks for understanding in native language.	For conceptually demanding or abstract content, when students' English is not suficiently developed Preview-review helps English Learners access the core curriculum because it uses their own language to focus students on key points (preview) and check for understanding (review).
Intermediate	Mixed with native speakers With one or more students of the same native language background	For hands-on, concrete activities For highly conceptually demanding or abstract material
Early Advanced **Advanced**	Mixed with native-English-speakers	For all activities (although native language materials, instructional assistants, or tutors can be used for reinforcement)

Appendix

The following instructional strategies are reprinted with permission from *Strategic Teaching and Learning: Standards-Based Instruction to Promote Content Literacy*, CDE, 2000. Each strategy is printed in it's original form in the Appendices and is utilized and referenced within the context of a grade level Strategic Science Teaching lesson.

Graphic Outlining

Guided Reading

KWL Plus

Learning Log

Question-Answer Relationships

Questioning The Author

Reciprocal Teaching

The Research Process

Analogy Graphic Organizer

Concept Wheel/Circle

LINK

Contextual Redefinition

Think Aloud

Graphic Outlining

Graphic outlining is a method of representing information from a text so that the organizational pattern of the text is highlighted. It helps students understand what they read by leading them to predict and organize information they encounter.

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

Goals

1. Guide the student's comprehension process by creating graphic representations of the text (e.g., clusters or concept maps, such as a flow chart).
2. Help students recognize and use the organizational patterns inherent in informational texts (e.g., description, sequence, comparison, cause and effect, problem-solution).

Teacher Preparation

1. Introduce to the students the five organizational patterns of informational text.
2. Identify a section of text that clearly follows one of the five organizational patterns.

Instructional Procedures

1. Have students survey the text passage by examining the title and headings, looking for clues to the organizational pattern used by the author.
2. Ask questions that focus on the differences between the different patterns. For instance, does the author describe a cause-and-effect relationship? Are two or more concepts being compared?
3. Guide students to make predictions about the text's basic structure. When they think they have begun to develop a relatively clear sense of the pattern being used, ask them to make a graphic representation of the pattern.
4. Direct students to check their graphic outline as they continue reading to see whether it picks up the important ideas in the text selection and shows the relationship among those ideas. Students should also be looking for ideas that are not yet represented in their outline. Add subtopics to the outline as needed.
5. Model the process for completing the graphic outlines, and provide students with samples of the various patterns.
6. Guide students through the process of using their outlines to write a summary of the selection.

Variations

Bubble map. The map may be useful for stimulating students' ideas about a given topic. When asked to describe a topic or idea studied, students jot down associated words and draw a bubble around words, clustering them in some kind of order. Students may use the map for a prewrite, generate ideas before writing in journals, or review for a test.

Double bubble map. The map may be used for drawing comparisons. Students note the qualities that are unique in the outer parts of two overlapping circles. Attributes common to both things are listed in the middle. This technique helps students to distinguish common qualities from unique qualities before writing about or discussing a topic.

Flow chart. The chart is useful for helping students organize a series of items or thoughts in a logical order. Students write major stages of the sequence in large rectangles and substages in smaller rectangles under the larger rectangles.

Cause-and-effect chart. The chart is an aid for students to learn cause-effect reasoning. In the center of a sheet of paper, write the topic (the focus of the lesson). On the left-hand side, write the apparent causes of the topic. On the right-hand side, write the apparent effects of the topic.

Supporting idea chart. The chart helps students become aware of the relationship between a whole thing (structure) and its parts. Write the idea on a single line to the left. On the next set of lines to the right, write the major parts of the idea. Finally, fill in the subparts on lines that branch off the major parts of the idea.

Relevant English–Language Arts Content Standards

Grade Four: Reading Comprehension

2.1 [Students] identify structural patterns found in informational text (e.g., compare and contrast, cause and effect, sequential or chronological order, proposition and support) to strengthen comprehension.

Grades Five Through Eight: Reading Comprehension

2.0 Students read and understand grade-level-appropriate material. They describe and connect the essential ideas, arguments, and perspectives of text by using their knowledge of text structure, organization, and purpose.

Grade Six: Reading Comprehension

2.4 [Students] clarify an understanding of texts by creating outlines, logical notes, summaries, or reports.

Further Resources

Cook, Doris. *Strategic Learning in the Content Areas.* Madison: Wisconsin Department of Public Instruction, 1989.

Guided Reading

Guided reading is a technique to guide students to deeper levels of thought by considering aspects of the author's craft, the relevance of the information, or the meaning of the text. It is a flexible approach that needs to be carefully adjusted to the reading competencies of students. It should be used intuitively and spontaneously to help students read beyond the superficial level and to assume control for considering, evaluating, and assimilating what they read.

Goals

1. Help students know how to apply the cognitive strategies of predicting, sampling, and confirming text and to regain control when meaning is lost.
2. Make students aware of how they can use the strategies noted above to cope with more complex challenges in the content and structure of the text.
3. Stimulate readers to ask more questions of themselves or of the text.

Teacher Preparation

1. Identify texts that will yield complex challenges, such as math, science, social studies texts, and many of the books students choose to read for their own pleasure and study. Guided reading works best, however, when students are asked to read materials at their instructional reading level (see step 10 on page 49 for definitions of reading levels).
2. Think of key questions to ask before, during, and after guided reading that show students how to go beyond the superficial and how to assume control for considering, evaluating, and assimilating what they read.

Instructional Procedures

1. When introducing a reading, ask questions that require students to consider aspects of the author's craft, the relevance of the information or its meaning, such as the following:
   a. How do you think the author will treat this topic (or theme)?
   b. Think about what you already know about the topic. What extra information are you seeking?
   c. What other books have you read by the same author? What comments do you have about the author's writing style or choice of topic? Do you expect this book to follow the author's usual style?
   d. What other books have you read about a similar topic? How does this one differ? Does the blurb or cover give any clues about how this book treats the topic? What about the table of contents or chapter headings? Did you get any clues from your first skimming of the text?
   e. What genre is this? What do you know about works of this kind?
   f. What kind of a book do you expect from looking at the cover?
   g. The title (or subtitle or blurb) indicates that this work is *(writing form)* text. Think about the way you expect the ideas or information to be presented. What are some of the conventions you expect to find?
2. While the reading is in progress, pose questions to help students clarify, amend, and confirm their purpose for the reading and their expectations of the text. The questions may engender some discussion about different understandings or viewpoints, but this should not cause students to lose sight of the meaning or diminish their interest in the text. Have the students do the following:
   a. Read until a change occurs in the plot.
   b. Read to the end of the episode. How did the ending add to your understanding?

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

c. Read until _____. Is this how you expected the story line to unfold (or the information to be presented)?

d. How did the text confirm, add to, or change what you already know about _____?

