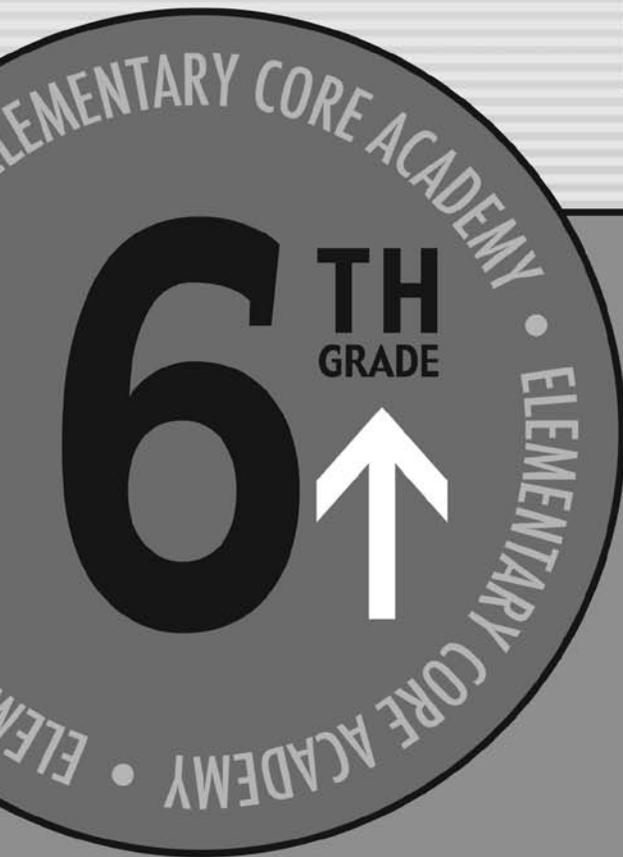




Participant Handbook



2006



ELEMENTARY CORE ACADEMY

6517 Old Main Hill
Logan, UT 84322-6517

435-797-0939
<http://coreacademy.usu.edu>

UtahState UNIVERSITY

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In Memory



During the past four years Elizabeth Thomas has been a part of the Elementary CORE Academy. On March 27, 2006, Liz was freed from the pain and sickness she endured in her fight with leukemia. She was a wonderful example of passionate teaching and skillful instruction. We honor her as we continue to enthusiastically teach as she did. Her desire to teach was a wonderful and powerful example to all educators. All who knew her were touched by her love of life.

Her influence and example will continue on in print through this publication. She was the principle author of the section containing Science Standard I and II.



Acknowledgements

These materials have been produced by and for the teachers of the State of Utah. Appreciation is expressed to the numerous individuals who provided input and effort into the creation of this curriculum. Delivery of the Elementary CORE Academy, including the development and delivery of content, coordination of sessions, distribution of materials, and participant interaction, has been a collaborative effort of many educational groups across Utah. The following organizations, Utah teachers, and educational leaders contributed ideas and activities as part of this professional development project:

Organizations:

Utah State Office of Education (USOE)
Utah State University (USU)
State Science Education Coordination Committee (SSECC)
State Mathematics Education Coordination Committee (SMECC)
Special Education Services Unit (USOE)
WestEd Eisenhower Regional Consortium

Individuals:

Academy Coordination Committee: Max Longhurst, Brett Moulding, Nicole Paulson, Velma Itamura, Janet Gibbs

Academy Director: Max Longhurst

Academy Coordinator: Megan Richards

Academy Facilitators: Vickie Ahlstrom, Janeen Graham, Donna Ward, Meri-lyn Stark

Academy Presenters and Contributors: Penny Archibald-Stone, Denise Demille, Tom Freeman, Amy Kinder, Lizz Thomas

Credits for editing, compiling, formatting, and assisting with the materials and delivery of the Elementary CORE Academy are given to James Evans, Ami Israelsen, Eric Rowley, and Elizabeth Shaw.

UTAH STATE OFFICE OF EDUCATION

Leadership...Service...Accountability

Patti Harrington, Ed.D. State Superintendent of Public Instruction
Voice: (801) 538-7500 Fax: (801) 538-7521 TDD: (801) 538-7876
250 East Cesar E. Chavez Blvd. (500 South) P.O. Box 144200 Salt Lake City, Utah 84114-4200

Dear CORE Academy Teachers:

Thank you for your investment in children and in building your own expertise as you participate in the Elementary CORE Academy. I hope your involvement helps you to sustain a laser-like focus on student achievement.

Teachers in Utah are superb. By participating in the Academy, you join a host of teachers throughout the state who understand that teaching targeted on the core curricula, across a spectrum of subjects, will produce results of excellence. The research is quite clear—the closer the match of explicit instruction to core standards, the better the outcome on core assessments.

I personally appreciate your excellence and your desire to create wonderful classrooms of learning for students. Thank you for your dedication. I feel honored to associate with you and pledge my support to lead education in ways that benefit all of our children.

Sincerely,



Patti Harrington, Ed.D.
State Superintendent of Public Instruction

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Funding Sources

Appreciation is expressed for the tremendous educational input and monetary commitment of several organizations for the successful delivery of the Elementary CORE Academy. This year's Elementary CORE Academy was developed and funded through a variety of sources. The Utah State Office of Education (USOE), in collaboration with Utah State University (USU) and local school districts of Utah, have supported kindergarten through sixth grade teachers with professional development experiences that will enhance the educational experience for Utah children.

Major funding for the Academy comes from the following sources:

Federal/State Funds:

- Utah State Office of Education
 - Staff Development Funds
 - Special Education Services Unit
- ESEA Title II
- Utah Math Science Partnership
- WestED Eisenhower Regional Consortium

District Funds:

Various sources including Quality Teacher Block, Federal ESEA Title II, and District Professional Development Funds

School Funds:

- Trust land, ESEA Title II, and other school funds
- Utah State Office of Education Special Education Services

The state and district funds are allocations from the state legislature. ESEA is part of the “No Child Left Behind” funding that comes to Utah.

Additionally, numerous school districts, individual schools, and principals in Utah have sponsored teachers to attend the Academy. Other educational groups such as the Utah Division of Water Resources, National Energy Foundation, Utah Energy Office, and the Utah Mining Association have assisted in the development and delivery of resources in the Academy.

Most important is the thousands of teachers who take time from their summer to attend these professional development workshops. It is these teachers who make this program possible.

Goals of the Elementary CORE Academy

Overall

The purpose of the Elementary CORE Academy is to create high quality teacher instruction and improve student achievement through the delivery of professional development opportunities and experiences for teachers across Utah.

The Academy will provide elementary teachers in Utah with:

1. Models of exemplary and innovative instructional strategies, tools, and resources to meet the Core Curriculum standards, objectives, and indicators.
2. Practical models and diverse methods of meeting the learning needs of all children, with instruction implementation aligned to the Core Curriculum.
3. Meaningful opportunities for collaboration, self-reflection, and peer discussion specific to innovative and effective instructional techniques, materials, teaching strategies, and professional practices in order to improve classroom instruction.

Learning a limited set of facts will no longer prepare a student for real experiences encountered in today's world. It is imperative that educators have continued opportunities to obtain instructional skills and strategies that provide methods of meeting the needs of all students. Participants of the Academy experience will be better equipped to meet the challenges faced in today's classrooms.

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**Sixth Grade
Science
Core Curriculum**

Utah Elementary Science Core Curriculum

Introduction

Science is a way of knowing, a process for gaining knowledge and understanding of the natural world. The Science Core Curriculum places emphasis on understanding and using skills. Students should be active learners. It is not enough for students to read about science; they must do science. They should observe, inquire, question, formulate and test hypotheses, analyze data, report, and evaluate findings. The students, as scientists, should have hands-on, active experiences throughout the instruction of the science curriculum.

The Elementary Science Core describes what students should know and be able to do at the end of each of the K–6 grade levels. It was developed, critiqued, piloted, and revised by a community of Utah science teachers, university science educators, State Office of Education specialists, scientists, expert national consultants, and an advisory committee representing a wide variety of people from the community. The Core reflects the current philosophy of science education that is expressed in national documents developed by the American Association for the Advancement of Science, the National Academies of Science. This Science Core has the endorsement of the Utah Science Teachers Association. The Core reflects high standards of achievement in science for all students.

Organization of the Elementary Science Core

The Core is designed to help teachers organize and deliver instruction.

The Science Core Curriculum’s organization:

- Each grade level begins with a brief course description.
- The INTENDED LEARNING OUTCOMES (ILOs) describe the goals for science skills and attitudes. They are found at the beginning of each grade, and are an integral part of the Core that should be included as part of instruction.
- The SCIENCE BENCHMARKS describe the science content students should know. Each grade level has three to five Science Benchmarks. The ILOs and Benchmarks intersect in the Standards, Objectives and Indicators.



- A STANDARD is a broad statement of what students are expected to understand. Several Objectives are listed under each Standard.
- An OBJECTIVE is a more focused description of what students need to know and be able to do at the completion of instruction. If students have mastered the Objectives associated with a given Standard, they are judged to have mastered that Standard at that grade level. Several Indicators are described for each Objective.
- An INDICATOR is a measurable or observable student action that enables one to judge whether a student has mastered a particular Objective. Indicators are not meant to be classroom activities, but they can help guide classroom instruction.

Guidelines Used in Developing the Elementary Science Core

Reflects the Nature of Science

Science is a way of knowing, a process of gaining knowledge and understanding of the natural world. The Core is designed to produce an integrated set of Intended Learning Outcomes (ILOs) for students. Please see the Intended Learning Outcomes document for each grade level core.

As described in these ILOs, students will:

1. Use science process and thinking skills.
2. Manifest science interests and attitudes.
3. Understand important science concepts and principles.
4. Communicate effectively using science language and reasoning.
5. Demonstrate awareness of the social and historical aspects of science.
6. Understand the nature of science.

Coherent

The Core has been designed so that, wherever possible, the science ideas taught within a particular grade level have a logical and natural connection with each other and with those of earlier grades. Efforts have also been made to select topics and skills that integrate well with one another and with other subject areas appropriate to grade level. In addition, there is an upward articulation of science concepts, skills, and content. This spiraling is intended to prepare students to understand and use more complex science concepts and skills as they advance through their science learning.

Developmentally Appropriate

The Core takes into account the psychological and social readiness of students. It builds from concrete experiences to more abstract understandings. The Core describes science language students should use that is appropriate to each grade level. A more extensive vocabulary should not be emphasized. In the past, many educators may have mistakenly thought that students understood abstract concepts (such as the nature of the atom), because they repeated appropriate names and vocabulary (such as electron and neutron). The Core resists the temptation to tell about abstract concepts at inappropriate grade levels, but focuses on providing experiences with concepts that students can explore and understand in depth to build a foundation for future science learning.

Encourages Good Teaching Practices

It is impossible to accomplish the full intent of the Core by lecturing and having students read from textbooks. The Elementary Science Core emphasizes student inquiry. Science process skills are central in each standard. Good science encourages students to gain knowledge by doing science: observing, questioning, exploring, making and testing hypotheses, comparing predictions, evaluating data, and communicating conclusions. The Core is designed to encourage instruction with students working in cooperative groups. Instruction should connect lessons with students' daily lives. The Core directs experiential science instruction for all students, not just those who have traditionally succeeded in science classes. The vignettes listed on the "Utah Science Home Page" at <http://www.usoe.k12.ut.us/curr/science> for each of the Core standards provide examples, based on actual practice, that demonstrate that excellent teaching of the Science Core is possible.

Comprehensive

The Elementary Science Core does not cover all topics that have traditionally been in the elementary science curriculum; however, it does provide a comprehensive background in science. By emphasizing depth rather than breadth, the Core seeks to empower students rather than intimidate them with a collection of isolated and eminently forgettable facts. Teachers are free to add related concepts and skills, but they are expected to teach all the standards and objectives specified in the Core for their grade level.

Feasible

Teachers and others who are familiar with Utah students, classrooms, teachers, and schools have designed the Core. It can be taught with

The Core is:

- Coherent
- Developmentally Appropriate
- Encourages Good Teaching Practices
- Comprehensive
- Feasible
- Useful and Relevant
- Encourages Good Assessment Practices

easily obtained resources and materials. A Teacher Resource Book (TRB) is available for elementary grades and has sample lessons on each topic for each grade level. The TRB is a document that will grow as teachers add exemplary lessons aligned with the new Core. The middle grade levels have electronic textbooks available at the Utah State Office of Education's "Utah Science Home Page" at <http://www.usoe.k12.ut.us/curr/science>.

Useful and Relevant

This curriculum relates directly to student needs and interests. It is grounded in the natural world in which we live. Relevance of science to other endeavors enables students to transfer skills gained from science instruction into their other school subjects and into their lives outside the classroom.

Encourages Good Assessment Practices

Student achievement of the standards and objectives in this Core are best assessed using a variety of assessment instruments. One's purpose should be clearly in mind as assessment is planned and implemented. Performance tests are particularly appropriate to evaluate student mastery of science processes and problem-solving skills. Teachers should use a variety of classroom assessment approaches in conjunction with standard assessment instruments to inform their instruction. Sample test items, keyed to each Core Standard, may be located on the Utah Science Home Page. Observation of students engaged in science activities is highly recommended as a way to assess students' skills as well as attitudes in science. The nature of the questions posed by students provides important evidence of students' understanding of science.

The Most Important Goal

Elementary school reaches the greatest number of students for a longer period of time during the most formative years of the school experience. Effective elementary science instruction engages students actively in enjoyable learning experiences. Science instruction should be as thrilling an experience for a child as seeing a rainbow, growing a flower, or holding a toad. Science is not just for those who have traditionally succeeded in the subject, and it is not just for those who will choose science-related careers. In a world of rapidly expanding knowledge and technology, all students must gain the skills they will need to understand and function responsibly and successfully in the world. The Core provides skills in a context that enables students to experience the joy of doing science.

Sixth Grade Science Core Curriculum

The theme for Sixth Grade Science is Scale, with Relative Position as an underlying concept. Sixth graders should begin to relate to the incredible size and distance of objects in the solar system, galaxy, and universe, as well as compare their world to the miniscule scale of microorganisms. Students will also understand how relative position affects such events as the appearance of the moon and the changing of the seasons. Students will experiment with heat, light, and sound, and begin to understand concepts of energy.

Students should begin to design and perform experiments and value inquiry as the fundamental scientific process. They should be encouraged to maintain an open and questioning mind as they plan and conduct experiments. They should be helped and encouraged to pose their own questions about objects, events, processes, and results. They should have the opportunity to plan and conduct their own experiments, and come to their own conclusions as they read, observe, compare, describe, infer, and draw conclusions. The results of their experiments need to be compared for reasonableness to multiple sources of information. It is important for students at this age to begin to formalize the processes of science and be able to identify the variables in a formal experiment.

Good science instruction requires hands-on science investigations in which student inquiry is an important goal. Teachers should provide opportunities for all students to experience many things. Sixth graders should experience the excitement of locating the North Star and Little Dipper, and the wonders of gazing into the night sky. They should find the fascination of peering into the world of microorganisms, experimenting and watching them as they move and feed and reproduce. Students should come to enjoy science as a process of discovering the natural world.

Science Core concepts should be integrated with concepts and skills from other curriculum areas. Reading, writing, and mathematics skills should be emphasized as integral to the instruction of science. Technology issues and the nature of science are significant components of this Core. Personal relevance of science in students' lives is always an important part of helping students to value science, and should be emphasized at this grade level.

This Core was designed using the American Association for the Advancement of Science's Project 2061: Benchmarks For Science Literacy and the National Academy of Science's National Science

- Design and perform experiments
- Value inquiry
- Maintain an open and questioning mind
- Pose questions about objects, events, processes, and results
- Plan and conduct experiments
- Read, observe, compare, describe, infer, and draw conclusions
- Formalize the process of science
- Identify variables in a formal experiment



Education Standards as guides to determine appropriate content and skills.

The sixth grade Science Core has three online resources designed to help with classroom instruction; they include Teacher Resource Book –a set of lesson plans, assessment items and science information specific to sixth grade; Sci-ber Text –an electronic science textbook specific to the Utah Core; and the science test item pool. This pool includes multiple-choice questions, performance tasks, and interpretive items aligned to the standards and objectives of the sixth grade Science Core. These resources are all available on the Utah Science Home Page at <http://www.usoe.k12.ut.us/curr/science> .

SAFETY PRECAUTIONS

The hands–on nature of this science curriculum increases the need for teachers to use appropriate precautions in the classroom and field. Proper handling and disposal of microorganisms is crucial for a safe classroom. Teachers must adhere to the published guidelines for the proper use of animals, equipment, and chemicals in the classroom. These guidelines are available on the Utah Science Home Page.

Intended Learning Outcomes for Sixth Grade Science

The Intended Learning Outcomes (ILOs) describe the skills and attitudes students should learn as a result of science instruction. They are an essential part of the Science Core Curriculum and provide teachers with a standard for evaluation of student learning in science. Instruction should include significant science experiences that lead to student understanding using the ILOs.

The main intent of science instruction in Utah is that students will value and use science as a process of obtaining knowledge based upon observable evidence.

By the end of sixth grade students will be able to:

1. Use Science Process and Thinking Skills
 - a. Observe simple objects, patterns, and events, and report their observations.
 - b. Sort and sequence data according to criteria given.
 - c. Given the appropriate instrument, measure length, temperature, volume, and mass in metric units as specified.
 - d. Compare things, processes, and events.
 - e. Use classification systems.
 - f. Plan and conduct simple experiments.
 - g. Formulate simple research questions.
 - h. Predict results of investigations based on prior data.
 - i. Use data to construct a reasonable conclusion.
2. Manifest Scientific Attitudes and Interests
 - a. Demonstrate a sense of curiosity about nature.
 - b. Voluntarily read and look at books and other materials about science.
 - c. Pose science questions about objects, events, and processes.
 - d. Maintain an open and questioning mind toward new ideas and alternative points of view.
 - e. Seek and weigh evidence before drawing conclusions.
 - f. Accept and use scientific evidence to help resolve ecological problems.
3. Understand Science Concepts and Principles

- Use Science Process and Thinking Skills
- Manifest Scientific Attitudes and Interests
- Understand Science Concepts and Principles
- Communicate Effectively Using Science Language and Reasoning
- Demonstrate Awareness of Social and Historical Aspects of Science
- Understand the Nature of Science

- a. Know and explain science information specified for the grade level.
- b. Distinguish between examples and non-examples of concepts that have been taught.
- c. Solve problems appropriate to grade level by applying science principles and procedures.
4. Communicate Effectively Using Science Language and Reasoning
 - a. Record data accurately when given the appropriate form (e.g., table, graph, chart).
 - b. Describe or explain observations carefully and report with pictures, sentences, and models.
 - c. Use scientific language in oral and written communication.
 - d. Use reference sources to obtain information and cite the source.
 - e. Use mathematical reasoning to communicate information.
5. Demonstrate Awareness of Social and Historical Aspects of Science
 - a. Cite examples of how science affects life.
 - b. Understand the cumulative nature of science knowledge.
6. Understand the Nature of Science
 - a. Science is a way of knowing that is used by many people not just scientists.
 - b. Understand that science investigations use a variety of methods and do not always use the same set of procedures; understand that there is not just one “scientific method.”
 - c. Science findings are based upon evidence.

Sixth Grade Science Standards

Science Benchmark

The appearance of the lighted portion of the moon changes in a predictable cycle as a result of the relative positions of Earth, the moon, and the Sun. Earth turns on an axis that is tilted relative to the plane of Earth's yearly orbit. The tilt causes Sunlight to fall more intensely on different parts of the Earth during various parts of the year. The differences in heating of Earth's surface and length of daylight hours produce the seasons.

Standard I: Students will understand that the appearance of the moon changes in a predictable cycle as it orbits Earth and as Earth rotates on its axis.

Objective 1: Explain patterns of changes in the appearance of the moon as it orbits Earth.