3. After this first reading, encourage students with further questions or prompts to reread the text and show them how to read with a more specific or different purpose in mind. For example, prompt students as follows:

a. Read as though you were planning notes for an illustrator.

b. Which character do you think you know the best? Why? Read the text again to see what else you can find out about that character.

c. As you reread, consider which incident had the most impact on the story line.

d. As you reread, think about the techniques the author uses to create a mood or tension; portray characters; and set the scene and the pace without long explanations.

e. What do you think was the significance of _____?

f. Reread the introduction and survey the glossary. Consider how much information you were given before you began reading. How did this influence your purpose for reading or the way you read?

4. After the reading, offer additional questions to encourage deeper levels of thought. Some questions should encourage further discussion about different perspectives or views; others should provoke further thought or reflection.

5. During a guided reading lesson, your role is to act as a group member by taking the following actions:

a. Listen to the students' discussion to gain insight into how they perceive their world and themselves as both readers and users of language.

b. Judge the most appropriate moments to intervene.

c. Observe each student's contribution to the reading and to the discussion.

d. Provide students an opportunity to assist and guide each other so that you can gain more insight into each student's competencies as a reader and as a group member.

e. Involve students in responding to the contributions of their peers by highlighting either complementary or divergent points of view.

6. The focus should be on guiding students toward making informed decisions about the most appropriate paths to take through and beyond the text. When students seem unable to draw upon the appropriate resources within themselves or within the text, try to hint at some of the options and favor only one option above others when danger zones (being unable to maintain or regain meaning) are imminent.

Relevant English–Language Arts Content Standards

Grades One Through Twelve: Reading Comprehension

2.0 Students read and understand grade-level-appropriate material.

Grades One Through Four: Reading Comprehension

2.0 [Students] draw upon a variety of comprehension strategies as needed (e.g., generating and responding to essential questions, making predictions, comparing information from several sources).

Grade Six: Literary Response and Analysis

3.1 [Students] identify the forms of fiction and describe the major characteristics of each form.

Grade Seven: Reading Comprehension

2.1 [Students] understand and analyze the differences in structure and purpose between various categories of informational materials (e.g., textbooks, newspapers, instructional manuals, signs).

Further Resources

Mooney, Margaret. "Guided Reading Beyond the Primary Grades," *Teaching K–8* (September 1995), 75–77.

KWL Plus

KWL Plus is based on three principal components of KWL, a reading-thinking strategy that activates and builds on the student's prior knowledge and natural curiosity to learn more. KWL requires a reader to identify what is *known* about a particular subject *(K),* what the reader *wants* to know *(W),* and what is *learned* as a result of reading the text *(L).* KWL Plus adds mapping (see page 54) and summarization to the original KWL strategy; these two tasks incorporate the powerful tools of restructuring of text and rewriting to help students process information. After learning KWL Plus under teacher direction, students implement it on their own while receiving corrective feedback until they can complete the task independently.

Goals

1. Engage students in an active reading process that demonstrates that reading means asking questions and thinking about ideas while reading.
2. Enhance students' proficiency in setting purposes for reading, gleaning information from texts, organizing that information into graphic outlines, and writing summaries based on those graphic outlines.

Teacher Preparation

1. Select an informational passage or article appropriate to the grade level and reading ability of your students. Note manageable segments within the text.
2. Prepare copies of the KWL work sheet for the class, and write the KWL grid on an overhead transparency or chalkboard.

Instructional Procedures

1. After listing the main topic of the selection at the top of the KWL grid, activate background knowledge through brainstorming what students know about the topic. Students note on their KWL work sheets what they think they know about the topic under *K* (what is known). They create a column titled "Categories of Information We Expect to Use."
2. Guide students in categorizing the information they have generated and anticipate categories of information they may find in the article. By awaking students' expectation at the outset, KWL enhances awareness of content and how it may be structured. Model the categorization process by thinking aloud while identifying categories and combining and classifying information.
3. Guide students in generating questions they want answered as they read. These questions become the basis for *W* (what students want to learn). Questions may be developed from information gleaned in the preceding discussion and from thinking of the major categories of anticipated information. This process helps students to define independently their purpose(s) for reading.
4. After a manageable segment (one or two paragraphs for struggling readers), have students interrupt their reading and pause to monitor their comprehension by checking for answers to questions listed in column *W.* This should help students become aware of what they have learned and what they have not comprehended. As students read and encounter new information, additional questions can be added to the *W* column.
5. As they read, students should note new information in the *L* portion of the work sheet. This helps them select important information from each paragraph, and it provides a basis for future reference and review.
6. After reading, students discuss what they learned from the passage. Questions developed before and

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

during the reading should be reviewed to determine how they were resolved. If some questions have not been answered, students can be guided to seek further information in appropriate materials.

7. To produce a map or graphic outline of the text, students categorize the information listed under *L.* To do so, students ask themselves what each statement describes. Through listing and categorizing, the students accomplish the most difficult tasks of constructing a map: selecting and relating important information from the text. (See page 54, "Example of a Concept Map.")

   Students use the article title or topic as the center of their map. The categories on the KWL work sheet become the map's major concepts; explanatory details are supplied underneath. Lines show the relationship of the main topic to the categories.

8. Guide students in writing a summary of the material. The most difficult part of summarizing—selecting information and organizing it—has already been completed. Instruct students to use the map as an outline for their summary. Because the map depicts the organization of the information, a summary is comparatively easy to construct. The map's center will probably be the title of the summary. Then students should number the categories on the map as they see fit. Each category becomes the topic for a new paragraph. Finally, supporting details in each category are used to expand the paragraph or explain the main idea.

Relevant English–Language Arts Content Standards

Grade Six: Reading Comprehension

2.4 [Students] clarify an understanding of texts by creating outlines, logical notes, summaries, or reports.

Grades Five Through Eight: Writing Strategies

1.0 Students write clear, coherent, and focused essays.

Further Resources

Bryan, Jan. "K-W-W-L: Questioning the Known," *The Reading Teacher,* Vol. 7 (April 1998), 618–20.

Carr, E., and D. Ogle. "K-W-L Plus: A Strategy for Comprehension and Summarization," *Journal of Reading* (April 1987), 626–31.

Hanf, Marilyn B. "Mapping: A Technique in Translating Reading into Thinking," *Journal of Reading,* Vol. 14 (January 1971), 225–30, 270.

Ogle, Donna. "K-W-L: A Teaching Model That Develops Active Reading of Expository Text," *The Reading Teacher,* Vol. 39 (February 1986), 564–70.

Winograd, P. "Strategic Difficulties in Summarizing Texts," *Reading Research Quarterly,* Vol. 19 (Summer 1984), 404–25.

Learning Log

A learning log is a written record of students' perceptions of how and what they are learning as well as a record of student growth and learning over time.