- a. Describe changes in the appearance of the moon during a month.
- b. Identify the pattern of change in the moon's appearance.
- c. Use observable evidence to explain the movement of the moon around Earth in relationship to Earth turning on its axis and the position of the moon changing in the sky.
- d. Design an investigation, construct a chart, and collect data depicting the phases of the moon.

Objective 2: Demonstrate how the relative positions of Earth, the moon, and the Sun create the appearance of the moon's phases.

- a. Identify the difference between the motion of an object rotating on its axis and an object revolving in orbit.
- b. Compare how objects in the sky (the moon, planets, stars) change in relative position over the course of the day or night.
- c. Model the movement and relative positions of Earth, the moon, and the Sun.

Standard I:

Students will understand that the appearance of the moon changes in a predictable cycle as it orbits Earth and as Earth rotates on its axis.



Standard II:
Students will understand how Earth's tilt on its axis changes the length of daylight and creates the seasons.

Standard II: Students will understand how Earth's tilt on its axis changes the length of daylight and creates the seasons.

Objective 1: Describe the relationship between the tilt of Earth's axis and its yearly orbit around the Sun.

- a. Describe the yearly revolution (orbit) of Earth around the Sun.
- b. Explain that Earth's axis is tilted relative to its yearly orbit around the Sun.
- c. Investigate the relationship between the amount of heat absorbed and the angle to the light source.

Objective 2: Explain how the relationship between the tilt of Earth's axis and its yearly orbit around the Sun produces the seasons.

- a. Compare Earth's position in relationship to the Sun during each season.
- b. Compare the hours of daylight and illustrate the angle that the Sun's rays strikes the surface of Earth during summer, fall, winter, and spring in the Northern Hemisphere.
- c. Use collected data to compare patterns relating to seasonal daylight changes.
- d. Use a drawing and/or model to explain that changes in the angle at which light from the Sun strikes Earth, and the length of daylight, determine seasonal differences in the amount of energy received.
- e. Use a model to explain why the seasons are reversed in the Northern and Southern Hemispheres.

Science language students should use:

Earth's tilt, seasons, axis of rotation, orbits, phases of the moon, revolution, reflection

Science Benchmark

The solar system consists of planets, moons, and other smaller objects including asteroids and comets that orbit the Sun. Planets in the solar system differ in terms of their distance from the Sun, number of moons, size, composition, and ability to sustain life. Every object exerts gravitational force on every other object depending on the mass of the objects and the distance between them. The Sun's gravitational pull holds Earth and other planets in orbit. Earth's gravitational force holds the moon in orbit. The Sun is one of billions of stars in the Milky Way galaxy, that is one of billions of galaxies in the universe. Scientists use a variety of tools to investigate the nature of stars, galaxies, and the universe. Historically, cultures have observed objects in the sky and understood and used them in various ways.

Standard III: Students will understand the relationship and attributes of objects in the solar system.

Objective 1: Describe and compare the components of the solar system.

- a. Identify the planets in the solar system by name and relative location from the Sun.
- b. Using references, compare the physical properties of the planets (e.g., size, solid or gaseous).
- c. Use models and graphs that accurately depict scale to compare the size and distance between objects in the solar system.
- d. Describe the characteristics of comets, asteroids, and meteors.
- e. Research and report on the use of manmade satellites orbiting Earth and various planets.

Objective 2: Describe the use of technology to observe objects in the solar system and relate this to science's understanding of the solar system.

- a. Describe the use of instruments to observe and explore the moon and planets.
- b. Describe the role of computers in understanding the solar system (e.g., collecting and interpreting data from observations, predicting motion of objects, operating space probes).
- c. Relate science's understanding of the solar system to the technology used to investigate it.

Standard III:

Students will understand the relationship and attributes of objects in the solar system.

Objective 3: Describe the forces that keep objects in orbit in the solar system.

- a. Describe the forces holding Earth in orbit around the Sun, and the moon in orbit around Earth.
- b. Relate a celestial object's mass to its gravitational force on other objects.
- c. Identify the role gravity plays in the structure of the solar system.

Standard IV: Students will understand the scale of size, distance between objects, movement, and apparent motion (due to Earth's rotation) of objects in the universe and how cultures have understood, related to and used these objects in the night sky.

Objective 1: Compare the size and distance of objects within systems in the universe.

- a. Use the speed of light as a measuring standard to describe the relative distances to objects in the universe (e.g., 4.4 light years to star Alpha Centauri; 0.00002 light years to the Sun).
- b. Compare distances between objects in the solar system.
- c. Compare the size of the Solar System to the size of the Milky Way galaxy.
- d. Compare the size of the Milky Way galaxy to the size of the known universe.

Objective 2: Describe the appearance and apparent motion of groups of stars in the night sky relative to Earth and how various cultures have understood and used them.

- a. Locate and identify stars that are grouped in patterns in the night sky.
- b. Identify ways people have historically grouped stars in the night sky.
- c. Recognize that stars in a constellation are not all the same distance from Earth.
- d. Relate the seasonal change in the appearance of the night sky to Earth's position.
- e. Describe ways that familiar groups of stars may be used for navigation and calendars.

Science language students should use:

asteroids, celestial object, comets, galaxy, planets, satellites, star, distance, force, gravity, gravitational force, mass, scale, solar system, constellation, Milky Way galaxy, speed of light, telescope, universe, Sun, light years

Standard IV:

Students will understand the scale of size, distance between objects, movement, and apparent motion (due to Earth's rotation) of objects in the universe and how cultures have understood, related to and used these objects in the night sky.



Standard V:
Students will understand that microorganisms range from simple to complex, are found almost everywhere, and are both helpful and harmful.

Science Benchmark

Microorganisms are those living things that are visible as individual organisms only with the aid of magnification. Microorganisms are components of every ecosystem on Earth. Microorganisms range in complexity from single to multicellular organisms. Most microorganisms do not cause disease and many are beneficial. Microorganisms require food, water, air, ways to dispose of waste, and an environment in which they can live. Investigation of microorganisms is accomplished by observing organisms using direct observation with the aid of magnification, observation of colonies of these organisms and their waste, and observation of microorganisms' effects on an environment and other organisms.

Standard V: Students will understand that microorganisms range from simple to complex, are found almost everywhere, and are both helpful and harmful.

Objective 1: Observe and summarize information about microorganisms.

- a. Examine and illustrate size, shape, and structure of organisms found in an environment such as pond water.
- b. Compare characteristics common in observed organisms (e.g., color, movement, appendages, shape) and infer their function (e.g., green color found in organisms that are producers, appendages help movement).
- c. Research and report on a microorganism's requirements (i.e., food, water, air, waste disposal, temperature of environment, reproduction).

Objective 2: Demonstrate the skills needed to plan and conduct an experiment to determine a microorganism's requirements in a specific environment.

- a. Formulate a question about microorganisms that can be answered with a student experiment.
- b. Develop a hypothesis for a question about microorganisms based on observations and prior knowledge.
- c. Plan and carry out an investigation on microorganisms. {Note: Teacher must examine plans and procedures to assure the safety of students; for additional information, you may wish to read microbe safety information on Utah Science Home Page.}
- d. Display results in an appropriate format (e.g., graphs, tables, diagrams).

- e. Prepare a written summary or conclusion to describe the results in terms of the hypothesis for the investigation on microorganisms.

Objective 3: Identify positive and negative effects of microorganisms and how science has developed positive uses for some microorganisms and overcome the negative effects of others.

- a. Describe in writing how microorganisms serve as decomposers in the environment.
- b. Identify how microorganisms are used as food or in the production of food (e.g., yeast helps bread rise, fungi flavor cheese, algae are used in ice cream, bacteria are used to make cheese and yogurt).
- c. Identify helpful uses of microorganisms (e.g., clean up oil spills, purify water, digest food in digestive tract, antibiotics) and the role of science in the development of understanding that led to positive uses (i.e., Pasteur established the existence, growth, and control of bacteria; Fleming isolated and developed penicillin).
- d. Relate several diseases caused by microorganisms to the organism causing the disease (e.g., athlete's foot -fungi, streptococcus throat -bacteria, giardia -protozoa).
- e. Observe and report on microorganisms' harmful effects on food (e.g., causes fruits and vegetables to rot, destroys food bearing plants, makes milk sour).

Science language students should use:

algae, fungi, microorganism, decomposer, single-celled, organism, bacteria, protozoan, producer, hypothesis, experiment, investigation, variable, control, culture

Science Benchmark

Heat, light, and sound are all forms of energy. Heat can be transferred by radiation, conduction and convection. Visible light can be produced, reflected, refracted, and separated into light of various colors. Sound is created by vibration and cannot travel through a vacuum. Pitch is determined by the vibration rate of the sound source.

Standard VI:
Students will understand properties and behavior of heat, light, and sound.

Standard VI: Students will understand properties and behavior of heat, light, and sound.

Objective 1: Investigate the movement of heat between objects by conduction, convection, and radiation.

- a. Compare materials that conduct heat to materials that insulate the transfer of heat energy.
- b. Describe the movement of heat from warmer objects to cooler objects by conduction and convection.
- c. Describe the movement of heat across space from the Sun to Earth by radiation.
- d. Observe and describe, with the use of models, heat energy being transferred through a fluid medium (liquid and/or gas) by convection currents.
- e. Design and conduct an investigation on the movement of heat energy.

Objective 2: Describe how light can be produced, reflected, refracted, and separated into visible light of various colors.

- a. Compare light from various sources (e.g., intensity, direction, color).
- b. Compare the reflection of light from various surfaces (e.g., loss of light, angle of reflection, reflected color).
- c. Investigate and describe the refraction of light passing through various materials (e.g., prisms, water).
- d. Predict and test the behavior of light interacting with various fluids (e.g., light transmission through fluids, refraction of light).

- e. Predict and test the appearance of various materials when light of different colors is shone on the material.

Objective 3: Describe the production of sound in terms of vibration of objects that create vibrations in other materials.

- a. Describe how sound is made from vibration and moves in all directions from the source in waves.
- b. Explain the relationship of the size and shape of a vibrating object to the pitch of the sound produced.
- c. Relate the volume of a sound to the amount of energy used to create the vibration of the object producing the sound.
- d. Make a musical instrument and report on how it produces sound.

Science language students should use:

angle of incidence, angle of reflection, absorption, conduction, conductor, convection, medium, pitch, prism, radiation, reflection, refraction, spectrum, vibration



Facilitated Activities

Science IV

Activities

Scale & Size

Scale from the Solar System to a Monster Bee

Standard III:
Students will understand the relationships and attributes of objects in the solar system.
Objective 1:
Describe and compare the components of the solar system.
Standard IV:
Students will understand the scale of size, distance between objects, movement, and apparent motion (due to Earth’s rotation) of objects in the universe and how cultures have understood, related to and used these objects in the sky.
Objective 1:
Compare the size and distance of objects within systems in the universe.
Intended Learning Outcomes:
1. Use Science Process and Thinking Skills.
2. Communicate Effectively Using Science Language and Reasoning.
Content Connections:
Mathematics IV-2
Language Arts “produce observation reports”

Science
Standard
III&IV

Objective
1

Connections

Background Information

Scale is the Grade 6 science theme. We exist somewhere in an awesome reality that expands many powers of ten above us and submerges many powers of ten below us. At our level of reality, we cannot draw or make a picture of objects such as a bacterium or a planet at its real size. We have to adjust the scale in order to visualize the object and its parts. Describing the scale of very small and very large objects requires using exponents.

While scale can help us visualize the world of the very small and the very large, some things in which we are interested, such as the solar system, pose challenges. Because the Sun is so much larger than the planets, we cannot draw the sizes of the Sun and its planets correctly to scale on the same piece of paper. Any scale that we use to draw the planets will not be compatible with showing how far apart they are. We need a different kind of model to correctly scale the objects in the solar system and their distances from the Sun. We also need different units, such as the light year, to describe the incredibly large distances of the Milky Way galaxy and the universe.

Learning about scale is important because things can change in very surprising ways in going from one level of size to another. In the early 1900s, physicists went crazy because they kept trying to understand

electrons and protons based on how things behave on our level of reality. It turns out that electrons and protons are incredibly different from anything we experience. The changes in scale that we investigate may not manifest such profound changes, but we should always be aware that whole systems are often very different than their parts. Even exactly the same system can appear very different when examined at different scales of perception.

Research Basis

Pang, J., & Good, R. (2000). A review of the integration of science and mathematics: implications for further research. *School science and mathematics*, Volume 100 (February), p. 73.

Hurley, M. M. (2001). Reviewing integrated science and mathematics: the search for evidence and definitions from new perspectives. *School science and mathematics*, Volume 101 (May), p. 259.

Teaching about and using concepts of scale inherently involves both mathematics and science. Integrating mathematics and science education attracts many educators, has some obvious benefits, but also conflicting interpretations, and a weak research base.

Invitation to Learn

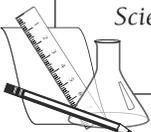
Discuss the following prompt after viewing the dung beetle movie. What thoughts about scale do you have after watching the heroic struggle of the dung beetle?

Instructional Procedures

1. Ponder a dung beetle's heroic struggle.
2. Scale both size and distance in modeling Earth and the Moon.
3. Create a scale model of the solar system that uses the same scale for the sizes of the planets and the distances within the solar system.
4. Explore the use of light years as a measure of distance, and compare it with other distance measurements that combine speed and time (such as crawling seconds or bicycle hours).
5. Dina the Monster Bee illustrates how changing scale can cause unexpected changes.
6. Learn about the book you received, *Dr. Art's Guide to Science*, and how it relates to the Grade 6 Science Core.

Materials

- MicroCosmos* DVD
- Marbles (1 cm)
- Metric rulers
- Calculators
- Various round objects (diameters of 0.5 cm, 0.25 cm, 0.1 cm)
- Yellow beach ball (20 cm)
- A variety sizes of nuts and seeds
- Pinheads
- Heavy construction paper
- Paper
- Tape
- Dr. Art's Guide to Science*



Assessment Suggestions

- Show students the typical pictorial drawing of the solar system where the planets are correctly to scale with each other with respect to size, but not to scale with the Sun with respect to size, and totally out of scale with respect to distances. Ask them to write one feature that is correct with respect to scale, and two features that are not accurate with respect to scale.
- Show students a model of a toy car crossing a toy bridge over a toy creek. Say that the real car and the real creek are both 500 times larger than the model. If the real bridge were exactly the same as the model except 500 times larger, ask if they would be comfortable driving the car across the bridge. Have them justify their response.
- Have students state which of the following distances are best described in terms of kilometers, light seconds, and light years: distance from Earth to the Moon; distance from Earth to the Sun; distance from Earth to the nearest star; distance from Earth to the edge of the Milky Way; distance from Earth to the nearest neighboring galaxy.

Curriculum Extensions/Adaptations/Integration

- Have students make scale models of very large and very small objects. Instruct them to mathematically describe the scale they are using, and to use that scale consistently.
- Develop and share different units (such as running minutes) within the school, from the school to home, and from the school to another state or country.
- Have students make a specific kind of structure using newspaper. Construct the same structure using the same materials at a scale ten times smaller. Construct the same structure using the same materials at a scale ten times larger than the original. Discuss how the structures and construction process changed at the different scales. See the “Scaled Newspaper Structures” activity.

Family Connections

- Make models using other materials at three different construction scales (see *The Exploratorium Guide to Scale and Structure Part III* for ideas).

- Develop and share different units (such as running hours) to describe distances such as from home to a store, to a person in another city, to the capital of a foreign country, or to anything that you collectively choose.
- Watch the *MicroCosmos* DVD and note how changing scale influences our perceptions, and also changes how life interacts with the physical environment. (Caution: DVD includes scenes of insects mating.)

Additional Resources

Books

Dr. Art's Guide to Science: Connecting Atoms, Galaxies, and Everything in Between, by Art Sussman; ISBN 0-7879-8326-8

The Exploratorium Guide to Scale and Structure: Activities for the Elementary Classroom, by Barry Kluger-Bell and the School in the Exploratorium, ISBN 0-435-08372-4.

Videos

The Films of Charles & Ray Eames – The Powers of Ten, by Image Entertainment, ASIN 6305943877

MicroCosmos, by Miramax, ISBN 0-7888-5091-1

Web sites

<http://www.wordwizz.com/pwrsof10.htm>

micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/

<http://www.guidetoscience.net>

Where to Put the Moon

Your group has a marble representing Earth, a metric ruler, and at least one calculator.

Your group also has three objects of different sizes. Please choose the object whose size best represents the Moon's size using the scale that the marble represents planet Earth. After selecting the object whose size best represents the Moon, place that object at a distance from the marble (Earth) that is true to the same scale.

Share with the whole group which object you selected and the distance separating Earth and the Moon at the scale that we are using.

The presenter will provide the information about the real sizes of Earth and the Moon, and the real distance separating them. As a group, decide if you want to change the object representing the Moon and/or its distance from the marble. Be prepared to justify why your group did not make changes, or the changes you made.

Scale Model of the Solar System

Your group has a variety of objects to represent the planets of the solar system. We are all using a yellow beach ball that is 20 cm in diameter to represent the Sun. The Sun is actually 1,400,000 km in diameter.

We are going to create a scale model of the solar system that accurately represents the sizes of all the planets and the distances separating them. We are using the same scale for the planets as for the Sun. Using the Table below, calculate the scaled sizes for all the planets, and select an object to represent each of the planets.

Planet	Actual Diameter in Kilometers	Diameter in Scale Model	Object Representing Planet in Scale Model
Sun	1,400,000 km	20 cm	Yellow beach ball
Mercury	5,000 km		
Venus	12,000 km		
Earth	13,000 km		
Mars	7,000 km		
Jupiter	143,000 km		
Saturn	120,000 km		
Uranus	51,000 km		
Neptune	49,000 km		
Pluto	2,200 km		

We will share as a whole group our scaled diameters and the objects selected to represent the planets. Then, we must decide how far to place these model planets from the yellow beach ball. Using the Table below and the same scale, calculate the distances for all the planets.

Planet	Actual Distance in Kilometers	Scaled Distance Between Planets	Scaled Distance of Planet from the Sun
Mercury	58,000,000 km from Sun	N/A	
Venus	50,000,000 km from Mercury		
Earth	41,000,000 km from Venus		
Mars	78,000,000 km from Earth		
Jupiter	550,000,000 km from Mars		
Saturn	649,000,000 km from Jupiter		
Uranus	1,443,000,000 km from Saturn		
Neptune	1,627,000,000 km from Uranus		
Pluto	1,404,000,000 km from Neptune		

Groups share the objects they have chosen for the different planets, and the distances for each planet. We will write the name of each planet on an index card. As a whole group, we will decide how many large steps to take from the Sun to Mercury, with each large step being one meter. We will write that number of steps on the Mercury card. For Venus, we will decide how many large steps to take from Mercury to Venus, and write that number on the Venus card. We will continue for the rest of the planets.

Everyone goes outside to set up one class model of the solar system using the beach ball Sun and the objects that have been chosen. We will pace off the steps from the Sun, and look back from each planet towards the Sun. Of course, we will remember that the planets do not line up in a straight line from the Sun.

Proxima Centauri, the star closest to our solar system, is 40,000,000,000,000 (40 trillion or 40×10^{12}) km away. Where would it be using the same scale as we just used for the solar system?

The distance from our solar system to the center of the Milky Way galaxy is about 30,000 light years which is approximately 30×10^{16} kilometers. How far away would it be in our model using the same scale as we have used previously for the solar system?

Light Years and Crawling Seconds

The speed of light is 300,000 km/second. How long is a light second?

Show how you would calculate the distance of one light year:

How many kilometers is one light year?

The distance from Earth to the Sun is 150,000,000 kilometers. Is the light year a convenient measuring unit for describing the distance from Earth to the Sun? Explain your answer.