Goals

1. Increase students' awareness of their own learning process and progress.
2. Identify gaps in student learning.
3. Help students explore relationships between what they are learning and their past experiences.
4. Promote fluency and flexibility in student writing that can be transferred to other written assignments.
5. Provide a vehicle for student reflection and metacognition (learning about one's own learning).

Teacher Preparation

1. Decide whether it is necessary to provide specific prompts to students. Often, teachers need to offer suggestions when learning logs are first assigned; for example, what did (or didn't) I understand about the work we did in class today? At what point did I get confused? What did I do about it? How does what we studied relate to experiences I have had in the past?
2. Use an alternative to specific prompts by having students focus on either "process" entries or "reaction" entries. The former records *how* they have been learning, and the latter records *what* they have been learning. Students will need to record both types of entries.

Instructional Procedures

1. Explain the rationale for keeping a learning log. This activity will be particularly important in classes in which writing, especially reflective writing, is not a regular part of the curriculum.
2. Allocate a specific amount of time for writing in the logs (suggestions range from five to 15 minutes per day) and, if possible, schedule it consistently. Many teachers find that the practice works best and comes most logically at the end of class. Others prefer to begin class with this activity when there is a quiet, reflective atmosphere.
3. Develop a system for responding to student entries. Quick, impressionistic responses are usually sufficient and need to be given regularly. Teachers should respond at least once a week.
4. Consider encouraging students to share their entries periodically in small groups. Such sharing may lead to discussions about the material and comparisons of different points of view.

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

Relevant English–Language Arts Content Standards

Grades Five Through Eight: Literary Response and Analysis

3.0 Students read and respond to historically or culturally significant works of literature that reflect and enhance their studies of history and social sciences. They clarify the ideas and connect them to other literary works. The selections in *Recommended Readings in Literature, Kindergarten Through Grade Eight* illustrate the quality and complexity of the materials to be read by students.

Grades One to Four: Writing Strategies

1.0 Students write clear and coherent sentences and paragraphs that develop a central idea.

Further Resources

Alvermann, Donna E., and Stephen F. Phelps. *Content Reading and Literacy: Succeeding in Today's Diverse Classrooms.* Needham Heights, Mass.: Allyn and Bacon, 1998.

Commander, Nannette E., and Brenda D. Smith. "Learning Logs: A Tool for Cognitive Monitoring," *Journal of Adolescent and Adult Literacy*, Vol. 39 (March 1996), 446–53.

Sample Learning Log

What I Did	How I Worked and Learned	What I Learned
I watched and listened to the history of tessellations and looked at some of M. C. Escher's artwork.	I wanted to try and create some tessellating artwork.	I have to learn some geometric basics in order to make the artwork.
I went on a walk with the class around the campus to look for tessellations. We made patterns out of leaves we found.	It was interesting to see tessellations in ordinary things like leaves.	I learned that tessellations are all around me in places I never thought of before and that not all patterns are tessellations.
We took notes on the definition and properties of a polygon. We made tessellations with pattern blocks and then on dot paper.	I enjoyed making tessellations with the pattern blocks and then making a tessellation on dot paper.	I learned that the word *polygon* means "many angles." I also found out that the corners are vertices and that polygons are named according to the number of sides they have. I also learned the Greek prefixes for the names.
I measured the angles of several different triangles and different polygons using tangram pieces and then together we discovered the formula for the sum of angles.	At first I was confused because I didn't understand how to use the tangrams to measure angles, but once I understood how to do it, it was interesting.	I learned that to find the sum of angles means to add up all the angles of the polygon. The sum of a triangle always adds up to 180 degrees; for a quadrilateral, the sum adds up to 360 degrees. The formula for finding the sum of angles is (n - 2) 180. To find the sum of angles of a hexagon, take the number of sides (6) and subtract 2, then multiply it by 180, which equals 720.
Today, we ripped the corners off many different triangles and placed them around a point. We measured the degrees that they filled around the point. Then we all made our own triangles and tessellated them.	I really liked this activity because I was amazed that all the triangle tessellations really worked. I thought that some triangles would not tessellate.	After all the different triangle tessellations were displayed, I noticed they all tessellated. I think they tessellated because one triangle's sum is 180 degrees, which fills up halfway around the point. Two triangles completely fill the space around the point with no gaps or overlaps, which would be 360 degrees. If they could all meet evenly around a point, then all triangles would tessellate.

Question-Answer Relationships

The question-answer relationship (QAR) strategy is based on a four-part system for classifying questions: *right there, think and search, author and you,* and *on your own*. Students learn to classify questions and locate answers, recognizing in the process that reading is influenced by the characteristics of the reader, the text, and the context.

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

Goals

1. Develop students' ability to recognize the relationship between a question and the location or source of possible answer locations (i.e., readers' background knowledge as well as information presented in a text).
2. Enhance students' performance in answering questions about content area materials.

Teacher Preparation

1. Select or prepare three passages based on familiar topics. Keep in mind the grade level and reading ability of your students when selecting passages.
2. Prepare at least one question for each passage from each of the four QAR categories.

Instructional Procedures

1. Introduce the concept of QAR categories, in reference to the first passage, by discussing with the class the questions, answers, categories, and reasons why the categories are appropriate.
2. Provide the students with the second passage and set of questions. They answer the questions while working in small groups, indicate the QAR categories, and justify their selections. Provide each group with immediate feedback on the accuracy and completeness of its explanations.
3. Give students the third passage and have them work in groups to prepare questions representing each QAR category. Groups then exchange questions, answer them, and evaluate the appropriateness of the questions in relation to the QAR categories they are supposed to represent.
4. Allow students to practice the QAR approach on progressively longer passages while increasing the number of questions asked.

Relevant English–Language Arts Contents Standards

Grade Four: Reading Comprehension

2.2 Use appropriate strategies when reading for different purposes (e.g., full comprehension, locating information, and personal enjoyment).

2.4 Evaluate new information and hypotheses by testing them against known information.

Further Resources

McIntosh, Margaret E., and Roni Jo Draper. "Applying the Question-Answer Relationship Strategy in Mathematics," *Journal of Adolescent and Adult Literacy,* Vol. 39 (October 1995), 120–31.

Raphael, T. E., and C. Wonnacott. "Heightening Fourth-Grade Students' Comprehension: Sources of Information for Answering Comprehension Questions," *Reading Research Quarterly,* Vol. 20 (Spring 1985), 282–96.

Example of QAR in Action

Right There

The answer is explicitly stated in the text. The question asks for details that are *right there*.

Think and Search

The answer will require integrating information from different areas in the text. The question asks the reader to *think and search* for related information in more than one paragraph.

Author and You

The answer is a combination of information that the reader already knows and what the author states in the text. The question asks for information from the *author and you*.