The diameter of the Milky Way galaxy is approximately 100,000 light years. The observable universe is about 15 billion light years, but that might only be a small part of our physical universe or all that exists. People often have difficulty understanding that a light year is a measure of distance since the word year is a measure of time, not distance. You can practice using other units of distance that include a unit of time.

How far is the longest distance from one end of the room to the other in:

Crawling seconds:

Crawling minutes:

Walking seconds:

Running seconds:

Make up one or more units of measurement to describe the three distances in the Table below:

Name of your unit of measurement	Distance home to school	Distance home to friend's house	Distance bedroom to refrigerator

Dina the Monster Bee

PART A: Making a Model of Sweeta the Honeybee

Working as a group, you will make a model of Sweeta the Honeybee. Use heavy construction paper (card stock, manila, cardboard, etc) to make the bee model. Sweeta is the approximate size of a natural honeybee. Her body is made of four rectangular strips 3 cm x 2 cm that are taped together to form a rectangular cylinder with openings at either end.

Cover one end with a 2 cm x 2 cm piece that represents her head (okay, she has a flat head, but you can draw on it to make it more realistic). Tape it to cover the opening

Cover the other end with a 2 cm x 2 cm piece that represents her tail (okay, she has a flat tail, but that's better than getting stung). Tape it to cover the opening.

Attach two wings made of paper each 2 cm by 3 cm.

Insects breathe through holes in the surface of their bodies. To do this, they need to have more surface area than volume (more places for air to come in than all the places in the body that need to get air). To make sure that Sweeta can live, we will need to calculate the ratio of the surface area of Sweeta's body to the volume of her body.

Measure the total surface area of the bee, not including the wings. Enter your measurements and calculations here:

Sweeta's total body surface area =

Calculate the volume of Sweeta's body. Enter your measurements and calculations here.

Sweeta's total body volume =

Divide the surface area by the volume:

If your answer is greater than 1, then Sweeta has enough surface area to bring in air for her body. If your answer is less than 1, Sweeta is in trouble.

Will Sweeta have enough air?

Sweeta also has to fly. The surface area of her wings has to be large enough to generate the lift to raise her body. Measure the total surface area of Sweeta's wings. Enter your measurements and calculations here:

Sweeta's total wing surface area =

To be able to fly, the ratio of the surface area of the wings to the volume should be at least 0.5.

Divide the wing surface area by the body volume:

If your answer is greater than 0.5, then Sweeta has enough surface area in her wings to lift her body and fly. If your answer is less than 0.5, Sweeta cannot fly.

Will Sweeta be able to fly?

PART B: Making Dina the Monster Bee

Working as a group, you will make a model of Dina the Monster Bee. Use heavy construction paper (card stock, manila, cardboard, etc) to make the bee model. Dina is ten times size of a natural honeybee in every direction. Her body is made of four rectangular strips 30 cm x 20 cm that are taped together to form a rectangular cylinder with openings at either end.

Cover one end with a 20 cm x 20 cm piece that represents her head. Tape it to cover the opening

Cover the other end with a 20 cm x 20 cm piece that represents her tail. Tape it to cover the opening.

Attach two wings made of paper, each 20 cm by 30 cm.

Insects breathe through holes in the surface of their bodies. To do this, they need to have more surface area than volume (more places for air to come in than all the places in the body that need to get air). To see if Dina can live, we will need to calculate the ratio of the surface area of Dina's body to the volume of her body.

Measure Dina's total surface area, not including the wings. Enter your measurements and calculations here:

Dina's total body surface area =

Calculate the volume of Dina's body. Enter your measurements and calculations here.

Dina's total body volume =

Divide the surface area by the volume:

If your answer is greater than 1, then Dina has enough surface area to bring in air for her body, and she will have enough energy to attack us. If your answer is less than 1, we are safe from Dina the Monster Bee.

Will Dina have enough air?

Dina also has to fly. The surface area of her wings has to be large enough to generate the lift to raise her body. Measure the total surface area of Dina's wings. Enter your measurements and calculations here:

Dina's total wing surface area =

To be able to fly, the ratio of the surface area of the wings to the volume should be at least 0.5.

Divide Dina's wing surface area by the body volume:

If your answer is greater than 0.5, then Dina has enough surface area in her wings to lift her body and fly. If your answer is less than 0.5, we don't have to worry about the Dina the Monster Bee.

Will Dina be able to fly?

Do you think that scaling up in size just involves getting bigger and bigger, or do other things change when you scale up in size? Explain your answer.

Scaled Newspaper Structures

- A. Build a structure made of pieces of newspaper. The structure must have an inside and an outside. One of the dimensions (either height, width, or length) of Structure A must be exactly 45 cm. The structure must have strength. You can use up to 72 pieces of paper to make the structure. Each piece of paper is one ninth the size of a full sheet of Sunday newspaper. You can get 9 pieces of paper by cutting a full sheet of Sunday newspaper into three equal lengths, and then cutting each of these lengths into three equal rectangles. You may use up to 3 meters of tape in making the structure. You can fold, roll, crumple, or stack the pieces of paper.

After you make Structure A, discuss what worked, what caused problems, what changes you made during the building process, any surprises, and what you think you learned.

- B. Build a small structure made of pieces of newspaper. The pieces of paper used in this construction are one-ninth the size of the pieces used to build the first structure. Start with eight of the rectangular papers used in A. Cut each piece into three lengths, and then cut each length into three equal rectangles. Again you can use up to 72 of the rectangles to make this Structure B. This structure must have strength. One of the dimensions (either height, width, or length) of Structure B must be exactly 20 cm. You may use up to 1.5 meters of tape in making the structure. You can fold, roll, crumple, or stack the pieces of paper.

After you make Structure B, discuss what worked, what caused problems, what changes you made during the building process, any surprises, and what you think you learned. Compare your experience in making the two different structures.

- C. Build a large structure made of sheets of newspaper. The pieces of paper used in this construction are the full sheets from a Sunday newspaper. You can use up to 72 full Sunday newspaper sheets to make this Structure C. This structure must have strength. One of the dimensions (either height, width, or length) of Structure C must be exactly 180 cm. You may use up to 12 meters of tape in making the structure. You can fold, roll, crumple, or stack the pieces of paper.

After you make Structure C, discuss what worked, what caused problems, what changes you made during the building process, any surprises, and what you think you learned. Compare your experience in making the three different structures.

Which of the following statements do you agree with and why?

Changing scale just involves making things bigger or smaller.

Changing scale causes more changes than just making things bigger or smaller.

This activity is adapted from “Scaled Newspaper Structures” with permission from the Exploratorium, from the book *The Exploratorium Guide to Scale and Structure*. c 1995 Exploratorium, www.exploratorium.edu

Science I&III

Activities

Solar System Objects

The Solar System and the Forces Behind It

Standard III:
Students will understand the relationship and attributes of objects in the solar system.
Objective 1:
Describe and compare the components of the solar system.
Objective 2:
Describe the use of technology to observe objects in the solar system and relate this to science’s understanding of the solar system.
Objective 3:
Describe the forces that keep objects in orbit in the solar system.
Intended Learning Outcomes:
1. Use Science Process and Thinking Skills. 3. Understand Science Concepts and Principles. 4. Communicate Effectively Using Science Language and Reasoning.
Content Connections:
LA I – Develop effective oral language; LA VI – Use grade level vocabulary to increase understanding; LA VII – Interpret and analyze to increase comprehension Math IV – Apply measurement tools and techniques; Math V – Collect, analyze, and draw conclusions from data

Science
Standard
III

Objective
1,2,&3

Connections

Background Information

In Greece, during the third century B.C., Aristotle, one of the greatest ‘thinkers’ and philosophers of all times decided Earth is the center of all existence and all heavenly bodies revolved around it in perfect circles. On what evidence or observational data did Aristotle base his theory on? None. He thought and thought about it and concluded that was the most logical explanation. However, everyone loved this idea of a geocentric (Earth-centered) universe. It made everyone feel important.

A Greco-Egyptian astronomer named Claudius Ptolemaeus, known as Ptolemy, refines Aristotle’s ideas in the second century A.D. that Earth was the center of the universe. People remained feeling special, happy and content because it’s only right that everything should revolve us. Besides, there are references in the Bible that seem to support the idea of geocentricity.

For thousands of years this theory was so widely accepted -- it became accepted truth. It wasn’t until the mid 1500’s that a Polish astronomer named Nicholas Copernicus challenged the idea of a geocentric system because it did not explain the planetary motions. He

developed a theory that Earth and the other planets orbit the Sun and is heliocentric (“Sun-centered”). People were angry at this idea because they lost the center of attention. However, Copernicus never had to deal with the wrath of the general populous because he died right after his ideas and theories were published.

In the early 1600’s, an Italian astronomer Galileo Galileo, with his telescope and observations of Jupiter’s moons and Venus’s phases proved that Copernicus was correct. The Sun is at the center of our system of planets, moons, and all heavenly objects orbit around it. However the public outrage was incredible! Nearly everyone accepted the Church’s teachings that the Sun orbits Earth. Even with evidence to support a Sun-centered system, Galileo was put on trial for publishing his ‘heretical’ observations. Under threat of torture (and Galileo is now quite old these days), renounced his ideas and spent the rest of his life under house arrest.

Our Solar System consists of a star, our Sun, nine orbiting known planets and their moons, asteroids, meteoroids, and comets. Our Sun, like other stars, is a huge ball of burning gases that produces tremendous amounts of heat and light. The Sun contains 99.86 percent of the mass of the entire solar system. Because of its mass, its gravitational force is able to keep the planets and all other objects in our Solar System in their elliptical orbit. Scientists believe that energy from the Sun is transferred through space in waves or magnetic energy known as the electromagnetic spectrum.

Planets are large heavenly bodies that orbit a star, in our case it’s the Sun. The word planet comes from the Greek word meaning ‘wanderer’. Ancient astronomers did not know how to explain how these moving objects could change their position in the heavens. The planets are at times referred to as the inner planets consisting of Mercury, Venus, Earth, and Mars. Each of these terrestrial (‘land’) planets have a rocky core and are extremely small in comparison to the giant gas planets. The giant gas planets are known to be the outer planets and are both massive in size, and mostly made of gases with a small solid core. Then there’s Pluto. Not necessarily an inner planet, but it is considered another small, terrestrial rocky planet.

Moons are natural satellites that orbit planets. Every planet has at least one moon except the planets Mercury and Venus.

Asteroids! There’s tens of thousands of them tumbling and bumping lumps of rock orbiting the Sun. Asteroids are also known as ‘minor planets’ or ‘planetoids’ and get their name from the Greek word that means ‘starlike’. When seen through a telescope, an asteroid looks like a faint star. There is an enormous gap of space in between

the inner planets and the outer planets which consists of the ‘Asteroid Belt’. The vast majority of asteroids orbit the Sun between Mars and Jupiter. But they can also inhabit different regions of the solar system. Asteroids range in size from less than one kilometer in diameter to hundreds of km. They are usually irregular in shape and bumpy, not smooth and round like larger planets. Their surface is pockmarked with craters because over time they eventually crashed into one another. They split apart into smaller and smaller fragments leaving dust and smaller asteroids in the Asteroid Belt. Asteroids are made mostly of different types of rock, often rich in iron and other metals, and some ice. Since many meteorites found on Earth contain similar materials, astronomers believe that most meteorites are broken bits and pieces of asteroids that land on Earth.

Meteoroids are fragments from asteroids that have collided and split apart in small bits and pieces. These asteroid collisions send the meteoroids flying off in all directions across the Solar System. Some zoom toward Earth but the friction from our atmosphere makes the meteoroids so hot that they burn up in our atmosphere making a fiery streak of light called a meteor. People have referred to these ‘falling stars’ or ‘shooting stars’. When a meteoroid survives its hot journey through Earth’s atmosphere and falls to the ground, it is called a meteorite.

Comets have been referred to by astronomers as ‘dirty snowballs’ and ‘as close to nothing as something can get’ because they seem to be nothing more than rock dust wrapped around a spongy ball of ice. Throughout history there have been many superstitions about comets and many people were terrified calling them ‘terrible stars’ and ‘death-bringing stars’. Other people thought they were a sign of good fortune sent from the gods. Comets are made up of extremely small quantities of very simple chemicals like water, carbon dioxide, ammonia, methane, and space dust. They have a small head, called a nucleus and as it travels in its orbit toward the Sun, it slowly melts and releases space dust and gases. The space dust reflects light from the Sun looking like a giant ponytail in the sky. This is how comets originally got their name, from a Greek word meaning ‘longhair’. As a comet nears the Sun, it warms up. Ice evaporates from its surface and forms a large, tenuous cloud called a coma and the gases released form a yellowish dust tail and a bluish gas tail. The tail of a comet can stretch out for millions of kilometers. As the comet loops around the Sun and then speeds away in the same direction of its orbit, its tail is ahead of the comet rather than behind. Coming or going, the comet’s tail always points away from the Sun. Astronomers have studied enough comets to be sure that these visitors are members of the Solar System, just very

Materials

- ❑ 12" piece of PVC tubing (3/8" CTS - 1/2" OD)
- ❑ 1.5 meter of braided nylon string, fused on both ends
- ❑ One small cork
- ❑ Various sizes of corks, rubber stoppers, and balls
- ❑ A piece of large spandex (100% thick, stretchy polyester can work as well)
- ❑ A variety of balls with various masses and sizes
- ❑ A bowling bowl or another very heavy ball
- ❑ A variety of reading material on each planet
- ❑ *Planetary Summary Chart*
- ❑ *Clark Planetarium Solar System 2002 Fact Sheets*
- ❑ *Clark Planetarium Solar System 2003 Fact Sheets*
- ❑ *Clark Planetarium Solar System 2004 Fact Sheets*
- ❑ *Clark Planetarium Solar System 2005 Fact Sheets*
- ❑ *Clark Planetarium Solar System 2006 Fact Sheets*



distant members. Comets seem to have 'home ground' in the farthest reaches of the Solar System beyond Pluto. The home ground is a huge region called the Oort Cloud. The gravitational force of a passing star can snatch a comet from the Oort Cloud and fling it into a cigar-shaped elliptical orbit that brings it close to the Sun. Often times, comets will be pulled into Jupiter's gravitational pull and never return to the Oort Cloud. This was the case in 1994, when Comet Shoemaker/Levy 9 rammed into Jupiter. Jupiter's powerful gravity pulled the comet apart, so the planet was pelted by almost two dozen impacts.

A force is needed to cause something to move in a curved path, the planets and all heavenly objects, are no exception to this rule. A force of some kind must be acting to hold them in their orbits around the Sun. Isaac Newton connected this concept with the same force that pulls objects to Earth's surface. Newton theorized that the moon revolves around the Earth. He called this phenomenon gravity and described it as an attractive force between any two objects. The strength of the force is related to the object's mass (which is the amount of material an object contains).

The force of gravity attracts objects to each other. This attraction is not noticeable unless one of the objects is very large, such as a planet. The area within which gravity has an effect is called a 'gravitational field'. The Earth and Moon both have gravitational fields, although the Earth's is many times greater than the Moon's because it is a much bigger object.

The strength of the pull of gravity between two objects also depends on how far apart they are and their masses. Weight is the measure of the pull of gravity on an object's mass. The further away an object is from the center of the Earth, the less pull gravity has on it. Gravity is a fundamental force in the sense that it cannot be explained in terms of any other force. Gravitational forces act between all bodies everywhere and hold planets, their moons, stars, and galaxies together.

Research Basis

National Research Council (2000). *Inquiry and the National Science Education Standards—A Guide for Teaching and Learning*

"Inquiry-based instruction is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to what is already know; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and

interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking and consideration of alternative explanations.”

Freedman, R.L.H. (1994). *Open-ended Questionings—A Handbook for Educators*

“Student-centered authentic assessment occurs when critical-thinking skills, the writing process, and content-area instruction are combined and used in open-ended questions. By their nature, open-ended questions assess writing, conceptual understanding, and thinking skills--especially students’ abilities to analyze, to evaluate, and to solve problems.”

Invitation to Learn

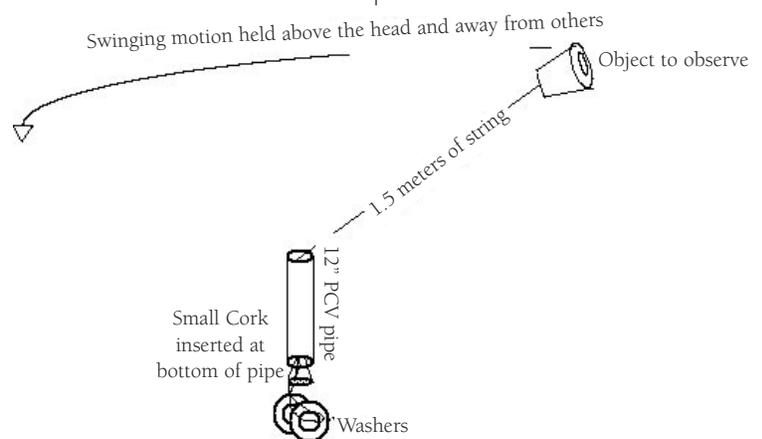
Why do planets stay in orbit? This activity will help make the connection between gravitational force and orbital motion. Participants will make observations, record discoveries, and graph data as they change different variables: such as, the size and mass of different corks and rubber stoppers, and length of string.

Instructional Procedures

1. Thread the string through the PVC pipe, then string through the hole in the cork, rubber stopper, or ball, and tie a knot.
2. Hold the PVC pipe handle with the washers at the bottom of the tube and insert the small cork into the pipe to keep the weights at a constant. (Optional extension: The number of washers used at the bottom can become another experiment and variable.)
3. Raise handle above your head and begin to rotate so that the object is circling (orbiting).
4. Record observations made in Science Journal

Activity #1 – Oops! There It Goes!

1. Discuss the concept of gravity and determine what students know about it.
2. Drop a ball and have students explain why it falls downward.
3. Ask students questions such as: How does the mass of an object determine the strength of its gravitational pull? How would the



effect of a gravitational pull change if both objects had close to the same amount of mass? If one had much more mass than the other? Have students justify their responses and give examples.

4. Have four to six students stretch, as taut as they can, using a piece of spandex material. Explain to students that this represents space.
5. Give six to eight other students select different size and weights of balls. Roll them across the stretched spandex material and make observations about how and where they move.
6. Place a bowling ball (or another heavy round object) in the center of the spandex material and repeat the same procedure with rolling the small balls across 'space'. Have students make observations and discuss the differences.
7. Ask questions such as: How is it that when the balls were rolled across the spandex the first time, they went straight? How is it that the balls changed their movement direction after placing the bowling ball in the center? How would changing the bowling ball to a ball with less mass affect the movement of the other balls? A ball with a larger mass than the bowling ball? How does this activity demonstrate gravitational pull? Have students justify they answers with evidence from their observations. Encourage them to give samples of this phenomena.

Activity #2 – My Very Energetic Mother Just Served Us Nine Pizzas (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto)

1. As a class, make a list of objects found in our solar system.
2. Explain that each group of students (there should be 10-12 groups working in pairs or triads) which will focus on one object listed on the board. Each group will then become the 'class expert' on that topic. (Objects that must be covered are the nine known planets, asteroids, meteoroids, and comets.)
3. Teacher models questioning techniques on 'wanting to know more' about their topic. Individually, students think and write about (three to five) questions they want answered during the research activity. Each member of the group then shares their questions and they make a group list of their top five questions of what they 'want to know more' about.
4. Students will be given specific information and criteria to be included in their presentation. This specific information will

be used by the rest of the class to fill in a Planetary Summary Chart.

5. Distribute a packet of Clark Planetarium Solar System Fact Sheets to each student. Focus on the following: length of year, length of day, average orbital velocity kph, equatorial diameter in km, surface gravity, temperature extremes in °C, number of known satellites, and inclination of equator (tilt). Discuss in detail each category and to what it is referring. Make a class chart, using the students own words to describe each category. Have students record this chart in their Student Journal for future reference.
6. In a class discussion, use the Clark Planetarium Solar System Fact Sheets to compare data from year to year. What are some categories that stay the same? Which ones have changed? Compare the velocity of a planet to its length of day? Compare the surface gravity of other planets to Earth? Which is the hottest planet? The coldest? Which planet is tilted the most? the least? What happens to a planet's orbit when its tilt is more than 90 degrees?
7. While doing their readings and research, have students to take note of the date of publication of the resource and reference materials they are using—encourage them to use the most current data available.
8. Students are then given several resources to read and research to help generate an interest in wanting to know more and essential background knowledge regarding their topic. They are also expected to find and use five additional resources from other sources, with the Internet being one.
9. After their research work, each member will individually write a one to two page summary of the findings about their topic of expertise. Each group will then collaborate on how they are going to report their findings to the class.
10. These presentations can be as creative and varied as determined by the group. However, presentations *MUST* include the specific factual information given to them previously so the class can fill out their Planetary Summary Chart worksheet.
11. For presentations on meteors, asteroids, and comets, students will use a graphic organizers to record information presented by those groups.

12. Give 10-15 minutes after each presentation. Students listening to the presentation need to reflect and write in their Science Journals a paragraph about “Something new I learned was . . .”

Assessment Suggestions

1. Give each student a long black sheet of bulletin board paper measuring five meters by two meters. This represents space in within the Solar System and offers a great way to integrate art with science.

*This assessment activity can also use six 8 1/2” x 11” sheets of copy paper taped horizontally together. This would allow them to keep it in their Science Journal.
2. Give each student two to three pieces of white card stock and a compass and have them draw to scale, each planet using the equator’s diameter (Scale: 1 mm = 1 km) Planets will initially be white circles which will then be colored with its proper physical characteristics.
3. Using a meter stick, set the colored planets in order from the Sun keeping in mind approximately its correct tilt (i.e., Uranus should be placed with its rings almost vertical). Each planet needs to be at the correct distance using the same scale of 1 mm = 1 km, from the Sun.
4. Above each planet label it with its name. Under each planet, indicate both km and its AU units from the Sun. (*For labeling on black paper, silver pens work great.)
5. Using colored chalk, add details such as moons and rings, the Asteroid Belt, meteoroids, and comets, the Oort Cloud, etc.

Curriculum Extensions/Adaptations/Integration

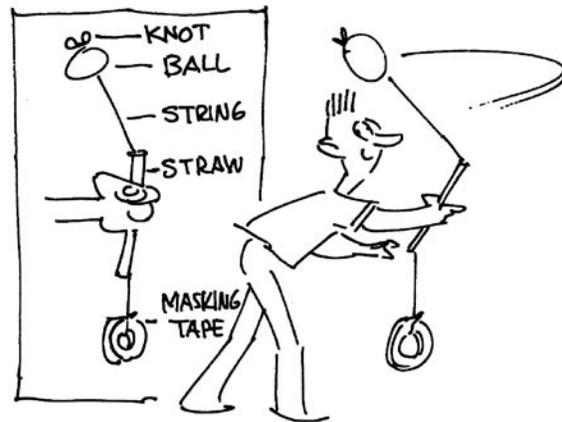
Staying Up While Falling Down

This activity demonstrates how a satellite (natural or man-made) stays in orbit by modeling the effects of Earth’s gravity on a satellite and the Sun’s gravity on the planets. Participants will observe gravity acting as a centripetal “center-seeking” force.

1. Using a fine grade sanding paper, sand the top end of the PVC pipe smooth. (*Do not* sand both ends, the rough cut end is needed for the Invitation to Learn activity.)

2. Thread the string through the PVC pipe and attach the weights (a gravitational force) at the bottom of a the PVC pipe. *Remove the small cork stopper.*
3. Place a ‘satellite’ on the top end of the PVC pipe. Hold the PVC pipe and swing the satellite in orbit, the weight pulls on the string to keep the satellite from flying off. Also make observations of how the weights move up and down.

Note: Gravity and centripetal motions are two different forces. Gravity helps to keep objects in orbit by using centripetal force. (However, centripetal force makes objects go in a circular path rather than elliptical.) If gravity did not exist, objects would keep moving out and eventually fly off into space.



Writing A Persuasive Paper - Is Pluto A Planet?

This writing activity integrates reading comprehension, the writing process, and science skills of logical reasoning and using evidence to support a particular conclusion.

1. Have students compare different definitions of what makes a planet. As a class, decide what characteristics and components determine whether an object in our Solar System is a planet.
2. Review with students the nine ‘known’ planets determine whether or not each fits the class’s definition of a planet and justify why. Also review the Asteroid Belt, Kuiper Belt, and the Oort Cloud and their locations within the Solar System.
3. Pose the question, “Is Pluto A Planet?” Before any other information is given, take an initial class vote on where they stand on this controversial question.

Additional Resources

Books

National Geographic Picture Atlas of Our Universe, by Roy A. Gallant ISBN# 0-87044-644-4

Exploring the Night Sky, by Terence Dickinson ISBN# 0-90656-66-8

Science Encyclopedia with 1,000 Recommended Web Sites, The Usborne Internet-Linked ISBN# 07945-0331-4

The Macmillan Book of ASTRONOMY, by Roy A. Gallant ISBN# 0-02-274941-1

Journey to the Planets, by Patricia Lauber ISBN# 0-517-59029-8

Gregory L.Vogt - Has a series of books on each planet. Published by Millbrook Press.

Seymour Simon - Has a series of books on each planet. Published by Morrow Junior Books.

Videos

Eyewitness - Planets, DK. <http://www.dk.com>

How and Why - Planets and Space Travel, Volume 7. 1-888-661d-8104 www.mediakids.com

Websites

<http://pds.jpl.nasa.gov/planets/>

(Welcome to the Planets)

<http://www.seds.org/nineplanets/nineplanets/nineplanets.html>

(A wondrous overview of the nine planets – pictures and info.)

<http://www.windows.ucar.edu/tour/link=/windows3.htm>

(Windows to the Universe: Our Solar System)

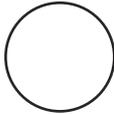
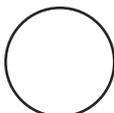
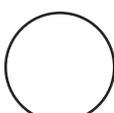
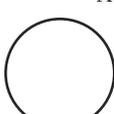
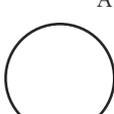
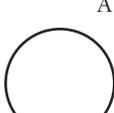
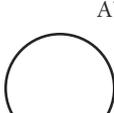
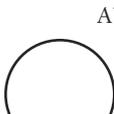
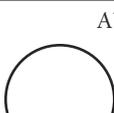
<http://spaceplace.nasa.gov/en/kids/cosmic/index.shtm>

<http://starchild.gsfc.nasa.gov>

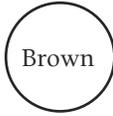
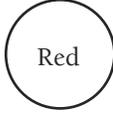
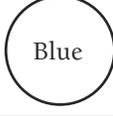
<http://starchild.gsfc.nasa.gov/docs/StarChild/teachers/gravityeffects.html>

<http://planetquest.jpl.nasa.gov>

Planetary Summary Chart

Planet	Distance from Sun in miles	Diameter Surface Temp	Period of Revolution	Rotation Period	Moons Rings	Tilt of Axis	Astro. Units
						Spec. Gravity	Color 
Roman God: Mercury		Surface Temp.				° Tilt	AU
Greek God:						S. Gravity	
Roman God: Venus		Surface Temp.				° Tilt	AU
Greek God:						S. Gravity	
Roman God: Earth		Surface Temp.				° Tilt	AU
Greek God:						S. Gravity	
Roman God: Mars		Surface Temp.				° Tilt	AU
Greek God:						S. Gravity	
Roman God: Jupiter		Surface Temp.				° Tilt	AU
Greek God:						S. Gravity	
Roman God: Saturn		Surface Temp.				° Tilt	AU
Greek God:						S. Gravity	
Roman God: Uranus		Surface Temp.				° Tilt	AU
Greek God:						S. Gravity	
Roman God: Neptune		Surface Temp.				° Tilt	AU
Greek God:						S. Gravity	
Roman God: Pluto		Surface Temp.				° Tilt	AU
Greek God:						S. Gravity	

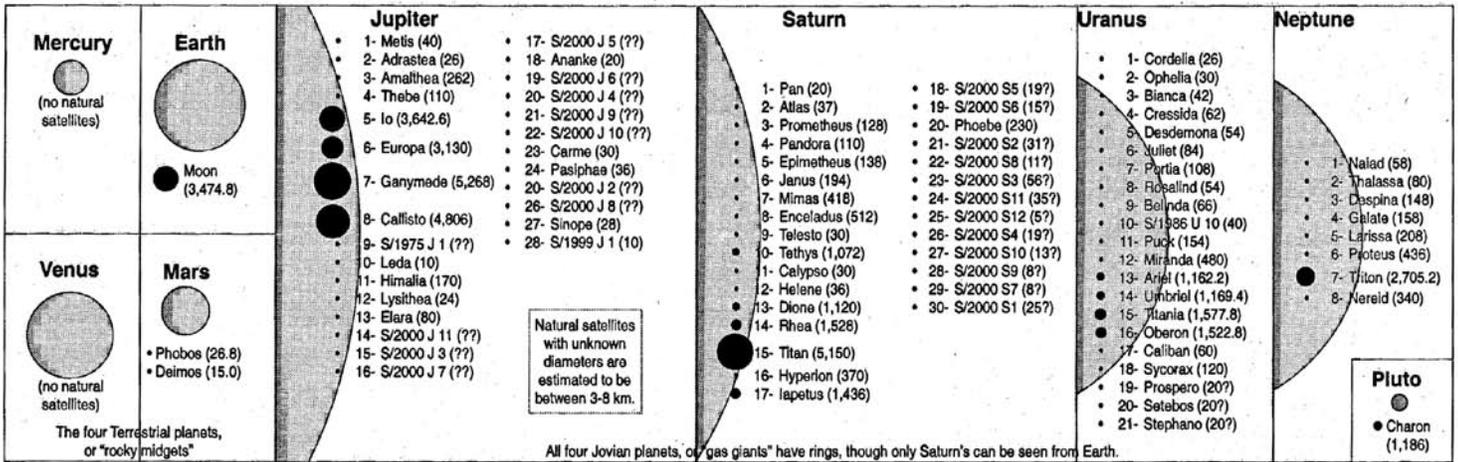
Planetary Summary Chart Answer Key

Planet	Distance from Sun in miles	Diameter Surface Temp	Period of Revolution	Rotation Period	Moons / Rings		Tilt of Axis	Astro. Units
							Spec. Gravity	Color 
Roman God: Mercury ♀ Greek God: Hermes	36 M	3,031 miles Surface Temp. -300° to 800° F	88 days	59 days	0	0	.01° Tilt S. Gravity .37 *(32 lbs)	0.38 AU 
Roman God: Venus ♀ Greek God: Aphrodite	67 M	7,521 miles Surface Temp. 850° F	225 days	Retrograde 243 days	0	0	177.36° Tilt S. Gravity .90 *(77lbs)	0.72 AU 
Roman God: Earth ⊕ Greek God: Gaea	93 M	7,926 miles Surface Temp. -125° to 130° F	365.25 days	23 hrs. 56 min.	1	0	23.5° Tilt S. Gravity 1.0 *(85 lbs)	1.0 AU 
Roman God: Mars ♂ Greek God: Aries	142 M	4,217 miles Surface Temp. -190° to 60° F	687 days	24 hrs. 37 min.	2	0	25.19° Tilt S. Gravity .37 *(32 lbs)	1.5 AU 
Roman God: Jupiter ♃ Greek God: Zeus	483 M	88,846 miles Surface Temp. -170° F	11.86 days	9 hrs. 55 min.	60	0	3.13° Tilt S. Gravity 2.53 *(244 lbs)	5.2 AU 
Roman God: Saturn ♄ Greek God: Cronus	888 M	74,900 miles Surface Temp. -215° F	29.46 years	10 hrs. 39 min.	31	thousands	26.73° Tilt S. Gravity 1.07 *(112 lbs)	9.5 AU 
Roman God: Uranus ♅ Greek God: Uranus	1,786 M or 1.8 B	31,763 miles Surface Temp. -280° F	84 years	Retrograde 17.3 hrs.	21	11	97.77° Tilt S. Gravity .90 *(79 lbs)	19.2 AU 
Roman God: Neptune ♆ Greek God: Poseidon	2,798 M or 2.8 B	30,775 miles Surface Temp. -235° F	165 years	18 hrs.	11	5	28.32° Tilt S. Gravity 1.14 *(105 lbs)	30.1 AU 
Roman God: Pluto ♇ Greek God: Hades	3,666 M or 3.6 B	1,450 miles Surface Temp. -385° F	248 years	Retrograde 6 days	1	0	119.6° Tilt S. Gravity .06 *(2.5 lbs)	39.5 AU 

Hansen Planetarium Solar System Fact Sheet 2001

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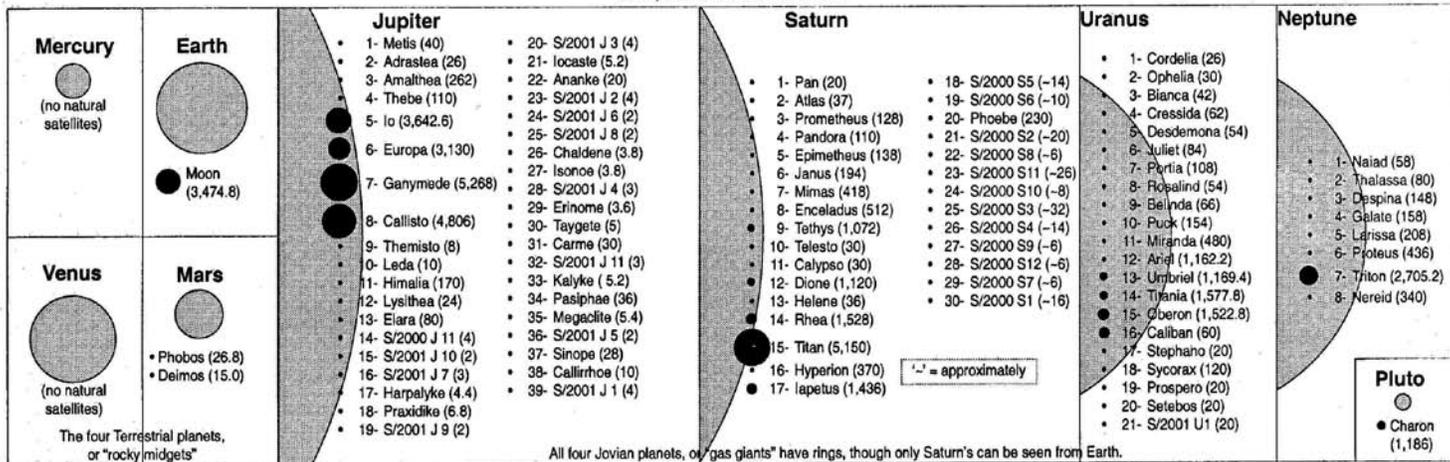


	Mercury	Venus	Earth	Moon	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Sun	
Average Distance from Sun	Millions of Kilometers	57.91	108.21	149.60	.3844 from Earth	227.94	778.30	1,429.39	2,875.04	4,504.45	5,915.80	39.95 trillion km to nearest star
	Light Travel Time	3 ^m 13 ^s	6 ^m 1 ^s	8 ^m 19 ^s	1.3 ^s from Earth	12 ^m 40 ^s	43 ^m 16 ^s	1 ^h 19 ^m 28 ^s	2 ^h 39 ^m 50 ^s	4 ^h 10 ^m 25 ^s	5 ^h 28 ^m 53 ^s	4.22y to nearest star
	Astronomical Units	0.3871	0.7233	1.0000	0.0026 from Earth	1.5237	5.203	9.555	19.218	30.110	39.545	267,032 to nearest star
Length of Year	Period of Orbit	87.969d	224.701d	365.256d	27.32d to orbit Earth	1.8808y	11.862y	29.457y	84.020y	164.770y	248.67y	226 million y to orbit galaxy
Length of Day	Period of Rotation	58 ^m 15 ^s 31 ^{ms}	243 ^d 0 ^h 26 ^m R	23 ^h 56 ^m 04 ^s	27 ^h 7 ^m 43 ^s	24 ^h 37 ^m 23 ^s	9 ^h 55 ^m 30 ^s †	10 ^h 39 ^m 22 ^s †	17 ^h 14 ^m 24 ^s †	16 ^h 6 ^m 36 ^s †	6 ^h 9 ^m 18 ^s R	25-35d†
	y=years d=days h=hours m=minutes s=seconds R=retrograde †=Depending on latitude ‡=Exact value not known											
Average Orbital Velocity	Kilometers per second	47.87	35.02	29.79	1.023	24.13	13.06	9.66	6.81	5.44	4.7	217.35 around center of galaxy
	Kilometers per hour	172,339	126,074	107,225	3,683	86,865	47,029	34,781	24,527	19,595	17,051	782,460 around center of galaxy
Equatorial Diameter	Kilometers	4,879.4	12,103.6	12,756.28	3,474.8	6,792	142,984**	120,536**	51,118**	49,528**	2,390	1,382,000
	Sun = 1	0.0035	0.0087	0.0092	0.0025	0.0049	0.1027**	0.0866**	0.0367**	0.0356**	0.0017	1.0
	Earth = 1	0.383	0.949	1.0	0.2724	0.532	11.209**	9.449**	4.007**	3.883**	0.187	109
Mass	Earth = 1	0.0553	0.8150	1.0	0.0123	0.1074	317.83	95.159	14.500	17.204	0.0022	332,946
Volume	Earth = 1	0.0562	0.857	1.0	0.0203	0.151	1,321.35	763.59	63.09	57.72	0.0066	1,300,000
Mean Density	Grams per cubic centimeter Water = 1	5.43	5.24	5.515	3.34	3.94	1.33	0.70	1.30	1.76	2.0	1.41
Surface Gravity	Earth = 1	0.378	0.905	1.0	0.166	0.379	2.53	1.07	0.903	1.14	0.062	27.96
Escape Velocity	Kilometers per second	4.25	10.36	11.18	2.38	5.02	59.5	35.5	21.3	23.5	1.2	617.5
	Kilometers per hour	15,300	37,303	40,249	8,553	18,081	214,300	127,700	76,600	84,700	4,300	2,223,000
Temperature Extremes	High °C	425	462	58	127	17	20,000*	12,000*	6,000*	6,000*	-210	15,000,000*
	High K	698	735	331	400	290	20,000*	12,000*	6,000*	6,000*	63	15,000,000*
	Low °C	-173	462	-88	-173	-143	438**	407**	346**	347**	-235	4,000**
	Low K	100	735	185	100	130	711**	680**	619**	620**	38	4,000**
*Core **At 1 atmosphere (altitude where barometric pressure equals Earth's barometric pressure at sea level—1,1013 mb)												
Atmosphere	Principal Gases	O ₂ , Na, H ₂ , He	CO ₂ , N ₂	N ₂ , O ₂	none	CO ₂ , N ₂ , Ar	H ₂ , He	H ₂ , He	H ₂ , He, CH ₄	H ₂ , He, CH ₄	CH ₄ , N ₂ , CO	H ₂ , He
# of Known Satellites		0	0	1	0	2	28 plus rings	30 plus rings	21 plus rings	8 plus rings	1	9 planets
Eccentricity of Orbit	Circular Orbit = 0	0.2056	0.0068	0.0167	0.0549	0.0934	0.0485	0.0555	0.0464	0.0095	0.2491	—
Inclination of Equator	To Planet's Orbital Plane	0.01°	177.36°	23.44°	6.68°	25.19°	3.13°	26.73°	97.77°	28.32°	119.6°	7.25° Sun's equator to ecliptic
Oblateness of Planet	Spherical Planet = 0	0	0	0.003354	0	0.005889	0.06487	0.0980	0.02293	0.01708	0	0