On Your Own

The answer will come from the reader's own personal knowledge and experience. The question asks for an opinion or information from the reader.

Electricity

All matter is made up of atoms. Within each atom there is a nucleus, and this nucleus has tiny particles called electrons orbiting around it. Atoms with different atomic numbers have different numbers of electrons. When electrons break from their orbit and become free-flying, they form electricity. Rubbing objects against each other, also known as friction, is one way to free electrons.

The term *electricity* dates back to ancient Greece and the experiments of a man named Thales. Thales took an amber stone and rubbed it between his fingers. He noticed that the stone attracted threads from his clothes. In Greek the word *amber* is called *electron*.

1. Where are the charged particles called electrons found?

   Right There _____

   Think and Search _____

   Author and You _____

   On Your Own _____

2. What happened to the electrons in the amber stone that Thales used?

   Right There _____

   Think and Search _____

   Author and You _____

   On Your Own _____

Example of QAR in Action *(Continued)*

3. Why does static electricity occur in newly carpeted rooms?

   Right There _____

   Think and Search _____

   Author and You _____

   On Your Own _____

4. Should Thales have taken more time and thought when he named this new energy source? Why?

   Right There _____

   Think and Search _____

   Author and You _____

   On Your Own _____

Questioning the Author

Questioning the author is an approach designed to engage students in the ideas of the text and build understanding.

Goals

1. Provide a concrete way for students to experience the key to successful comprehension: transforming an author's ideas into a reader's ideas.
2. Encourage students to judge the author's success in making ideas clear and admit to finding difficulties in the text without viewing themselves as failures.
3. Overcome students' tendency to resist grappling with text that does not come easily by stimulating young readers to become engaged with the text and consider ideas deeply.

Teacher Preparation

1. Identify a text to use for modeling the questioning-the-author strategy or prepare a copy of the sample text provided. The text should be representative of the content area textbooks students are expected to read and contain some vague or confusing language so that questioning the author can be modeled.
2. Prepare several passages from content area texts on a variety of topics to use for further applications of the questioning-the-author strategy.

Instructional Procedures

1. Remind students of the presence of an author of a textbook; tell them that textbooks are just someone's ideas written down. Explain that different people write things in different ways and that sometimes textbooks are not written as well or as clearly as they should be because what someone has in their mind to say does not always come through clearly in their writing. Because written text is the product of a fallible author, students may need to work to figure out what the ideas are behind an author's words.
2. Demonstrate an application of the questioning-the-author strategy to text. Ask your students to follow along as you read a brief text and model your interaction with it. An example follows:

A Russian Traveler

The day is Friday, October 4. The year is 1957. People in many parts of the earth turned on radios and heard strange news. "Russia has used rockets to put a new moon in the sky," said one station.

At this point in the text, express puzzlement over putting "a new moon in the sky." Read the next segment:

The tiny new moon is a metal ball. It has a radio in it. The radio goes "Beep! Beep! Beep!" as the moon travels along.

Express confusion over how a metal ball with a radio in it can be a moon. Continue reading:

The new moon is named Sputnik.

Explain that now you understand, because you remember that the first Russian satellite was named *Sputnik.* Mention that the author could have said that in a clearer way. Then read:

The ship is just big enough to carry a little dog. The ship sends out signals about the dog.

Say: "Oh! There is a dog on the spaceship! I thought they just meant that's what size it was—big enough for a dog!" Read on:

Everywhere people became interested in rockets and spaceships.

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

Say: "That seems like a big jump from talking about the dog. I guess maybe the author is trying to connect the sentence with the beginning about people all over the world turning on their radios."

Culminate the discussion by making clear the analogy in a revised version of the text, as follows:

Russia has used rockets to put a satellite into space. The tiny satellite is shaped like a metal ball.

After introducing students to the strategy, proceed with several sessions presenting passages from content area texts on a variety of topics. The teacher's role is to guide the student through the text, making sense of the author's words by using prompts. A general procedure for continuing sessions follows in steps 3, 4, and 5.

3. Ask students to read the text and talk about the ideas the author is trying to get across and to judge whether the author has made those ideas clear. As students read, prompts are offered to keep the focus on seeking out and putting together the author's ideas:
   - What is the author trying to tell you?
   - Why is the author telling you that?
   - Is the message stated clearly?

   Examples of further queries developed to guide questioning-the-author discussions are provided on the following pages.
4. As students discover confusing problems in the text, prompt them to recast those ideas in clearer language:
   - How could the author have stated the ideas in a clearer way?
   - What would you want to say instead?
5. Keep the interaction going by reacting conversationally to the students, sometimes recapping what the students have said or reinforcing a student's point, saying, "You're right; that's not very clear, is it?" or "I think you've got something there." Foster interaction among students by asking a student to elaborate on another student's comment.

Relevant English–Language Arts Contents Standards

Grade Four: Reading Comprehension

2.4 Evaluate new information and hypotheses by testing them against known information and ideas.

Grade Five: Reading Comprehension

2.3 Discern main ideas and concepts presented in texts, identifying and assessing evidence that supports those ideas.

2.4 Draw inferences, conclusions, or generalizations about text and support them with textual evidence and prior knowledge

The questioning-the-author approach, if skillfully extended, would also address the Literary Response and Analysis standards (grades four through twelve) and the standards under Expository Critique (grades five through twelve).

Further Resources

Beck, Isabel L., and others. "Questioning the Author: A Yearlong Classroom Implementation to Engage Students with Text," *The Elementary School Journal,* Vol. 96 (March 1996), 4.

Beck, Isabel L., and others. *Questioning the Author*. Newark, Del.: International Reading Association, 1997.

McKeown, Margaret G.; Isabel L. Beck; and M. Jo Worthy. "Grappling with Text Ideas: Questioning the Author," *The Reading Teacher,* Vol. 46 (April 1993), 7.

Sample 1
Questioning the Author

Focusing Queries Developed for Informational Text

Goal	Queries
Initiate discussion.	What is the author trying to say? What is the author's message? What is the author talking about?
Help students focus on the author's message.	That's what the author says, but what does it mean?
Help students link information.	How does that connect with what the author already told us? What information has the author added here that connects to or fits in with _____?
Identify difficulties with the way the author has presented information or ideas.	Does that make sense? Is that said in a clear way? Did the author explain that clearly? Why or why not? What's missing? What do we need to figure out or find out?
Encourage students to refer to the text either to show them they have misinterpreted a text statement or to help them recognize that they have made an inference.	Did the author tell us that? Did the author give us the answer to that?