Hansen Planetarium Solar System Fact Sheet 2002

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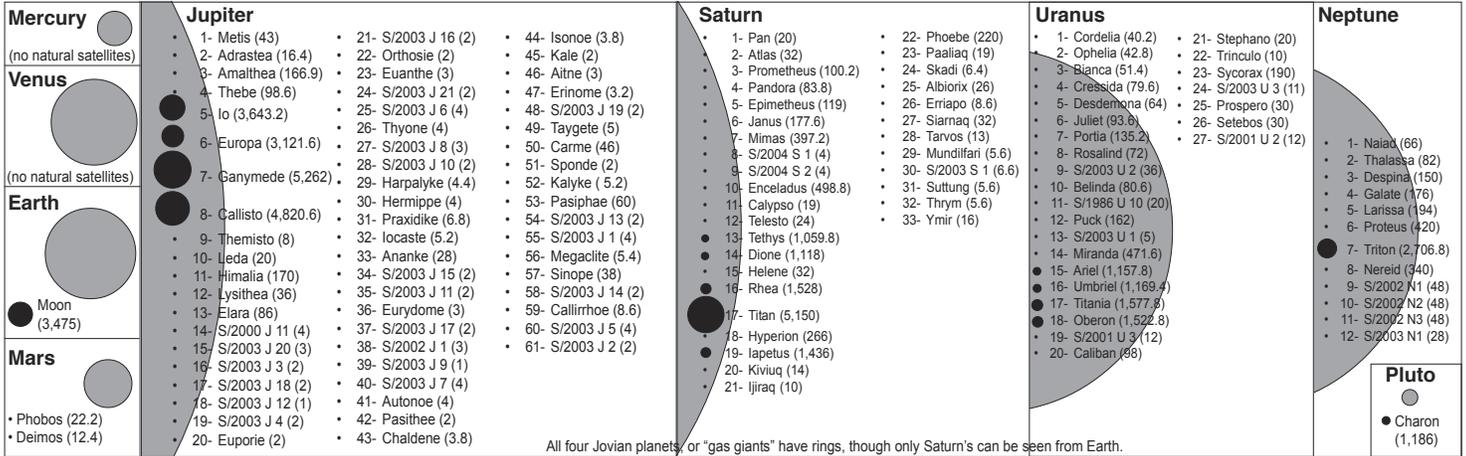


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Length of Year	Period of Orbit	87.969d	224.701d	365.256d	27.32d to orbit Earth	1.8808y	11.862y	29.457y	84.020y	164.770y	248.67y	226 million y to orbit galaxy
	Length of Day	Period of Rotation	58 ^m 15 ^s 31 ^{ms}	243 ^d 0 ^h 26 ^m R	23 ^h 56 ^m 04 ^s	27 ^m 7 ^s 43 ^{ms}	24 ^h 37 ^m 23 ^s	9 ^h 55 ^m 30 ^s †	10 ^h 39 ^m 22 ^s †	17 ^h 14 ^m 24 ^s R†	16 ^h 6 ^m 36 ^s †	6 ^h 9 ^m 18 ^s R
Average Orbital Velocity	Kilometers per second	47.87	35.02	29.79	1.023	24.13	13.06	9.66	6.81	5.44	4.7	217.35 around center of galaxy
	Kilometers per hour	172,339	126,074	107,225	3,683	86,865	47,029	34,781	24,527	19,595	17,051	782,460 around center of galaxy
Equatorial Diameter	Kilometers	4,879.4	12,103.6	12,756.28	3,474.8	6,792	142,984**	120,536**	51,118**	49,528**	2,390	1,392,000
	Sun = 1	0.0035	0.0087	0.0092	0.0025	0.0049	0.1027**	0.0886**	0.0367**	0.0356**	0.0017	1.0
	Earth = 1	0.383	0.949	1.0	0.2724	0.532	11.209**	9.449**	4.007**	3.883**	0.187	109
Mass	Earth = 1	0.0553	0.8150	1.0	0.0123	0.1074	317.83	95.159	14.500	17.204	0.0022	332,946
Volume	Earth = 1	0.0562	0.857	1.0	0.0203	0.151	1,321.35	763.59	63.09	57.72	0.0066	1,300,000
Mean Density	Grams per cubic centimeter Water = 1	5.43	5.24	5.515	3.34	3.94	1.33	0.70	1.30	1.76	2.0	1.41
Surface Gravity	Earth = 1	0.378	0.905	1.0	0.166	0.379	2.53	1.07	0.903	1.14	0.062	27.96
Escape Velocity	Kilometers per second	4.25	10.36	11.18	2.38	5.02	59.5	35.5	21.3	23.5	1.2	617.5
	Kilometers per hour	15,300	37,303	40,249	8,553	18,081	214,300	127,700	76,600	84,700	4,300	2,223,000
Temperature Extremes	High °C	425	462	58	127	17	20,000*	12,000*	6,000*	6,000*	-210	15,000,000*
	High K	698	735	331	400	290	20,000*	12,000*	6,000*	6,000*	63	15,000,000*
	Low °C	-173	462	-88	-173	-143	438**	407**	346**	347**	-235	4,000**
	Low K	100	735	185	100	130	711**	680**	619**	620**	38	4,000**
*Core **At 1 atmosphere (altitude where barometric pressure equals Earth's barometric pressure at sea level—1,1013 mb)												
Atmosphere	Principal Gases	O ₂ , Na, H ₂ , He	CO ₂ , N ₂	N ₂ , O ₂	none	CO ₂ , N ₂ , Ar	H ₂ , He	H ₂ , He	H ₂ , He, CH ₄	H ₂ , He, CH ₄	CH ₄ , N ₂ , CO	H ₂ , He
# of Known Satellites		0	0	1	0	2	39 plus rings	30 plus rings	21 plus rings	8 plus rings	1	9 planets
Eccentricity of Orbit	Circular Orbit = 0	0.2056	0.0068	0.0167	0.0549	0.0934	0.0485	0.0555	0.0464	0.0095	0.2491	—
Inclination of Equator	To Planet's Orbital Plane	0.01°	177.36°	23.44°	6.68°	25.19°	3.13°	26.73°	97.77°	28.32°	119.6°	7.25° Sun's equator to ecliptic
Oblateness of Planet	Spherical Planet = 0	0	0	0.003354	0	0.005889	0.06487	0.0980	0.02293	0.01708	0	0

Clark Planetarium Solar System Fact Sheet 2003

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	Mercury	Venus	Earth	Moon	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Sun	
Average Distance from Sun	Millions of Kilometers	57.91	108.21	149.60	.3844 from Earth	227.94	778.30	1,429.39	2,875.04	4,504.45	5,915.80	39.95 trillion km to nearest star
	Light Travel Time	3 ^m 13 ^s	6 ^m 1 ^s	8 ^m 19 ^s	1.3 ^s from Earth	12 ^m 40 ^s	43 ^m 16 ^s	1 ^h 19 ^m 28 ^s	2 ^h 39 ^m 50 ^s	4 ^h 10 ^m 25 ^s	5 ^h 28 ^m 53 ^s	4.22y to nearest star
	Astronomical Units	0.3871	0.7233	1.0000	0.0026 from Earth	1.5237	5.203	9.555	19.218	30.110	39.545	267,032 to nearest star
Length of Year	Period of Orbit	87.969d	224.701d	365.256d	27.32d to orbit Earth	1.8809y	11.862y	29.458y	84.022y	164.774y	248.0y	226 million y to orbit galaxy
	Length of Day	Period of Rotation	58 ^h 15 ^m 31 ^s	243 ^h 0 ^m 26 ^s R	23 ^h 56 ^m 04 ^s	27 ^h 47 ^m 43 ^s	24 ^h 37 ^m 23 ^s	9 ^h 55 ^m 30 ^s †	10 ^h 39 ^m 22 ^s †	17 ^h 14 ^m 24 ^s R†	16 ^h 6 ^m 36 ^s †	6 ^h 9 ^m 18 ^s R
Average Orbital Velocity	Kilometers per second	47.87	35.02	29.79	1.023	24.13	13.06	9.66	6.81	5.44	4.75	217.35 around center of galaxy
	Kilometers per hour	172,339	126,074	107,225	3,683	86,865	47,029	34,781	24,527	19,595	17,096	782,460 around center of galaxy
Equatorial Diameter	Kilometers	4,879.4	12,103.6	12,756.28	3,474.8	6,792	142,984**	120,536**	51,118**	49,528**	2,390	1,392,000
	Sun = 1	0.0035	0.0087	0.0092	0.0025	0.0049	0.1027**	0.0866**	0.0367**	0.0356**	0.0017	1.0
	Earth = 1	0.383	0.949	1.0	0.2724	0.532	11.209**	9.449**	4.007**	3.883**	0.187	109
Mass	Earth = 1	0.0553	0.8150	1.0	0.0123	0.1074	317.83	95.163	14.536	17.149	0.0022	332,946
Volume	Earth = 1	0.0562	0.857	1.0	0.0203	0.151	1,404.70	763.59	63.09	57.72	0.0066	1,300,000
Mean Density	Grams per cubic centimeter Water = 1	5.43	5.24	5.515	3.35	3.94	1.33	0.69	1.27	1.64	2.0	1.41
Surface Gravity	Earth = 1	0.378	0.905	1.0	0.166	0.379	2.53	1.07	0.905	1.14	0.062	27.96
Escape Velocity	Kilometers per second	4.25	10.36	11.18	2.38	5.02	59.5	35.5	21.3	23.5	1.2	617.6
	Kilometers per hour	15,300	37,303	40,249	8,553	18,080	214,300	127,700	76,700	84,600	4,300	2,223,000
Temperature Extremes	High °C	425	462	58	127	17	20,000*	12,000*	6,000*	6,000*	-210	15,000,000*
	High K	698	735	331	400	290	20,000*	12,000*	6,000*	6,000*	63	15,000,000*
	Low °C	-173	462	-88	-173	-143	438**	407**	346**	347**	-235	4,000**
	Low K	100	735	185	100	130	711**	680**	619**	620**	38	4,000**
*Core **At 1 atmosphere (altitude where barometric pressure equals Earth's barometric pressure at sea level—1,1013 mb)												
Atmosphere	Principal Gases	O ₂ , Na, H ₂ , He	CO ₂ , N ₂	N ₂ , O ₂	none	CO ₂ , N ₂ , Ar	H ₂ , He	H ₂ , He	H ₂ , He, CH ₄	H ₂ , He, CH ₄	CH ₄ , N ₂ , CO	H ₂ , He
# of Known Satellites		0	0	1	0	2	61 plus rings	31 plus rings	27 plus rings	12 plus rings	1	9 planets
Eccentricity of Orbit	Circular Orbit = 0	0.2056	0.0068	0.0167	0.0549	0.0934	0.0485	0.0555	0.0464	0.0095	0.2491	—
Inclination of Equator	To Planet's Orbital Plane	0.01°	177.36°	23.44°	6.68°	25.19°	3.13°	26.73°	97.77°	28.32°	119.6°	7.25° Sun's equator to ecliptic
Oblateness of Planet	Spherical Planet = 0	0	0	0.003354	0	0.005889	0.064874	0.097962	0.022927	0.017081	0	0

Clark Planetarium Solar System Fact Sheet 2005

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<p>Mercury </p> <p>(no natural satellites)</p>	<p>Venus </p> <p>(no natural satellites)</p>	<p>Earth </p> <p>Moon (3,475)</p>	<p>Mars </p> <p>• Phobos (22.2) • Deimos (12.4)</p>	<p>Jupiter</p> <ul style="list-style-type: none"> • 1- Metis (43) • 2- Adrastea (16.4) • 3- Amalthea (166.9) • 4- Thebe (98.6) • 5- Io (3,643.2) • 6- Europa (3,121.6) • 7- Ganymede (5,262) • 8- Callisto (4,820.6) • 9- Themisto (8) • 10- Leda (20) • 11- Himalia (170) • 12- Lysithea (36) • 13- Elara (86) • 14- S/2000 J 11 (4) • 15- S/2003 J 20 (3) • 16- S/2003 J 12 (1) • 17- Euporie (2) • 18- S/2003 J 3 (2) • 19- S/2003 J 18 (2) • 20- Orthosie (2) • 21- Euanthe (3) • 22- Harpalyke (4.4) • 23- Praxidike (6.8) • 24- Thyone (4) • 25- S/2003 J 16 (2) • 26- Io-caste (5.2) • 27- S/2003 J 21 (2) • 28- Hermippe (4) • 29- S/2003 J 22 (2) • 30- S/2003 J 6 (4) • 31- Ananke (28) • 32- S/2003 J 15 (2) • 33- Eurydome (3) • 34- S/2003 J 1 (4) • 35- S/2003 J 17 (2) • 36- Pasithee (2) • 37- S/2003 J 10 (2) • 38- Chaldene (3.8) • 39- Isonoe (3.8) • 40- Erinome (3.2) • 41- Kale (2) • 42- Aitne (3) • 43- Taygete (5) • 44- S/2003 J 9 (1) • 45- Carme (46) • 46- Sponde (2) • 47- Megacite (5.4) • 48- S/2003 J 5 (4) • 49- S/2003 J 19 (2) • 50- S/2003 J 23 (2) • 51- Kalyke (5.2) • 52- Pasiphage (60) • 53- S/2002 J 1 (3) • 54- S/2003 J 4 (2) • 55- Sinope (38) • 56- S/2003 J 8 (3) • 57- S/2003 J 13 (2) • 58- S/2003 J 7 (4) • 59- S/2003 J 14 (2) • 60- S/2003 J 11 (2) • 61- Autonoe (4) • 62- Callirrhoe (8.6) • 63- S/2003 J 2 (2) 	<p>Saturn</p> <ul style="list-style-type: none"> • 1- Pan (20) • 2- S/2005 S 1 (7) • 3- Atlas (32) • 4- Prometheus (100.2) • 5- Pandora (83.8) • 6- Epimetheus (119) • 7- Janus (177.6) • 8- Mimas (397.2) • 9- S/2004 S 1 (3) • 10- S/2004 S 2 (4) • 11- Enceladus (498.8) • 12- Calypso (19) • 13- Teleso (24) • 14- Tethys (1,059.8) • 15- Dione (1,118) • 16- Helene (32) • 17- Rhea (1,528) • 18- Titan (5,150) • 19- Hyperion (266) • 20- Iapetus (1,436) • 21- Kiviuq (14) • 22- Ijiraq (10) • 23- Phoebe (220) • 24- Paaliaq (19) • 25- Skadi (6.4) • 26- Albiorix (26) • 27- S/2004 S 11 (6) • 28- Erriapo (8.6) • 29- Siarnaq (32) • 30- Tarvos (13) • 31- S/2004 S 13 (6) • 32- S/2004 S 17 (4) • 33- Mundilfari (5.6) • 34- Narvi (6.6) • 35- S/2004 S 15 (6) • 36- S/2004 S 10 (6) • 37- Suttungr (5.6) • 38- S/2004 S 12 (5) • 39- S/2004 S 18 (7) • 40- S/2004 S 7 (6) • 41- S/2004 S 9 (5) • 42- S/2004 S 14 (6) • 43- Thrymr (5.6) • 44- S/2004 S 8 (6) • 45- S/2004 S 16 (4) • 46- Ymir (16) 	<p>Uranus</p> <ul style="list-style-type: none"> • 1- Cordelia (40.2) • 2- Ophelia (42.8) • 3- Bianca (51.4) • 4- Cressida (79.6) • 5- Desdemona (64) • 6- Juliet (93.8) • 7- Portia (135.2) • 8- Rosalind (72) • 9- S/2003 U 2 (36) • 10- Belinda (80.6) • 11- S/1986 U 10 (20) • 12- Puck (162) • 13- S/2003 U 1 (5) • 14- Miranda (471.6) • 15- Ariel (1,157.8) • 16- Umbriel (1,169.4) • 17- Titania (1,577.8) • 18- Oberon (1,522.8) • 19- S/2001 U 3 (12) • 20- Caliban (98) • 21- Stephano (20) • 22- Trinculo (10) • 23- Sycorax (190) • 24- S/2003 U 3 (11) • 25- Prospero (30) • 26- Setebos (30) • 27- S/2001 U 2 (12) 	<p>Neptune</p> <ul style="list-style-type: none"> • 1- Naiad (66) • 2- Thalassa (82) • 3- Despina (150) • 4- Galate (176) • 5- Larissa (194) • 6- Proteus (420) • 7- Triton (2,706.8) • 8- Nereid (340) • 9- S/2002 N1 (48) • 10- S/2002 N2 (48) • 11- S/2002 N3 (48) • 12- S/2003 N1 (28)
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All four Jovian planets or "gas giants" have rings, though only Saturn's can be seen from Earth.

	Mercury	Venus	Earth	Moon	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Sun	
Average Distance from Sun	Millions of Kilometers	57.91	108.21	149.60	.3844 from Earth	778.30	1,429.39	2,875.04	4,504.45	5,915.80	39.95 trillion km to nearest star	
	Light Travel Time	3 ^m 13 ^s	6 ^m 1 ^s	8 ^m 19 ^s	1.3 ^s from Earth	12 ^m 40 ^s	43 ^m 16 ^s	1 ^h 19 ^m 28 ^s	2 ^h 39 ^m 50 ^s	4 ^h 10 ^m 25 ^s	5 ^h 28 ^m 53 ^s to nearest star	
	Astronomical Units	0.3871	0.7233	1.0000	0.0026 from Earth	1.5237	5.203	9.555	19.218	30.110	39.545	267,032 to nearest star
Length of Year	Period of Orbit	87.969d	224.701d	365.256d	27.32d to orbit Earth	1.8809y	11.862y	29.458y	84.022y	164.774y	248.0y	226 million y to orbit galaxy
	Length of Day	Period of Rotation	58 ^h 15 ^m 31 ^s	243 ^h 0 ^m 26 ^s R	23 ^h 56 ^m 04 ^s	27 ^h 7 ^m 43 ^s	24 ^h 37 ^m 23 ^s	9 ^h 55 ^m 30 ^s †	10 ^h 39 ^m 22 ^s †	17 ^h 14 ^m 24 ^s R†	16 ^h 6 ^m 36 ^s †	6 ^h 9 ^m 18 ^s R
Average Orbital Velocity	Kilometers per second	47.87	35.02	29.79	1.023	24.13	13.06	9.66	6.81	5.44	4.75	217.35 around center of galaxy
	Kilometers per hour	172,339	126,074	107,225	3,683	86,865	47,029	34,781	24,527	19,595	17,096	782,460 around center of galaxy
Equatorial Diameter	Kilometers	4,879.4	12,103.6	12,756.28	3,474.8	6,792	142,984**	120,536**	51,118**	49,528**	2,390	1,392,000
	Sun = 1	0.0035	0.0087	0.0092	0.0025	0.0049	0.1027**	0.0866**	0.0367**	0.0356**	0.0017	1.0
	Earth = 1	0.383	0.949	1.0	0.2724	0.532	11.209**	9.449**	4.007**	3.883**	0.187	109
Mass	Earth = 1	0.0553	0.8150	1.0	0.0123	0.1074	317.83	95.163	14.536	17.149	0.0022	332,946
Volume	Earth = 1	0.0562	0.857	1.0	0.0203	0.151	1,404.70	763.59	63.09	57.72	0.0066	1,300,000
Mean Density	Grams per cubic centimeter Water = 1	5.43	5.24	5.515	3.35	3.94	1.33	0.69	1.27	1.64	2.0	1.41
Surface Gravity	Earth = 1	0.378	0.905	1.0	0.166	0.379	2.53	1.07	0.905	1.14	0.062	27.96
Escape Velocity	Kilometers per second	4.25	10.36	11.18	2.38	5.02	59.5	35.5	21.3	23.5	1.2	617.6
	Kilometers per hour	15,300	37,303	40,249	8,553	18,080	214,300	127,700	76,700	84,600	4,300	2,223,000
Temperature Extremes	High °C	425	462	58	127	17	20,000*	12,000*	6,000*	6,000*	-210	15,000,000*
	High K	698	735	331	400	290	20,000*	12,000*	6,000*	6,000*	63	15,000,000*
	Low °C	-173	462	-88	-173	-143	438**	407**	346**	347**	-235	4,000**
	Low K	100	735	185	100	130	711**	680**	619**	620**	38	4,000**
*Core **At 1 atmosphere (altitude where barometric pressure equals Earth's barometric pressure at sea level—1,1013 mb)												
Atmosphere	Principal Gases	O ₂ , Na, H ₂ , He	CO ₂ , N ₂	N ₂ , O ₂	none	CO ₂ , N ₂ , Ar	H ₂ , He	H ₂ , He	H ₂ , He, CH ₄	H ₂ , He, CH ₄	CH ₄ , N ₂ , CO	H ₂ , He
# of Known Satellites		0	0	1	0	2	63 plus rings	46 plus rings	27 plus rings	12 plus rings	1	9 planets
Eccentricity of Orbit	Circular Orbit = 0	0.2056	0.0068	0.0167	0.0549	0.0934	0.0485	0.0555	0.0464	0.0095	0.2491	—
Inclination of Equator	To Planet's Orbital Plane	0.01°	177.36°	23.44°	6.68°	25.19°	3.13°	26.73°	97.77°	28.32°	119.6°	7.25° Sun's equator to ecliptic
Inclination of Orbit to Ecliptic		7.0°	3.39°	0 (by definition)	5.2°	1.85°	1.31°	2.49°	0.77°	1.77°	17.15°	—