Sample 2
Questioning the Author

Focusing Queries Developed for Narrative Text

Goal	Queries
Encourage students to recognize plot development.	What do you think the author is getting at here? What's going on? What's happening? What has the author told us now?
Motivate students to consider how problems are addressed or resolved.	How did the author settle that? How did the author work that out?
Help students recognize the author's technique.	How has the author let you know that something has changed in the story? How is the author painting a picture here? How did the author let you see, feel, or smell something? What is the author doing here? How did the author create humor, suspense, sadness, and so on? Why do you suppose the author used foreshadowing or flashback, and so on?
Prompt students to consider characters' thoughts or actions.	How do things look for (character's name) now? What is the author trying to tell us about (character's name)?
Prompt students to predict what a character might do.	Given what the author has already told us, how do you think (character's name) will handle this situation?

Reciprocal Teaching

Reciprocal teaching is an instructional approach characterized by an interactive dialogue between the teacher and students in response to segments of a reading selection. The dialogue is based on four processes: questioning, summarizing, clarifying, and predicting.

Goals

1. Help students develop the ability to construct meaning from text and monitor their reading comprehension to ensure that they are in fact understanding what they read.
2. Provide modeling, role-playing practice, and feedback of effective strategies that good readers use to facilitate their comprehension.
3. Help students become actively engaged in their reading as they gradually assume the role of discussion leader and develop the ability to conduct the dialogues with little or no assistance from the teacher.

Teacher Preparation

1. Select materials that are sufficiently challenging and representative of the types of materials that students read in class.
2. Review the first few paragraphs of the reading selection and plan how to model the flexible and independent use of all four processes.

Instructional Procedures

1. Introduce questioning, summarizing, clarifying, and predicting as helpful processes that good readers use.
2. Work with a small group of readers (four to six). Use the four processes to model leading a dialogue about a short segment (typically one to two paragraphs) of a textbook.

   Question: After students read the selection, ask a student to answer an important question about the reading.

   Summarize: Restate what you have read in your own words.

   Clarify: Focus on what makes the reading difficult by discussing any confusing aspects of the selection.

   Predict: Speculate about what is likely to occur next.
3. Be sure students are comfortable with the four processes, then repeat the procedure with the next segment of text and a student in the role of discussion leader.
4. Provide guidance and feedback on the use of the four processes while students take turns leading the group through the steps in the succeeding segments.

Variation

Reciprocal teaching may be taught and practiced with videos as a warm-up exercise before students use the technique on written texts.

1. Divide the class in pairs. One person is designated "A" and the other, "B."
2. Introduce the video to the class, telling students what they will be viewing and what to examine.
3. Start the video and stop it every ten minutes.
4. When the video is stopped the first time, partner A will lead a dialogue by asking partner B questions that involve summarizing, questioning, clarifying, and predicting based on the content in the video.
5. Restart the video after approximately three minutes.
6. Continue the procedure, alternating the leadership role in the dialogue between partners A and B.
7. Discuss the video with the entire class, calling on students randomly.

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

Relevant English–Language Arts Content Standards

Grade Two: Reading Comprehension

2.4 [Students] ask clarifying questions about essential textual elements of exposition (e.g., *why, what if, how).*

2.5 [Students] restate facts and details in the text to clarify and organize ideas.

Grades Five Through Eight: Reading Comprehension

2.0 They describe and connect the essential ideas, arguments, and perspectives of the text by using their knowledge of text structure, organization, and purpose.

Grade Five: Reading Comprehension

2.3 [Students] discern main ideas and concepts presented in texts, identifying, and assessing evidence that supports those ideas.

2.4 [Students] draw inferences, conclusions, or generalizations about text and support them with textual evidence and prior knowledge.

Grade Six: Reading Comprehension

2.7 [Students] make reasonable assertions about text through accurate supportive citations.

Further Resources

Palinscar, A. M., and A. L. Brown. "Reciprocal Teaching of Comprehension-Fostering and Comprehension-Monitoring Activities," *Cognition and Instruction,* Vol. 1 (1984), 117–75.

Rosenshine, Barak, and Carla Meister. "Reciprocal Teaching: A Review of the Research," *Review of Educational Research,* Vol. 64 (Winter 1994), 479.

Example of Reciprocal Teaching Technique

Present students with a sample passage, such as the following:

> A light bulb consists of several components: a filament, an inert gas, electrical contacts, and a glass container called a bulb. Light is produced when an electric current passes through the filament, a threadlike conductor. The electric current heats the filament to a temperature that is high enough to produce white light.

The student leader directs a dialogue about the passage as follows:

Question: What are the components of a light bulb? What has to occur for light to be produced?

Summarize: Retell in your own words the steps needed to produce light, or draw a diagram.

Clarify: What exactly is a filament and how does the current react to it?

Predict: What will the author explain next?

The Research Process

The research process is a library research inquiry process that begins when a student first identifies a need for information and continues to access, evaluate, and use the information. Information literacy is achieved when the student finally analyzes and evaluates the results of the process and internalizes it for future application. The collaborative expertise of a library-media teacher will be valuable in carrying out the research process.

Goals

1. Help students become creative and critical thinkers and effective users of ideas and information.
2. Help students develop the ability to access, evaluate, and use information from a variety of sources.

Teacher Preparation

1. Plan the scope of the assignment and the most essential skill-building activities.
2. Plan the resources to be made available to students, including the help of a library-media teacher, if possible.

Instructional Procedures

1. Explain to students a problem or an assignment, including how the research process and the results will be evaluated, allowing students to generate questions or find topics of personal interest.
2. Have students identify general types of questions or other information needs. Generate ideas by using individual and group brainstorming, discussions, and prompted writing. Use cluster and map techniques (see page 130) to organize brainstorming notes.
3. Explain that the first step of the quest involves formulating a preliminary central question or thesis statement.
4. Have students record prior knowledge relating to the central question through prompted writing, brainstorming, noting key words, and organizing important ideas into a graphic organizer or outline (see page 42). If their prior knowledge is limited, use general sources of information (e.g., a knowledgeable person, encyclopedia, video) to focus on key terms, and encourage students to restate information in their own words.
5. Identify potential resources, which may include personal interviews, firsthand observations, newspapers and magazines, maps, online searches, web sites, video and laserdisc programs, museums, and print or online subject-specific reference sources.
6. Help students determine the components of the central question of the search and phrase these as subquestions, which will become a plan for the search. Encourage students to distinguish between more important and less important questions and to reanalyze search strategies as success or failure is experienced.
7. Support students as they locate and explore previously identified resources. This involves locating a citation or reference to a source, gaining access to the source itself, and using initial sources as a lead to other sources. Students revise or redefine the central question by narrowing or broadening it as necessary.
8. Encourage students to select the most useful resources by evaluating the strengths and weaknesses of the resources in light of the central research question.
9. Help students extract the relevant and useful information from the appropriate resources after skimming to locate relevant material. Teach students to interpret, paraphrase, and summarize

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

as they take notes and to organize their paraphrased notes according to their search questions. In some cases drawing diagrams, making audio recordings, or collecting artifacts may serve the purpose instead of writing notes.

10. Have students evaluate their information for objectivity, consistency, and usefulness in addressing the central question; consider whether it is up-to-date; and decide whether the source is an authority on the subject. Remind students of the distinctions between fact, opinion, and propaganda throughout this process. Direct students to organize their notes and ideas by developing an outline or graphic organizer.
11. Direct students to integrate the fragments of information into a comprehensible whole in preparation for presentation. Students may present papers, dramatizations, panel discussions, multimedia presentations, models, demonstrations, or schoolwide projects.
12. Conclude by having students evaluate in writing both the project and the search process. The student evaluation should include (1) the steps in the search, resources used, problems encountered, and breakthroughs; (2) what was learned; (3) what it means to the student; and (4) how the student has grown as a researcher.

Relevant English–Language Arts Content Standards

Grade Five: Reading Comprehension

2.1 Understand how text features (e.g., format, graphics, sequence, diagrams, illustrations, charts, maps) make information accessible and usable.

Grades Five Through Eight: Writing Applications

2.3 Write research reports.

Grades Nine and Ten: Writing Applications

2.3 Write expository compositions, including analytical essays and research reports.

Grades Eleven and Twelve: Writing Applications

2.4 Write historical investigation reports.

2.6 Deliver multimedia presentations.

Grade Eight: Writing Strategies

1.4 Plan and conduct multiple-step information searches by using computer networks and modems.

Grade Four: Speaking Applications

2.2c Make informational presentations that incorporate more than one source of information (e.g., speakers, books, newspapers, television or radio reports).

Grade Seven: Speaking Applications

2.3c Deliver research presentations that include evidence generated through the formal research process (e.g., use of a card catalog, *Reader's Guide to Periodical Literature,* computer databases, magazines, newspapers, dictionaries).

Grades Eleven and Twelve: Speaking Applications

2.4a Deliver multimedia presentations that combine text, images, and sound by incorporating information from a wide range of media, including films, newspapers, magazines, CD-ROMS, online information, television, videos, and electronic media-generated images.

Further Resources

From Library Skills to Information Literacy. Prepared by the California School Library Association. San Jose, Calif.: Hi Willow Research and Publishing, 1997.

Analogy Graphic Organizer

The analogy graphic organizer provides a visual framework for students to analyze important relationships among concepts and to identify the similarities and differences between a new concept and something with which they are already familiar.

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

Goals

1. Expand student understanding of important concepts.
2. Help students understand how an analogy can be used to illustrate the similarities and differences between a new concept and something familiar to them.

Teacher Preparation

1. Try to determine what students already know about possible analogous relationships involving a concept you want to introduce.
2. Select one concept familiar to students that can be used to develop an analogous relationship to the new concept.

Instructional Procedures

1. Discuss with students what an analogy is and provide an example, such as the following: Gills are to fish as lungs are to people.
2. Elicit from students a list of specific characteristics that the two concepts you have chosen have in common.
3. Elicit a similar list of differences.
4. Discuss with students the categories that form the basis for the relationship between the concepts.
5. Encourage students to use the analogy graphic organizer to write a summary describing the similarities and differences between the two concepts.
6. Demonstrate how the analogies can be used as retrieval clues or mnemonic (i.e., memory assistance) devices to help students recall information.

Relevant English–Language Arts Content Standards

Grades Five Through Eight: Word Analysis, Fluency, and Systematic Vocabulary Development

1.0 Students use their knowledge of word origins and word relationships, as well as historical and literary context clues, to determine the meaning of specialized vocabulary and to understand the precise meaning of grade-level-appropriate words.

Grade Eight: Word Analysis, Fluency, and Systematic Vocabulary Development

1.1 [Students] analyze idioms, analogies, metaphors, and similes to infer the literal and figurative meanings of phrases.

Further Resources

Buehl, Doug. *Classroom Strategies for Interactive Learning.* Schofield: Wisconsin State Reading Association, 1995.

Cook, Doris, *Strategic Learning in the Content Areas.* Madison: Wisconsin Department of Public Instruction, 1989.

Sample

Analogy Graphic Organizer

NEW CONCEPT	FAMILIAR CONCEPT
Decimals	Fractions

Similarities	Differences
Both express whole numbers and parts of a whole number.	Fractions have a numerator and a denominator.
The amounts they express may be the same.	Decimals use a decimal point to separate the whole numbers from the parts.
Both may have a value less than one, equal to one, or more than one.	Fractions are written as two numbers separated by a horizontal or diagonal line.
The four operations of adding, subtracting, multiplying, and dividing can be performed on both decimals and fractions.	Operations on fractions require a set of algorithmic steps different from those for whole numbers and decimals.
Any fraction can be expressed as a decimal.	

Relationship Categories

Forms
Amounts expressed
Operations
Algorithms

Concept Wheel/Circle

The concept wheel/circle is an instructional technique that builds on students' background knowledge, encourages brainstorming and discussion, and visually displays the connection between previous conceptual knowledge and the new word.

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

Goals

1. Promote growth in vocabulary, conceptual understandings, and comprehension.
2. Activate and extend the background knowledge of students.

Teacher Preparation

1. Select an important concept to teach.
2. Have dictionaries available.

Instructional Procedures

1. Introduce the concept to students, writing the word on the chalkboard.
2. Ask students to generate a list of other words or phrases that come to mind when they think of the target word.
3. Lead a class discussion on students' responses.
4. Write a list of words from their responses that fit appropriately with the target word on the chalkboard.
5. Direct students to find a definition of the word in the textbook, glossary, or dictionary.
6. Read the definition of the target word and direct students to compare their generated list of words with the definition.
7. Direct students to look over the words on the board very carefully and with the definition in mind to decide on at least three words from the list that will help them remember the target word.
8. Tell students to write their selected words in the concept wheel to help them remember the concept (see example).

Relevant English-Language Arts Content Standards

Grade Seven: Vocabulary and Concept Development

1.3 Clarify word meanings through the use of definition, example, restatement, or contrast.

Grade Eight: Vocabulary and Concept Development

1.3 Use word meanings within the appropriate context and show ability to verify those meanings by definition, restatement, example, comparison, or contrast.