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<p>Mercury</p> <p>(no natural satellites)</p>	<p>Venus</p> <p>(no natural satellites)</p>	<p>Earth</p> <p>Moon (3,475)</p>	<p>Mars</p> <p>• Phobos (22.2)</p> <p>• Deimos (12.4)</p>	<p>Jupiter</p> <ul style="list-style-type: none"> 1- Metis (43) 2- Adrastea (16.4) 3- Amalthea (166.9) 4- Thebe (98.6) 5- Io (3,643.2) 6- Europa (3,121.6) 7- Ganymede (5,262) 8- Callisto (4,820.6) 9- Themisto (8) 10- Leda (20) 11- Himalia (170) 12- Lysithea (36) 13- Elara (86) 14- S/2000 J 11 (4) 15- S/2003 J 20 (3) 16- S/2003 J 12 (1) 17- Euporie (2) 18- S/2003 J 3 (2) 19- S/2003 J 18 (2) 20- Orthosie (2) 21- Euanthe (3) 22- Harpalyke (4.4) 23- Praxidike (6.8) 24- Thyone (4) 25- S/2003 J 16 (2) 26- Iocaste (5.2) 27- S/2003 J 21 (2) 28- Hermippe (4) 29- S/2003 J 22 (2) 30- S/2003 J 6 (4) 31- Ananke (28) 32- S/2003 J 15 (2) 33- Eurydome (3) 34- S/2003 J 1 (4) 35- S/2003 J 17 (2) 36- Pasithee (2) 37- S/2003 J 10 (2) 38- Chaldene (3.8) 39- Isonoe (3.8) 40- Erinome (3.2) 41- Kale (2) 42- Aitne (3) 43- Taygete (5) 44- S/2003 J 9 (1) 45- Carme (46) 46- Sponde (2) 47- Megacite (5.4) 48- S/2003 J 5 (4) 49- S/2003 J 19 (2) 50- S/2003 J 23 (2) 51- Kalyke (5.2) 52- Pasiphae (60) 53- S/2002 J 1 (3) 54- S/2003 J 4 (2) 55- Sinope (38) 56- S/2003 J 8 (3) 57- S/2003 J 13 (2) 58- S/2003 J 7 (4) 59- S/2003 J 14 (2) 60- S/2003 J 11 (2) 61- Autonoe (4) 62- Callirhoe (8.6) 63- S/2003 J 2 (2) 	<p>Saturn</p> <ul style="list-style-type: none"> 1- Pan (20) 2- S/2005 S 1 (7) 3- Atlas (32) 4- Prometheus (100.2) 5- Pandora (83.8) 6- Epimetheus (119) 7- Janus (177.6) 8- Mimas (397.2) 9- S/2004 S 1 (3) 10- S/2004 S 2 (4) 11- Enceladus (498.8) 12- Calypso (19) 13- Teleso (24) 14- Tethys (1,059.8) 15- Dione (1,118) 16- Helene (32) 17- Rhea (1,528) 18- Titan (5,150) 19- Hyperion (266) 20- Iapetus (1,436) 21- Kiviuq (14) 22- Ijiraq (10) 23- Phoebe (220) 24- Paaliaq (19) 25- Skadi (6.4) 26- Albiorix (26) 27- S/2004 S 11 (6) 28- Erriapo (8.6) 29- Siarnaq (32) 30- Tarvos (13) 31- S/2004 S 13 (6) 32- S/2004 S 17 (4) 33- Mundilfari (5.6) 34- Narvi (6.6) 35- S/2004 S 15 (6) 36- S/2004 S 10 (6) 37- Suttungr (5.6) 38- S/2004 S 12 (5) 39- S/2004 S 18 (7) 40- S/2004 S 7 (6) 41- S/2004 S 9 (5) 42- S/2004 S 14 (6) 43- Thrymr (5.6) 44- S/2004 S 8 (6) 45- S/2004 S 16 (4) 46- Ymir (16) 	<p>Uranus</p> <ul style="list-style-type: none"> 1- Cordelia (40.2) 2- Ophelia (42.8) 3- Bianca (51.4) 4- Cressida (79.6) 5- Desdemona (64) 6- Juliet (93.8) 7- Portia (135.2) 8- Rosalind (72) 9- Cupid (24) 10- Belinda (80.6) 11- S/1986 U 10 (80) 12- Puck (162) 13- Mab (32) 14- Miranda (471.6) 15- Ariel (1,157.8) 16- Umbriel (1,169.4) 17- Titania (1,577.8) 18- Oberon (1,522.8) 19- S/2001 U 3 (12) 20- Caliban (98) 21- Stephano (20) 22- Trinculo (10) 23- Sycorax (190) 24- Margaret (12) 25- Prospero (30) 26- Setebos (30) 27- S/2001 U 2 (12) 	<p>Neptune</p> <ul style="list-style-type: none"> 1- Naiad (66) 2- Thalassa (82) 3- Despina (150) 4- Galateia (176) 5- Larissa (194) 6- Proteus (420) 7- Triton (2,706.8) 8- Nereid (340) 9- S/2002 N 1 (48) 10- S/2002 N 2 (48) 11- S/2002 N 3 (48) 12- S/2003 N 1 (28) 	<p>Pluto</p> <ul style="list-style-type: none"> • Charon (1,207.2) • S/2005 P 1 (60?) • S/2005 P 2 (50?)
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All four Jovian planets or "gas giants" have rings, though only Saturn's can be seen from Earth.

	Mercury	Venus	Earth	Moon	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Sun	
Average Distance from Sun	Millions of Kilometers	57.91	108.21	149.60	.3844 from Earth	227.94	778.30	1,429.39	2,875.04	4,504.45	5,915.80	39.95 trillion km to nearest star
	Light Travel Time	3 ^m 13 ^s	6 ^m 1 ^s	8 ^m 19 ^s	1.3 ^s from Earth	12 ^m 40 ^s	43 ^m 16 ^s	1 ^h 19 ^m 28 ^s	2 ^h 39 ^m 50 ^s	4 ^h 10 ^m 25 ^s	5 ^h 28 ^m 53 ^s	4.22y to nearest star
	Astronomical Units	0.3871	0.7233	1.0000	0.0026 from Earth	1.5237	5.203	9.555	19.218	30.110	39.545	267.032 to nearest star
Length of Year	Period of Orbit	87.969d	224.701d	365.256d	27.32d to orbit Earth	1.8809y	11.862y	29.458y	84.022y	164.774y	248.0y	226 million y to orbit galaxy
Length of Day	Period of Rotation	58 ^m 15 ^s 31 ^m	243 ^d 0 ^m 26 ^R	23 ^h 56 ^m 04 ^s	27 ^m 7 ^s 43 ^m	24 ^h 37 ^m 23 ^s	9 ^h 55 ^m 30 [†]	10 ^h 47 ^m 06 [†]	17 ^h 14 ^m 24 ^{R†}	16 ^h 6 ^m 36 [†]	6 ^h 9 ^m 18 ^R	25-35d [†]
		y=years d=days h=hours m=minutes s=seconds R=retrograde †=Depending on latitude ?=Exact value not known										
Average Orbital Velocity	Kilometers per second	47.87	35.02	29.79	1.023	24.13	13.06	9.66	6.81	5.44	4.75	217.35 around center of galaxy
	Kilometers per hour	172,339	126,074	107,225	3,683	86,865	47,029	34,781	24,527	19,595	17,096	782,460 around center of galaxy
Equatorial Diameter	Kilometers	4,879.4	12,103.6	12,756.28	3,474.8	6,792	142,984**	120,536**	51,118**	49,528**	2,390	1,392,000
	Sun = 1	0.0035	0.0087	0.0092	0.0025	0.0049	0.1027**	0.0866**	0.0367**	0.0356**	0.0017	1.0
	Earth = 1	0.383	0.949	1.0	0.2724	0.532	11.209**	9.449**	4.007**	3.883**	0.187	109
Mass	Earth = 1	0.0553	0.8150	1.0	0.0123	0.1074	317.83	95.163	14.536	17.149	0.0022	332,946
Volume	Earth = 1	0.0562	0.857	1.0	0.0203	0.151	1,404.70	763.59	63.09	57.72	0.0066	1,300,000
Mean Density	Grams per cubic centimeter Water = 1	5.43	5.24	5.515	3.35	3.94	1.33	0.69	1.27	1.64	2.0	1.41
Surface Gravity	Earth = 1	0.378	0.905	1.0	0.166	0.379	2.53	1.07	0.905	1.14	0.062	27.96
Escape Velocity	Kilometers per second	4.25	10.36	11.18	2.38	5.02	59.5	35.5	21.3	23.5	1.2	617.6
	Kilometers per hour	15,300	37,303	40,249	8,553	18,080	214,300	127,700	76,700	84,600	4,300	2,223,000
Temperature Extremes	High °C	425	462	58	127	17	20,000*	12,000*	6,000*	6,000*	-210	15,000,000*
	High K	698	735	331	400	290	20,000*	12,000*	6,000*	6,000*	63	15,000,000*
	Low °C	-173	462	-88	-173	-143	438**	407**	346**	347**	-235	4,000**
	Low K	100	735	185	100	130	711**	680**	619**	620**	38	4,000**
	*Core **At 1 atmosphere (altitude where barometric pressure equals Earth's barometric pressure at sea level—1,1013 mb)											
Atmosphere	Principal Gases	O ₂ , Na, H ₂ , He	CO ₂ , N ₂	N ₂ , O ₂	none	CO ₂ , N ₂ , Ar	H ₂ , He	H ₂ , He	H ₂ , He, CH ₄	H ₂ , He, CH ₄	CH ₄ , N ₂ , CO	H ₂ , He
# of Known Satellites		0	0	1	0	2	63 plus rings	46 plus rings	27 plus rings	12 plus rings	3	9 planets
Eccentricity of Orbit	Circular Orbit = 0	0.2056	0.0068	0.0167	0.0549	0.0934	0.0485	0.0555	0.0464	0.0095	0.2491	—
Inclination of Equator	To Planet's Orbital Plane	0.01°	177.36°	23.44°	6.68°	25.19°	3.13°	26.73°	97.77°	28.32°	119.6°	7.25° Sun's equator to ecliptic
Inclination of Orbit to Ecliptic		7.0°	3.39°	0 (by definition)	5.2°	1.85°	1.31°	2.49°	0.77°	1.77°	17.15°	—

Is It Lunar or Lunacy?

Science
Standard

I

Objective
1&2

Connections

Standard I:

Students will understand that the appearance of the moon changes in a predictable cycle as it orbits Earth and as Earth rotates on its axis.

Objective 1:

Explain patterns of changes in the appearance of the moon as it orbits Earth.

Objective 2:

Demonstrate how the relative positions of Earth, the Moon, and the Sun create the appearance of the Moon's phases.

Intended Learning Outcomes:

1. Use Science Process and Thinking Skills.
3. Understand Science Concepts and Principles.
4. Communicate Effectively Using Science Language and Reasoning.

Content Connections:

Language Arts I – Develop effective oral language;
Language Arts VI – Use grade level vocabulary to increase understanding;
Language Arts VII – Interpret and analyze to increase comprehension
Math IV – Apply measurement tools and techniques;
Math V – Collect, analyze, and draw conclusions from data

Background Information

When Buzz Aldrin first stepped on the lunar surface and looked around at the alien landscape, he exclaimed: "Magnificent desolation!" It was a perfect description of the stark, inhospitable lunar surface which has no atmosphere or water. Standing on the Moon's surface, the astronauts saw a barren vista of rocks, boulders and fine dust. In the distance, rounded hills and mountains reaching toward an utterly black sky, whether it was day or night.

Earth has one natural satellite, the Moon, which is our closest celestial neighbor. It is an airless little world less than one-fourth the size of Earth. We only see the Moon because Sunlight reflects back to us from its surface. It has no light source of its own. The visible side of the moon's surface texture has irregularities consisting of craters, mountain like mounds, enormously deep canyons, along with an abundance of rocks and dust. With no atmosphere to carry sound, the moon is completely silent and its surface is either extremely hot or cold. The moon has many large 'maria' (Latin for seas). Marias are extensive flat plains made of dark volcanic rock and they cover one third of the visible face of the moon.

Because of these surface irregularities are just the right size, Sunlight arriving at different angles is reflected back to Earth equally well. This special fact about our moon is not true of other moons

in the solar system. By possessing the correct size and distributed surface material, a consistent visual effect is created. Amazingly, the moon appears as bright in the center as it does at the edges! Without this special property, the moon would appear very bright in the center and rather dark along its edges. The moon gives consistent light to Earth's surface throughout throughout its monthly cycle.

The Moon has become 'locked' into a special kind of motion around Earth. It rotates counterclockwise when viewed above the North Pole and always exposes only one of its sides (the nearside) to Earth. It wasn't until the 1960's when satellites were sent to orbit the moon and study its gravitational field that this mysterious behavior was finally understood. Lunar scientists discovered that the moon is lopsided. The farside of the moon is very different from the visible side. The farside of the Moon is always facing the Sun and is always illuminated; however, this side of the Moon never faces Earth. On the Moon's farside side, however, there are virtually no maria. Instead, it is composed almost entirely of ancient highlands, the cratered and mountainous terrain that reflects two to three time more reflected Sunlight than the visible side. Its crust is considerably thicker on the farside. Because the moon's crust is unevenly distributed, Earth's gravitational field holds the moon in one position relative to Earth. As a result, the time it takes the Moon to rotate once on its axis is exactly equal to the time it takes the moon to revolve once around Earth. To us on Earth, relative to the Sun, the moon's complete cycle is 29 and 1/2 days. Since time on Earth is figured relative to the Sun, we see the moon return to the same place in the sky at the same time of day every 29 and 1/2 days.

Our Moon is unusual and unique compared to other moons throughout the Solar System. It is capricious because its orbit is elliptical and eccentric, looking bigger at certain times than others, rising above and below the horizon. It also has an unusual orbit around Earth. If Earth's moon were in geosynchronous orbit, it would only appear in the sky over one of Earth's hemispheres. But the Moon has a non-equatorial, non-geo-synchronous orbit, so that it can be seen anywhere on Earth. Another major difference in our Moon is its orbital path around Earth. Almost every major moon in our solar system orbits its planet close to, or exactly, in the plane of its planet's equator. Our Moon's orbit is tilted with respect to Earth's equator by plus or minus 5°. In combination with the tilt of the Earth's axis (which is 23 and 1/2°) the moon can appear between 18 and 1/2° and 28 and 1/2° above or below the celestial equator -- the line in the sky which is an extension of Earth's equator outward into space. What this means for us here on Earth is that our Moon dominates a larger portion of the night sky than it would otherwise do.

To understand the significance of this, consider the situation where a moon orbits directly above the equator of its respective planet. That moon could not be seen from the higher latitudes and polar regions of that planet. This is because the curvature of the planet blocks the view. This means that from high latitudes or near the poles, the moon never rises or sets, or is too close to the horizon to be easily seen. In comparison, because of our Moon's unique tilted orbit, it can rise to a significant altitude above the horizon and be seen anywhere on Earth, including the polar regions.

Another amazing feature of our Moon, is it appears to change shape, but in reality it doesn't. We see different amount of light being reflected from the Sun illuminating parts of the Moon in a predictable pattern. These different shapes we observe are called 'phases of the moon'. Beginning with the New Moon, the Moon is 'waxing' as it increases its illumination to a Full Moon. After the Full Moon phase the Moon decreases in its visible illumination and 'waning'. These different amounts of moon illuminations on its surface are visible to us in different parts of its orbit. When the moon is full, it is on the opposite side of Earth from the Sun. A new moon is moving approximately between Earth and the Sun so the side toward Earth and cannot be seen. Earth's shadow plays no role in the phases of the Moon.

Research Basis

Sequeira, P.V. (Summer 2001) What About Homework?. *National Association of Elementary School Principals*, Volume 19, Number 4, p. 1.

“Homework becomes effective and meaningful when the assignments are as important as the work completed in class . . . An effective homework assignment determines whether a student can apply the skills learned in class to everyday situations . . . A successful homework assignment also depends on a built-in mechanism for review and discussion in the classroom . . . Finally, for homework to be effective, teachers should examine and correct assignments before returning them with comments or grades.”

Marzano, R.J., Pickering, D.J., & Pollock, J.E. (2001). *Class instruction that works: research-based strategies for increasing student achievement*

“It is no exaggeration to say that homework is a staple of U.S. education. Homework extends learning opportunities beyond the confines of the school day. It can provide students with opportunities to deepen their understanding and skills relative to content that has been initially presented to them . . . The purpose, expectations, and instructions of the homework assignment should be clearly identified and clearly articulated to students . . . Not all homework should

be the same. It should be designed with a specific purpose which correlates to the curriculum being studied in class . . . Homework can be designed for practice, preparing students for new content, or elaborating and extending content that has been introduced.”

Shepardson, D.P., & Britsch, S. J. (February 1997). Children’s science journals: Tools for teaching, learning, and assessing. *Science and children*, p. 13.

“To expand our understanding of children’s science learning, we need to expand our science teaching methods. One way of expanding our methods is to incorporate science journals into our lessons. These journals provide an opportunity to access and take note of changes in children’s understands and thinking, identify misconceptions, and provide a more complete picture of children’s understanding of science phenomena (Dana, Lorsback, Hook, and Briscoe, 1991). To do this, we need to examine what children create with their drawings and writing as they construct and represent their understandings in science journals (Doris, 191).”

Worsley, D., & Mayer, R., (1989). The art of science writing. *Teachers and writers collaborative*.

“To permit writing is to permit thinking. Writing can be used as a method of solving problems. It is a mirror of the mind to writers and a window of the mind for readers, allowing both to see how well learning is taking place . . . It is a way for students to ask questions that they might otherwise be unable to ask. It captures elusive but valuable ideas. Writing not only develops existing knowledge, it also creates new knowledge on the part of the writer . . . It is the currency by which people acquire ownership of ideas; ideas owned are ideas remembered, and ideas remembered are ideas learned . . . It transforms boredom into curiosity.”