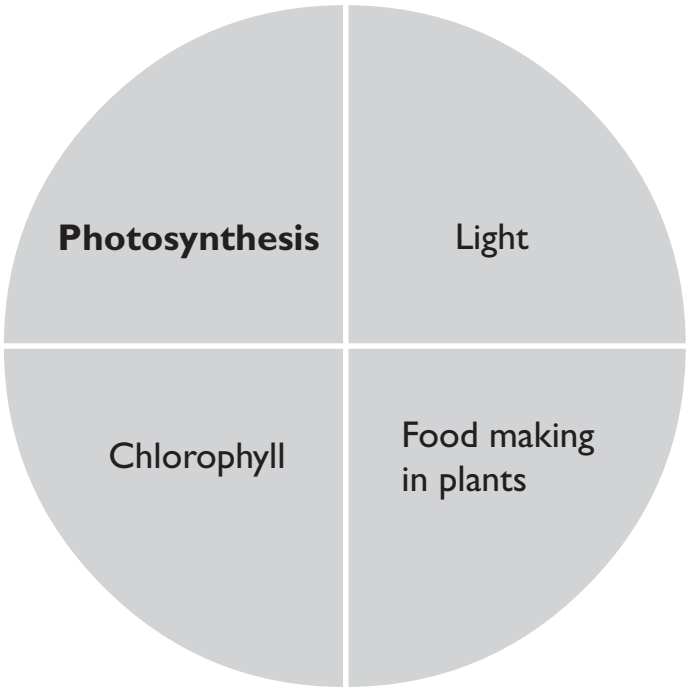
Further Resources

Rupley, William H.; John W. Logan; and William D. Nichols. "Vocabulary Instruction in a Balanced Reading Program," *The Reading Teacher*, Vol. 52 (December 1998/January 1999), 340.

Example of a Concept Wheel

Photosynthesis

light
combining
food making
chlorophyll
sun
green leaves
solar energy
oxygen
carbon dioxide



LINK

LINK is a preparation-for-learning strategy that prompts students to brainstorm what they will encounter in a reading selection and direct their own discussion of what they already know about a topic. The acronym stands for *List, Inquire, Note,* and *Know.*

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

Goals

1. Help students link their prior knowledge with the information they will be studying.
2. Prompt students to anticipate content and make associations, and motivate them to study new material carefully.

Teacher Preparation

Select an important concept or term in the material on which you intend to focus. Be sure it is a word that will trigger a response from the students.

Instructional Procedures

1. Display the term or concept on an overhead transparency or a chalkboard.

List

2. Ask the students to list on paper, within three minutes, words associated with the concept.
3. Display their responses on the overhead transparency or chalkboard. To ensure maximum participation, ask for one response from each student in the class. You may want to call on less active participants first to increase chances of their involvement. Allow students to offer a second idea after everyone has responded.

Inquire

4. Students ask other students about items on the list. The teacher's role at this stage is largely passive and neutral. The purpose of this activity is to allow students to share and elaborate on their understandings. Let *them* discover their errors and difficulties.

Note

5. Turn off the overhead projector or erase words on the chalkboard. Then instruct the students to turn over their papers and write down everything that comes to mind from prior experience and class discussion in response to the term or concept on the board. Limit the time for brainstorming to one minute. One variation is to have students write a definition of the concept.

Know

6. Students are now ready to read the passage. After reading, they may be asked to note what they now know after they have encountered new material.

Relevant English–Language Arts Content Standards

Grade Four: Reading Comprehension

2.3 [Students] make and confirm predictions about text by using prior knowledge and ideas presented in text itself.

Grades One Through Twelve: Reading Comprehension

2.0 Students read and understand grade-level-appropriate material.

Further Resources

Buehl, Doug. *Classroom Strategies for Interactive Learning*. Schofield: Wisconsin State Reading Association, 1995.

Cook, Doris. *Strategic Learning in the Content Areas.* Madison: Wisconsin Department of Public Instruction, 1989.

Vaughan, Joseph L., and Thomas H. Estes. *Reading and Reasoning Beyond the Primary Grades*. Boston: Allyn and Bacon, 1986.

Example of the LINK Technique

ABOLITIONISM

slavery	black people	Africans	North	South
antislavery	slave masters	cruelty	Civil War	conflict
"North Star"	Frederick Douglass	Canada	Lincoln	Harriet Tubman
overseers	John Brown	prejudice	lashing	*Uncle Tom's Cabin*
abolish	slave revolts	Quakers	protest	Underground Railroad

Student Brainstorm:

Abolitionism is the desire to abolish slavery. Before the Civil War many black people in the South were slaves. The Quakers (a religious group) in the North were against slavery and helped slaves escape to the North into Canada. Some abolitionists, like John Brown, led slave revolts; others, like Harriet Tubman, led slaves to freedom in the North. They were able to do this by using a system of signals, stops, and hiding places. This system was known as the Underground Railroad. A newspaper published and written by Frederick Douglass called the North Star often contained coded messages that helped people make their way to freedom.

Contextual Redefinition

Contextual redefinition is a strategy for showing students the importance of context in ascertaining meaning. It is useful in those instances in which difficult terms can be defined by the context in which they occur.

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

Goals

1. Help students realize that context can provide additional clues to the meaning of words and engage students in using context to discover the meaning of unknown words.
2. Help faltering readers experience the thinking processes involved in deriving a definition from context as students model appropriate reading behavior for one another.

Teacher Preparation

1. Select a few words students will encounter in text that are essential for comprehending important concepts and yet may be difficult for students as they read.
2. Provide a context with clues of definition or description for each word. If such a context already exists in the text, use that context instead of creating one. If the text lacks a sentence or short paragraph containing clues for a given word, create one that will provide significant information about the meaning of the word.

Instructional Procedures

1. Present the words in isolation. Using an overhead transparency or chalkboard, ask students to provide a meaning for each word. Students then support their choices and, as a group, arrive at a consensus on what they believe is the best meaning. Examples are as follows:
   - vapid
   - lummox
   - piebald
2. Present the words in a sentence. Using the sentence or short paragraph previously developed, present the word in its appropriate context, as in these examples:
   - Even though she intended to discuss a lively issue, her conversation with me was *vapid*, lacking animation and force.
   - As a result of his ungainly, slovenly appearance, Bill was often unjustly labeled a *lummox*.
   - Though described as *piebald* because of its spotted black and white colors, the horse was still considered beautiful by many horse lovers.
3. Ask students to offer suggestions for the meaning of each word and defend their definitions. This process exposes less able readers to the thinking processes involved in deriving a definition from context as students model appropriate reading and thinking behavior for one another.
4. Have students or groups of students consult a dictionary to verify the choices offered by class members.

Relevant English–Language Arts Content Standards

Grade Three: Word Analysis, Fluency, and Systematic Vocabulary Development

1.6 Use sentence and word context to find the meaning of unknown words.

Grade Five: Word Analysis, Fluency, and Systematic Vocabulary Development

1.5 Understand and explain the figurative and metaphorical use of words in context.

Grade Six: Word Analysis, Fluency, and Systematic Vocabulary Development

1.4 Monitor expository text for unknown words or words with novel meanings by using word, sentence, and paragraph clues to determine meaning.