Invitation to Learn

1. Give each student a blackline outline of the moon. Have them sketch a view of a full moon from memory. Use a black colored pencil for sketching and shading.
2. Have students read the short excerpt from Galileo. Have a class discussion about the reading excerpt, asking open-ending questions about Galileo’s approach to learning about the world around him.
3. Have students look through a simple model of a refracting telescope or binoculars at a poster-sized, actual photo of a full moon on the other side of the room. With the aid of the telescope or binoculars, add additional details to your sketch using a brown colored pencil.

- Using the Moon Map references, identify any major features on your sketch and the moon map and label.

KWL (Pre-Assessment)

- Have students individually write what they know about the Moon, also include at least three questions they have about the Moon.
- Have each group share their information to compile a group list of information and the top three questions they want answered.
- Each group shares with the class their list of facts about the Moon and their top three questions.
- Teacher will record a Master Class List of Moon Facts to be kept posted in the room and the top five questions to investigate.
- Have students complete a pre-assessment using the *Moon Phase Chart*.

Materials

- One 4" foam ball to represent Earth
- One foam ball to represent moon (1/4 size of the Earth)
- Twelve wooden Skewers pointed on each end
- Black paint
- Red paint or red permanent marker
- Heavy foam board measuring 26" X 26" between 3/4" to an inch" in thickness
- Hula hoop
- Protractor
- Straw
- String
- Two small washers
- Galileo*
- Moon Phase Chart*
- The Rising and Setting of the Sun Table*
- The Rising and Setting of the Moon Table*
- Instructions for Making Moon Model*

Instructional Procedures

Activity #1 - What's Your Angle?

Making simple tools, such as a sextant, will help students make their data and evidence gathering more accurate.

Making a Sextant

- Tape a drinking straw along the straight edge of the protractor.
- Pull and tie a string through the hole on the straight edge.
- Attach a washer to the end of the string giving it weight enough to dangle towards the 90° marking and to swing freely as the angle changes.

Activity #2 - Up Close and Personal

Beginning at a New Moon Cycle, have students make nightly observations in the changing of the Moon's appearance over a three-week period of time.

- Strongly encourage students to observe the Moon at approximately the same time of night and the same location.
- Using their sextant, record the Moon's angle to the horizon. Record where it is rising, from the west or east, and whether it is higher or lower from the horizon.
- Sketch changes in the Moon's appearance each night.



4. Indicate how much of the Moon is being illuminated (a sliver, a quarter, half, full, not seen) and from which side the reflected Sunlight is being reflected from left or right?
5. Record the date, time, and sky conditions.
6. Extensions:
 - Record other objects in the night sky that are visible and how their positions seem to change over the three weeks in relationship to the Moon’s position. (Venus and common constellations are good ones to observe.)
 - Use digital photography instead of sketches.
 - Full Moon Fest - Invite students and their families back to school at night just shortly before the rising of a Full Moon. Encourage students to bring telescopes or binoculars with them. Have students share their knowledge and experiences of observing the moon up to this Full Moon phase. It’s also fun to have hot chocolate and donuts (hopefully donated by the parents) to end the evening.

Activity #3 - Wanted: A Lunar Model

1. Discuss the advantages and limitations of using models.
2. Show students the model that will be used to illustrate the phases of the Moon. Discuss its particular advantages and limitations.
3. Discuss the model and what is being represented. (e.g., The hula hoop is the orbital path of the Moon around Earth, Earth is set on its axis and is always facing the light source, the eight wooden skewers represent the major phases of the Moon, the arrows represent the direction of reflected Sunlight, and the numbers represent where to begin, at #1 and go counterclockwise.)
4. Have students work with the model in small groups of four to six students. Ask probing questions to check their understanding of moon phases and misconceptions. After a student gives a possible answer to a question, have the other students respond to it. Do you agree? Why? Do you disagree? Why? Are you not sure? How can we find out? Questions might include:
 - How does the relative position of the Sun, Earth, and Moon affect the amount of illuminate light on the Moon?

- How does the tilt of Earth and the Moon's unique orbital path effect the different phases?
 - Which side of the Moon is being illuminated during its 'waxing' phase? Its 'waning phase'?
 - Most moons have their orbital path along the equatorial line of its planet, generally our Moon does not. However, if our Moon did orbit about Earth's equator, how would this affect the phases?
5. (*Both models representing the Moon and Earth should be facing the light source.) Set the model of the Moon on position #1. Have two students at a time come up to the model and stand directly behind position #5 and look straight across the model to where the Moon has been placed. Have student describe what they are seeing, the relative position of Earth, Moon, and Sun, and identify the phase. If there is a disagreement between the students, this opens up a discussion for the rest of the students.
(*With this particular model a light source or a darkened room is not necessary, but adding a bright light source makes the phases even more evident.)
 6. Reset the Moon to position #2 and have the pair of students then rotate to position #6. Repeat process until they have completed a full rotation of the moon phases. Then have another pair of students go through the same process.
 7. Have students return to their seats and record in their Science Journals their observations. They also need to write a summary why the Moon goes through phases, how the tilt of Earth's axis and the Moon's unique orbit affects the amount of light illuminated, and relative position of the Sun, Earth, and Moon and how it affects the Moon phases. Also have students use a detailed labeled diagram in their summaries.

Activity #4 – Moon Predictions

Using data chart of the Sun and Moon rising and setting, have students predict the next new moon cycle. Use The Rising and Setting of the Sun Table and The Rising and Setting of the Moon Table.

1. Give each student a copy of both charts. Review a New Moon that cannot be seen from Earth because it rises and sets with the Sun.
2. Ask students how they would determine the next New Moon by analyzing the times of the rising and setting of *both* the Sun and

the Moon. Students should conclude that a New Moon times of rising and setting be very close to the Sun’s rising and setting.

- * The blanks on the charts indicate that the Moon is below the horizon and times cannot be calculated.

Additional Resources

Books

Earth, Moon, and Sun—Earth Science Delta Science Module, Teacher's Guide. ISBN# 0-87504-166-3

Earth, Moon, and Stars -- LHS GEMS, Teacher's Guide ISBN# 0-912511-18-4

The Moon Book, by Gail Gibbons

Galileo, by Leonard Everett Fisher ISBN# 0-02-735235-8

The Universe at Your Fingertips—An Astronomy Activity and Resource Notebook

Project ASTRO

Astronomical Society of the Pacific

(415) 337 - 1100

ISBN# 1-886733-00-7

Videos

How and Why—The Moon and the Universe, Volume 4. 1-888-661d-8104

www.mediakids.com

Websites

<http://www.usno.navy.mil>

<http://www.aa.usno.navy.mil>

(Takes you directly to the data tables regarding the rising/setting of the Sun and the Moon in your particular area of Utah.)

<http://www.googol.com/moon>

(Phases of the moon)

<http://tycho.usno.navy.mil/vphase.html>

(Pick a day and see the phase of the moon)

http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery-moon.html

(Photos of the moon)

Galileo

Aristotle, an ancient Greek philosopher, believed that the Earth was the center of the universe, standing still as the Sun and stars traveled around it.

In 1543, over 1,500 years later, Nicholas Copernicus a Polish astronomer claimed that the Sun was at the center of the universe and that all celestial bodies, including Earth and its moon, revolved around it. During this time period a movement called the Reformation was sweeping across Europe. Galileo Galileo, a brilliant Italian mathematician, physicist, and astronomer set out to prove Copernicus was right.

Galileo was different than most people who were interested in explaining different phenomena. He not only made careful observations about what he saw but then designed experiments to prove or disprove his theories. It was Aristotle who had claimed that heavy objects fell to Earth faster than lighter ones. Galileo decided to prove that Aristotle was wrong. He dropped two balls of different weights at the same time from the same height at the top of a building. A crowd of students and professors watched the balls land together. Those who were loyal followers of Aristotle refused to believe what they saw. Galileo quickly made enemies by challenging a nearly 2,000 year old theory of Aristotle. Called, the father of modern science, Galileo was more interested in to bring to light truth about science, even though he was met with much resistance from university students he taught and colleagues he worked with. The most powerful resister to his discoveries, especially those related to astronomy, was the Catholic Church. High positioned churchmen, professors, and local princes thought that Church doctrine was more important than the truth about nature.

Galileo learned that a Dutch eyeglass maker, Hans Lippershey, had invented a 'spyglass'. With a tube and lenses, distant objects appear a little bigger and closer. Galileo was the first to make real efficient telescope and built a larger 'spyglass that enabled him to see an object thirty-three times larger than its actual size. A lifelong gazer of the night sky, he turned his 'spyglass' skyward -- something no one else had thought of doing.

As he observed the moon, Galileo was amazed when he saw mountains, valleys, and craters on its surface. This horrified the experts, among them Aristotelians who were certain it was a smooth, polished sphere. For the first time, he saw billions of stars that made up the Milky Way. It had been long thought that the Milky Way was an endless expanse in the sky made of a cloud of unknown material.

One night Galileo was observing Jupiter and saw near the planet four bright objects that no one had ever seen before. The next evening, he observed that they had changed positions. He realized they were Jupiter's own moons, traveling around the planet. Another important observation was watching the Sunlight on Venus move across the planet just as the light does on our moon. Its phases or changes from a full circle of light to a sliver of light were predictable.

Copernicus was correct. The Sun was at the center and the planets traveled around it. Earth was just another planet that, with its satellite, the Moon, traveled around the Sun.

Moon Phase Chart



	Phase of the Moon										
--	-------------------	--	-------------------	--	-------------------	--	-------------------	--	-------------------	--	-------------------

Instructions:



- Starting with a New Moon, show the waxing and waning of the Moon as it goes through its phases.
- The arrows indicate the direction of reflection Sunlight. Use this to correctly show which side of the Moon is being illuminated during each phase.
- Use a yellow colored pencil or crayon to show the illuminated portion of the Moon and a black colored pencil or crayon to show the portion not being directly effected by the Sun's reflected light.

Draw and label the relative positions of the Sun, the Earth, and the Moon during a *New Moon* phase.

Draw and label the relative positions of the Sun, the Earth, and the Moon during a *Full Moon* phase.

On the back of this sheet write a detailed summary explaining why the Moon's appearance seems to change. Include in your explanation the effects that the tilt of axis of Earth, the Moon's unique orbital path around the Earth, the direction that the Moon travels around the Earth, and the Sun's relative position to the Earth and Moon. Also include in your summary why we only see one side of the Moon and how long it takes to make one rotation on one revolution around Earth. Use of a labeled diagram along with your summary would be great, but is optional.

Sun or Moon Rise and Set Table

Astronomical Applications Dept.
U. S. Naval Observatory
Washington, DC 20392-5420

LOGAN, UTAH
Rise and Set for the Sun for 2006

o , o ,
Location: W111 50, N41 44

Mountain Standard Time

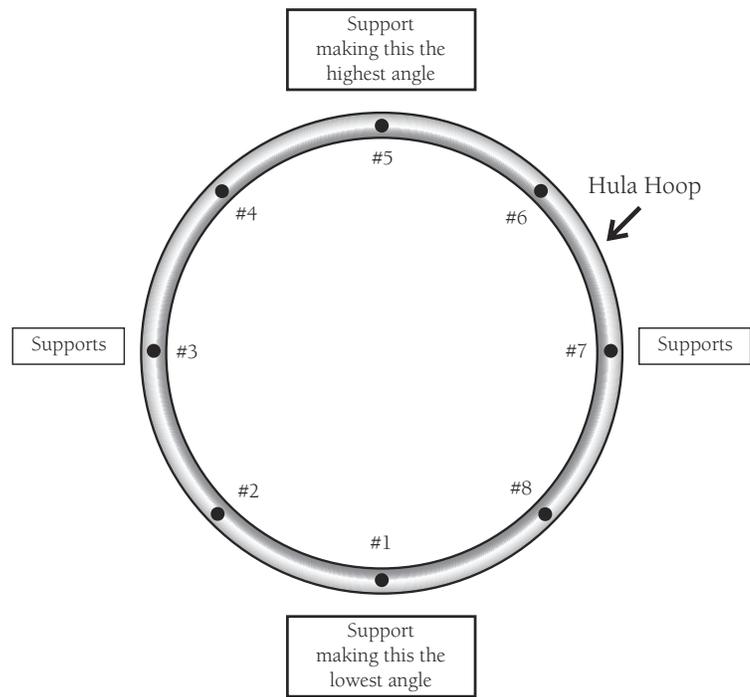
Day	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set														
	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
01	0755	1708	0740	1743	0702	1818	0610	1853	0524	1926	0455	1956	0456	2006	0521	1945	0553	1901	0624	1809	0700	1722	0735	1658
02	0755	1708	0738	1744	0701	1819	0609	1854	0523	1927	0455	1956	0457	2006	0522	1944	0554	1859	0625	1807	0701	1720	0736	1657
03	0755	1709	0737	1745	0659	1820	0607	1855	0521	1928	0454	1957	0458	2005	0523	1943	0555	1857	0626	1806	0702	1719	0737	1657
04	0755	1710	0736	1747	0657	1821	0605	1856	0520	1929	0454	1958	0458	2005	0524	1940	0556	1856	0627	1804	0703	1718	0738	1657
05	0755	1711	0735	1748	0656	1822	0603	1857	0519	1930	0454	1958	0459	2005	0525	1940	0557	1854	0629	1802	0704	1717	0739	1657
06	0755	1712	0734	1749	0654	1824	0602	1858	0517	1931	0453	1959	0459	2005	0526	1939	0558	1852	0630	1801	0706	1716	0740	1657
07	0755	1713	0733	1751	0652	1825	0600	1859	0516	1932	0453	2000	0500	2004	0528	1938	0559	1850	0631	1759	0707	1715	0741	1657
08	0754	1714	0732	1752	0651	1826	0559	1900	0515	1933	0453	2000	0501	2004	0529	1937	0600	1849	0632	1757	0708	1714	0742	1657
09	0754	1715	0731	1753	0649	1827	0557	1902	0514	1934	0453	2001	0502	2003	0530	1935	0601	1847	0633	1756	0709	1713	0743	1657
10	0754	1716	0729	1754	0648	1828	0555	1903	0513	1935	0452	2001	0502	2003	0531	1934	0602	1845	0634	1754	0711	1711	0744	1657
11	0754	1717	0728	1756	0646	1829	0554	1904	0512	1936	0452	2002	0503	2003	0532	1933	0603	1844	0635	1752	0712	1711	0744	1657
12	0753	1718	0727	1757	0644	1831	0552	1905	0511	1937	0452	2002	0504	2002	0533	1931	0604	1842	0636	1751	0713	1710	0745	1657
13	0753	1720	0725	1758	0643	1832	0550	1906	0510	1938	0452	2003	0504	2002	0534	1930	0605	1840	0637	1749	0714	1709	0746	1657
14	0753	1721	0724	1759	0641	1833	0549	1907	0509	1939	0452	2003	0505	2001	0535	1929	0606	1838	0638	1748	0715	1708	0747	1657
15	0752	1722	0723	1801	0639	1834	0547	1908	0508	1940	0452	2004	0506	2000	0536	1927	0608	1837	0640	1746	0717	1707	0748	1658
16	0752	1723	0721	1802	0637	1835	0546	1909	0507	1941	0452	2004	0507	2000	0537	1926	0609	1835	0641	1744	0718	1706	0748	1658
17	0751	1724	0720	1803	0636	1836	0544	1910	0506	1942	0452	2004	0508	1959	0538	1924	0610	1833	0642	1743	0719	1705	0749	1658
18	0751	1725	0719	1804	0634	1837	0543	1911	0505	1943	0452	2005	0508	1958	0539	1923	0611	1831	0643	1741	0720	1704	0750	1659
19	0750	1727	0717	1806	0632	1838	0541	1912	0504	1944	0452	2005	0509	1958	0540	1921	0612	1830	0644	1740	0721	1704	0750	1659
20	0749	1728	0716	1807	0631	1840	0540	1914	0503	1945	0453	2005	0510	1957	0541	1920	0613	1828	0645	1738	0723	1703	0751	1659
21	0749	1729	0714	1808	0629	1841	0538	1915	0502	1946	0453	2005	0511	1956	0542	1918	0614	1826	0646	1737	0724	1702	0751	1700
22	0748	1730	0713	1809	0627	1842	0537	1916	0501	1947	0453	2006	0512	1955	0543	1917	0615	1824	0648	1735	0725	1702	0752	1700
23	0747	1731	0711	1811	0626	1843	0535	1917	0501	1948	0453	2006	0513	1954	0544	1915	0616	1823	0649	1734	0726	1701	0752	1701
24	0747	1733	0710	1812	0624	1844	0534	1918	0500	1949	0454	2006	0514	1953	0545	1914	0617	1821	0650	1732	0727	1700	0753	1701
25	0746	1734	0708	1813	0622	1845	0532	1919	0459	1950	0454	2006	0515	1952	0546	1912	0618	1819	0651	1731	0728	1700	0753	1702
26	0745	1735	0707	1814	0620	1846	0531	1920	0458	1951	0454	2006	0516	1952	0547	1910	0619	1818	0652	1730	0730	1659	0753	1703
27	0744	1737	0705	1815	0619	1847	0529	1921	0458	1952	0455	2006	0517	1951	0548	1909	0620	1816	0654	1728	0731	1659	0754	1703
28	0743	1738	0704	1817	0617	1848	0528	1922	0457	1952	0455	2006	0518	1950	0549	1907	0621	1814	0655	1727	0732	1659	0754	1704
29	0742	1739			0615	1850	0527	1923	0457	1953	0456	2006	0519	1948	0550	1906	0622	1812	0656	1726	0733	1658	0754	1705
30	0741	1740			0614	1851	0525	1925	0456	1954	0456	2006	0519	1947	0551	1904	0623	1811	0657	1724	0734	1658	0754	1706
31	0741	1742			0612	1852			0456	1955			0520	1946	0552	1902		0658	1723					

Add one hour for daylight time, if and when in use.

Obtain local information at: http://aa.usno.navy.mil/data/docs/RS_OneYear.html

Instructions for Making Moon Model

1. Place hula hoop on any temporary support, such as books or wooden blocks, at an approximate angle desired to illustrate the Moon's unusual orbit path. (Refer to Background Information.) At the lowest angle #1 should be placed. (This will indicate the beginning of a New Moon Phase.)



2. Using a four inch Styrofoam® ball, designate the North and South Poles with push pins. Using these two reference points, divide the ball in equal halves. Paint one side black, leaving the other side white. Let paint completely dry and remove the push pins.

3. Using the diameter of the ball, find the 'equator' and make an indentation completely around the ball. (Suggestion: Using a piece of yarn or heavy string will help keep the equator straight and can also help with making the initial indentation. To widen and deepen the indentation a pointed object is recommended.)

4. After making an indentation around the ball, paint the 'equator' with white paint on the black side of the ball and use black paint to continue the 'equator' on the white side of the ball.

5. Using a wooden skewer, color it red with either a permanent marker or paint with red. Approximately locate the Earth's 23° tilt and push the painted red wooden skewer through the ball to show Earth's tilt.

6. Place a wooden skewer with the pointed end inserted into the South Pole and punch the flat end of the skewer into the foam base in the center of the hula hoop.

7. Using a two inch Styrofoam® ball, divide the ball in equal halves, Paint one side black, leaving the other side white. Let paint completely dry and place a wooden skewer through the bottom, with the pointed end down.