Grades Nine and Ten: Word Analysis, Fluency, and Systematic Vocabulary Development

1.2 Distinguish between the denotative and connotative meanings of words and interpret the connotative power of words.

Further Resources

Cunningham, J. W.; P. M. Cunningham; and S. V. Arthur. *Middle and Secondary School Reading*. New York: Longman, 1981.

Moore, David W.; John E. Readence; and Robert J. Rickelman. *Prereading Activities for Content Area Reading & Learning.* Newark, Del.: International Reading Association, 1989.

Readence, J. E.; T. W. Bean; and R. S. Baldwin. *Content Area Reading: An Integrated Approach* (Second edition). Dubuque, Iowa: Kendall Hunt, 1985.

Think Aloud

The think-aloud strategy is an approach in which teachers verbalize their own thought processes while reading orally to students. In this way teachers model for students the cognitive and metacognitive[1] processes that good readers use to construct meaning and monitor comprehension.

Goals

1. Give students the opportunity to see the kinds of strategies a skilled reader uses to construct meaning and cope with comprehension problems.
2. Develop students' ability to monitor their reading and take corrective action when needed.
3. Provide an opportunity for students to experience effective reading and problem solving and to transfer these strategies to their independent reading.

Teacher Preparation

1. Select a passage that contains points of difficulty, ambiguities, or unknown words in preparation for oral reading.
2. Preview the passage and imagine that you are reading it for the first time as one of your good readers would.
3. Use a copy of the passage to make note of the comments and questions to model for students.

Instructional Procedures

1. Read the passage aloud, telling students to follow along silently and listen to how you construct meaning and think through trouble spots. The following are examples of the thought processes you might model for your students:
   - Make predictions. (Show how to develop hypotheses.)
   - Describe any pictures forming in your head while you read. (Show how to develop images during reading.)
   - Share an analogy. (Show how to link prior knowledge with new information in the reading selection.)
   - Verbalize a confusing point. (Show how you monitor your ongoing comprehension and become aware of problems.)
   - Demonstrate fix-up strategies. (Show how you address comprehension problems by using fix-up strategies.)
2. Select a logical stopping point, and have students use some of those strategies during a silent reading of the passage.
3. Model several experiences, then have students work with partners to practice "think alouds" by taking turns in reading orally and sharing thoughts. For struggling readers, move from carefully developed materials with obvious problems to school materials of various types and lengths.

[1]Metacognition means awareness of one's own processing behaviors.

Relevant English–Language Arts Content Standards

Grades Two Through Four: Reading Comprehension

2.0 Students read and understand grade-level-appropriate material. They draw upon a variety of comprehension strategies as needed, including generating and responding to essential questions, making predictions, and comparing information from several sources.

Grade Four: Reading Comprehension

2.2 [Students] use appropriate strategies when reading for different purposes (e.g., full comprehension, locating information, personal enjoyment).

Further Resources

Davey, B. "Think Aloud—Modeling the Cognitive Process of Reading Comprehension," *Journal of Reading* (October 1983), 44–47.

STRATEGY INDEX
Student Audience
Beginning readers
Below grade level
At or above grade level
Text Type
Literary
Informational
Special Features
Automaticity with print
Prior knowledge and interest
Discussion about texts
Collaborative learning
Writing emphasis
Graphic representation
Student control of reading process
Student ownership of strategy

Example of Think Aloud

The following material is an example of a passage and the thoughts that a teacher might express aloud during the oral reading:

Passage

Salaam frantically searched for the address listed on his clipboard; he had six more packages to deliver before his shift ended. The building he had entered had eight floors, and he hoped that number 456 Lakeside was an apartment on the fourth floor of this old, dilapidated building.

Teacher Thinking Aloud

I predict that Salaam, who is a delivery man for a shipping company, will not find the address because the author described the building as being run-down.

I see the building as being one of many apartment buildings on a busy street in a big city. I imagine that there could be paint peeling off the walls and bars on the windows.

I can compare this situation to the time I was in my hometown, and I had driven into an area that looked like what the author is describing. I was afraid and wanted to leave.

Passage Continued

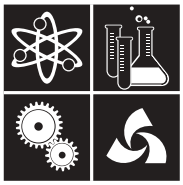
Salaam climbed the stairs to the fourth floor. As he walked from door to door checking numbers, he felt the floor vibrate. He felt invisible hands push him from side to side. The whole building started to rumble. Hanging on to the package, Salaam reached for the bannister on the stairwell as it gave way.

Teacher Thinking Aloud

I don't understand how invisible hands could be pushing him. I'm not sure what is happening to Salaam and where the story is going.

I'm going to keep reading and hope my level of understanding will increase. If it doesn't, then I will reread the passage or ask someone.

Earth Science



Physical Science

Life Science

Strategic Science Teaching, Grades K-12:

A Sampler of Science Lessons Connecting Literature with the California Standards

Through the leadership of the California County Superintendents Educational Services Associations science committee, you have an opportunity to purchase the June, 2002 publication "Strategic Science Teaching, Grades K-12: A Sampler of Science Lessons Connecting Literature with the California Standards." This publication features science lessons at each grade level, K-12, including:

1) focus on science standards and student outcomes,
2) use of a literature selection from the California Department of Education Suggested Reading in Science List,
3) teaching and learning strategies to promote content literacy,
4) use of the 5 E's Learning Cycle and science investigations,
5) strategies for English Learners, and
6) complete lesson plans.

Please complete all of the information requested.

Item Number	Item Description	Quantity	Unit Price	Total
1138	Strategic Science Teaching K-12		$15.00	
			Subtotal	
			7.75% Sales Tax	
			*Shipping and Handling 10% *before tax*	
			TOTAL	

SHIPPING AND HANDLING
All orders to be delivered within the continental U.S. are shipped via United Parcel Service (UPS), Ground ONLY, unless special shipping is requested.

No shipping and handling charge for San Diego County Office truck mail delivery.

Please make checks payable to: San Diego County Superintendent of Schools

Check # _____ **Purchase Order #** _____

Please send orders to: **SDCOE Graphic Communications, Room #212**
6401 Linda Vista Road • San Diego, CA 92111-7399
(858 569-5391 Fax (858) 292-3772

ALL SALES ARE FINAL
Damaged or incorrect shipments must be reported to the Sales Office *within 10 days of receipt*. Please order carefully; we cannot accept returns. **All sales are final.**

FAX ORDERS
Purchase orders may be placed by fax (858) 292-3772, **but do not mail the original or confirming order.** Any duplicate orders will be treated as separate (new) orders and will become the responsibility of the customer.

Ship To:

Name: _____ Position: _____

School Site: _____ District: _____

School Phone: _____ School Fax: _____

School Address: _____

City, State, Zip: _____ Home Phone: _____