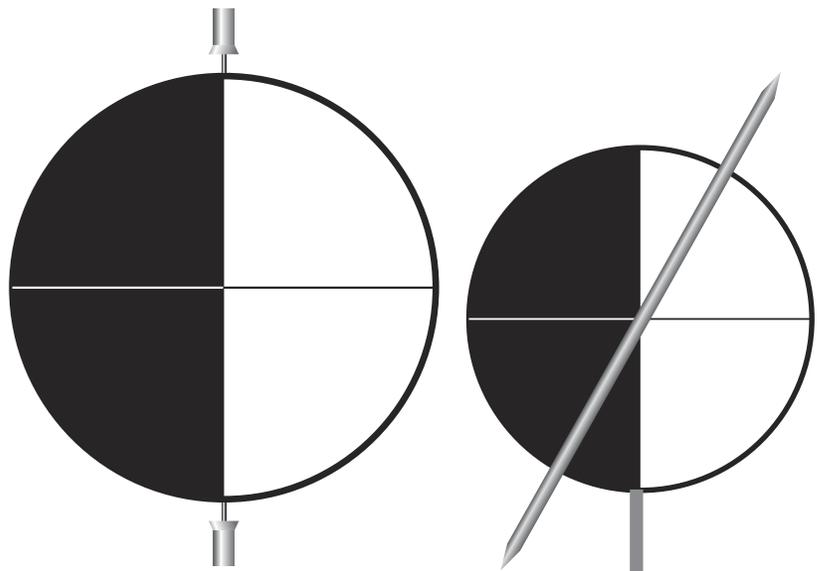
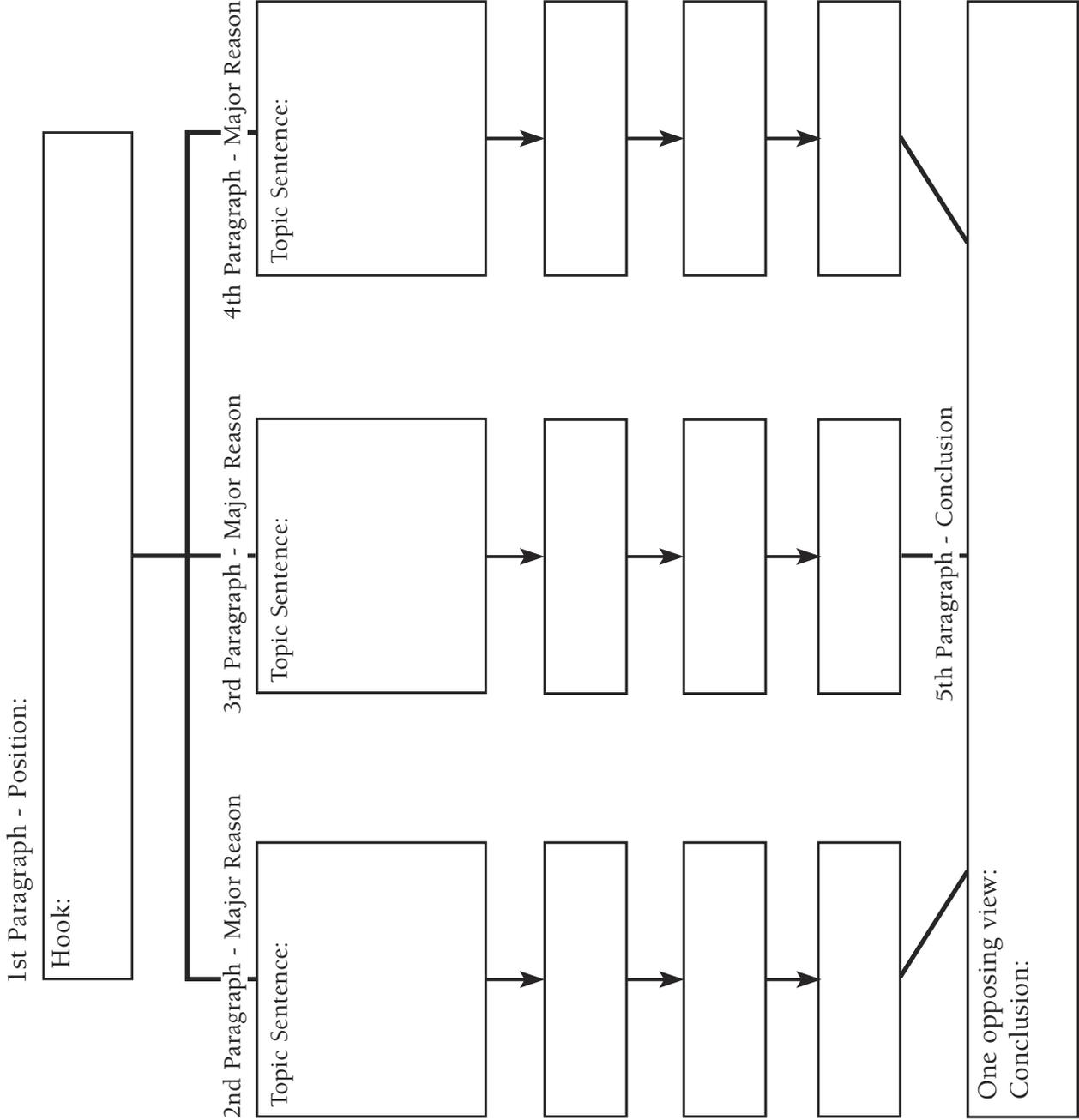


Diagram for Writing



Never begin a sentence with:

- And
- Because
- So
- But
- Then

Suggested Transition words:

- First case in point
- For instance
- For example
- For this reason
- In addition
- Another example
- Next
- Therefore
- In most cases
- Finally
- In conclusion
- In summary

When using an opposing view:

- On the other hand
- However
- Even though

Supporting Details:

- Dialogue
- Rhetorical question
- Analogy
- Personal experience
- Examples
- Statistics

Created by: Lizz Thomas 2003

Science II

Activities

Earth's Tilt on Its Axis

The Shadow Knows

Standard II:

Students will understand how Earth's tilt on its axis changes the length of daylight and creates the seasons.

Objective 3:

Explain how the relationship between the tilt of Earth's axis and its yearly orbit around the Sun produces the seasons.

Intended Learning Outcomes:

1. Use Science Process and Thinking Skills.
4. Communicate Effectively Using Science Language and Reasoning.
6. Understand the Nature of Science.

Science Standard II Objective 3

Connections

Background Information

In this activity students will discover the relationship between the angle which light strikes an object and the length of the shadow. When light strikes an object at a perpendicular angle to the surface where the shadow is cast, the shadow is almost nonexistent because the shadow is within the area covered by the object. As the angle of the light is changed the shadow falls in the opposite direction of the light source. The shadow length will increase with the decrease of the angle between the object and the surface where the shadow is observed. Before doing this activity it may be helpful to review terms: perpendicular, acute angle, right angle, obtuse angle, angle of incidence, angle of reflection. Students should also review the use of a protractor.

Research Basis

Bass, Kristin.M., Glaser, Robert.(2004) Developing Assessments to inform teaching and learning. *CSE Report 628*

A key aspect of teaching has always been monitoring students' progress. Teachers traditionally do this by giving curriculum-based classroom tests and judging the number of correct responses. Unfortunately, this usual approach to assessment often does not provide the information that teachers could use in order to improve student proficiency.

Deboer,G.(1991). *A history of ideas in science education*. New York: Teachers College Press.

A key component of fostering learning is getting students to identify their ideas and then clarifying and challenging the validity of those ideas. This process enables students to redesign their thinking and create a stronger, more accurate structure of knowledge. New

ideas and old ideas modify one another in a process of accommodation and assimilation.

Invitation to Learn

Discuss Groundhog Day... Ask students to share comments about whether it is Scientific or Not.

Instructional Procedures

The Shadow Knows

1. Cut a piece of the straw that is about six cm in length.
2. Use a small ball of clay and stick it to the table. Use the protractor to place the straw perpendicular to the surface.
3. Cut a slit in the remaining piece of the straw so it will fit over the protractor and be used as a guide to the angle of incidence.
4. Determine three acute angles that are relatively equal that will be used to gather shadow data (e.g., 90, 65, 45, 25).
5. Label the T-chart on the worksheet with the angles chosen.
6. Set the protractor and straw at 90 and use the flashlight to shine light. Measure and record the length of the shadow.
7. Repeat steps for the remaining angles.
8. After completing the experiment, students will write a statement that describes the relationship between the angle of incidence and the shadow's length.

Materials

Materials

- Quick Question form
- The Shadow Knows
- Straws
- Scissors
- Clay
- Protractors
- Flashlights
- Rulers.



Assessment Suggestions

- *Where's the Light* worksheet
- Quick Question: Puxitony Phil comes out of his hole and sees a very long shadow, what information could Phil determine shadow.

Curriculum Extensions/Adaptations/Integration

- Students can use a variety of straw lengths to explore ratio of straw length to shadow length.
- Sketch an object from multiple angles and predict shadow features.

Family Connections

- Find a relatively permanent object in the yard. Take several shadow measurements at different times over several days. Organize a table that provides time measurements based upon shadow observations.

Additional Resources

Books

The Real Reasons for the Seasons, by Alan Gould, Carolyn Willard, Stephen Pompea;
ISBN0-924886-45-5

Web sites

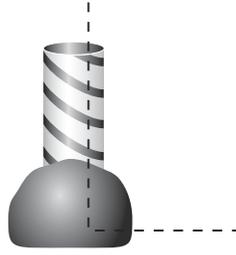
gems@uclink4.berkeley.edu

lhs.berkeley.edu/GEMS

The Shadow Knows

Procedures

1. Cut a six centimeter piece off of your straw. Use a small ball of clay to hold it perpendicular to your table.



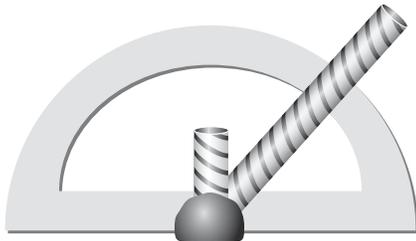
2. Split the remaining piece of the straw so it will fit over the protractor and work as a guide for the light beam.



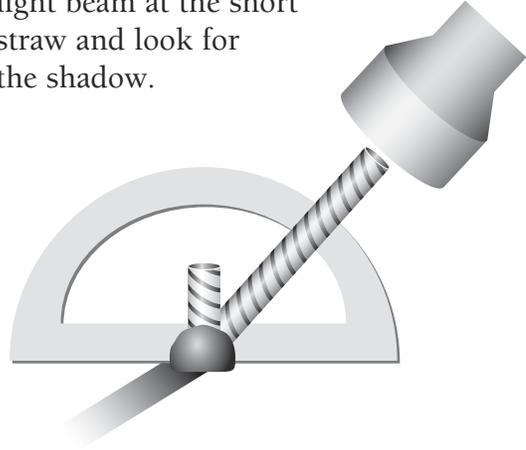
3. Choose three acute angles that divide the right angle relatively equally and write them on the chart.

Angle of Incidence	Shadow Length in centimeters
90°	

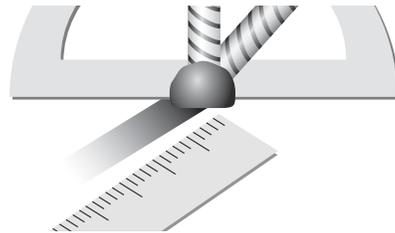
4. Line the straw on the protractor up on the angle from your chart. Center the protractor on the straw stuck to your table.



5. Using the long straw as a guide, aim the light beam at the short straw and look for the shadow.



6. Measure and record the length of the shadow on the chart.



7. Change the protractor and straw to the next angle and repeat the process.

8. Using the data from the chart, write a statement that describes the relationship between the angle of incidence and the shadow.

Hit Me With Your Best Shot

Standard II:
Students will understand how Earth’s tilt on its axis changes the length of daylight and creates the seasons.
Objective 3:
Explain how the relationship between the tilt of Earth’s axis and its yearly orbit around the Sun produces the seasons.
Intended Learning Outcomes:
1. Use Science Process and Thinking Skills. 6. Understand the Nature of Science.

Science
Standard
II
Objective
3

Connections

Background Information

An object in motion tends to stay in motion unless acted upon by another force or object. If an object encounters another object as it travels along a straight path, it will transfer some of its energy to the other object. The amount of energy transferred to the object is related to the angle of the impact. If the moving object grazes the object then only a small amount of energy is transferred and the moving objects path of travel is only affected slightly. If on the other hand the impact is direct and the moving object must completely change its path of travel, a more significant energy transfer takes place.

Research Basis

Bass, Kristin.M., Glaser, Robert.(2004) Developing Assessments to inform teaching and learning. *CSE Report 628*

Informative assessments for students incorporate methods for visualizing progress over time. Like teachers, students also need concise, comprehensible records of past and present accomplishments in order of set future learning goals. Some assessment programs address this need through student-friendly graphical displays.

Hodson, Derek (fall96). Rethinking the role and status of observation in science education. *European Education*, Volume 28.3

Teachers are too often unaware that children have their own intuitive views about scientific theory often flies in the face of common sense(children’s views) and if we do not recognize and cater to this conflict, a number of courses are likely: children may resist the teacher’s explanations, misinterpret them, become totally confused and lose the security even of their naive commonsense views, accept them blindly and unthinkingly, or become “conceptually schizophrenic”—

producing the “official” scientific viewpoint of formal occasions, while privately believing their personal views to be more sensible.

Invitation to Learn

Bumper Cars

Instructional Procedures

Materials

- Quick Question form
- Ramps
- Marbles
- Blocks
- Rulers
- Protractors
- Blank white paper
- Color pencils.



Hit Me With Your Best Shot

1. Fold a piece of blank paper in half so there are two short, thick, columns. Trace the crease.
2. Draw a line six cm from the left side that is perpendicular to the crease line.
3. This T-chart represents the right angle used to start The Shadow Knows activity. Use the protractor and a ruler to mark the angles used in The Shadow Knows activity on the new page. Make sure the lines are extended to the end of the paper.
4. Mark each of the angle lines at 12 cm from the vertices to assure the same distance between the ramp and the block.
5. Center the target block on the angle’s vertices and place the ramp on the 90° line at the 12 cm mark.
6. Roll the marble down the ramp and strike the target block.
7. Carefully hold the block down and use a colored pencil to mark a line that represents the block’s new position.
8. Replace the block to the original line and move the ramp to the next angle, placing it on the 12 cm line.
9. Roll the marble and strike the block. Use a different color pencil to represent the movement of the block when struck from the new angle.
10. Repeat the steps from the last two angles using a different color pencil each time.
11. When the activity is complete, students will write a statement that describes the relationship between the angle and the movement of the block.

Assessment Suggestions

- Bumping Better

Curriculum Extensions/Adaptations/ Integration

- Use cheap eye shadow on the marble to show the change in the objects path of travel.
- Using the information from the chart, is there a math formula that predicts the block movement based on the angle of impact?

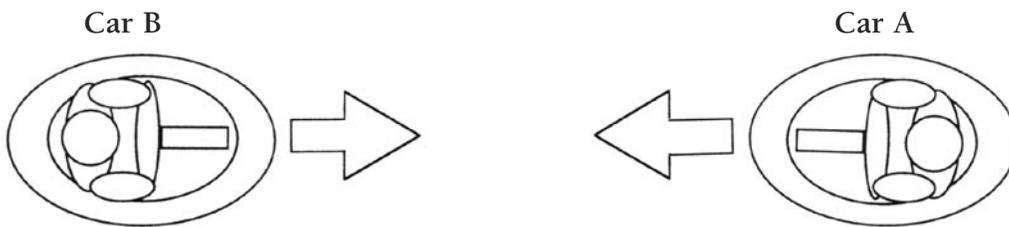
Name _____

Bumper Cars

These two bumper cars are about to collide!

Which one would you rather be driving? _____

Why would you rather be in this bumper car?



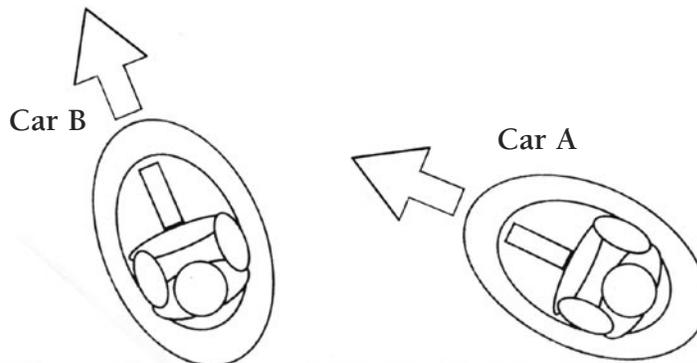
Name _____

Bumper Cars

These two bumper cars are about to collide!

Which one would you rather be driving? _____

Why would you rather be in this bumper car?



Name _____

Better Bumping

Imagine your best friend has never seen bumper cars before and is about to ride them for the first time. Write a sentence and diagram your top 4 strategies for better bumping.

Strategy 1

Strategy 2

Strategy 3

Strategy 4

Around the Sun We Go

Science
Standard

I

Objective

3

Connections

Standard I: Students will understand how Earth's tilt on its axis changes the length of daylight and creates the seasons.
Objective 3: Explain how the relationship between the tilt of Earth's axis and its yearly orbit around the Sun produces the seasons.
Intended Learning Outcomes: 1. Use Science Process and Thinking Skills. 2. Manifest Scientific Attitudes and Interests. 4. Communicate Effectively Using Science Language and Reasoning.

Background Information

Areas of Earth experience seasonal changes because they absorb different amounts of energy based on the angle which Sunlight strikes the surface and the amount of daylight hours. Earth sits at an angle of 23.45. This angle always points to the northern point regardless of the position in the orbit. As the model of Earth revolves around the light students should be directed to compare hours of light and the size of the shadow. Make sure students have observed shadow size when Earth is in its northern quadrant of its orbit. Due to Utah's position in the northern hemisphere, it receives a relatively short number of daylight hours and the light hits at a steep angle which results in less energy transferred to Earth. As Earth moves counterclockwise through the west, the daylight hours increase as the light rays become more direct.

Research Basis

Crockett, Cynthia. What do kids know and miSunderstand about science. *Educational Leadership*, Vol.61.5, pp. 34-37

Active classroom conversations enable students and teachers to examine ideas. Explore them aloud and reason, and re-reason through them. Such conversations can help teachers recognize and challenge students' misconceptions about science. Teachers should not only have conversations with students but also encourage students to have conversations and respectful debates with one another. When we make time for discussion. We get a more thorough understanding of each student's interpretation of the concepts or facts. These discussions enable us to pinpoint students' misconceptions and false ideas early on before the state test and to help students begin to reformulate their ideas into something more accurate and useful.

Hodson, Derek (fall96). Rethinking the role and status of observation in science education. *European Education*, Volume 28.3

The acquisition of new conceptual knowledge depends on the learner's existing conceptual framework and on the structure and organization of the new knowledge. New knowledge has to be firmly anchored to existing knowledge. As a consequence, we need to take much more account than previously of children's own view of the world.

Invitation to Learn

Use the *Where is the Sun and Earth Survey* and have students participate in a classroom discussion.

Instructional Procedures

Before class begins set up the room with signs marking north, south, east, and west. Set up a directional light in the middle of the room. Attach a staple or some object perpendicular to the surface of the globe to cast a shadow from the light. It also helps if you can darken the room as much as possible.

1. With the Earth's axis pointing north and the globe in the northern part of the revolution, have the students observe the amount of the rotation period that has light shining on the staple and the time that it is dark.
2. Next, have the students observe the length of the shadow. Text printed on the globe makes good reference points for comparison. Guide them back to *The Shadow Knows* activity and ask them what the length tells them. Once they arrive at the length relates to the angle, ask them to recall *Hit Me With Your Best Shot*. At this point it is imperative that the students make the connection between the shadows indication of the angle of incidence and the amount of energy that is transferred to the surface.
3. Move the globe counter clockwise to the west, south, and east. Each time you stop, ask the following questions: When in Earth's rotation does the Sun touch the land we have marked with the staple? What is happening to the amount of daylight hours? What is happening to the hours of darkness?

What do you notice about the shadows length? What does that tell you about the amount of energy transferred to the surface? What season do you think the northern hemisphere is experiencing? Once you have made a complete revolution introduce the southern



Materials

- Globe
- Signs to designate north, south, east, west
- Directional lamp
- Rulers
- Blank paper
- Protractors
- Round objects for circles
- Color pencils
- Temperature Zones*

hemisphere and guide them to discover that the season is an opposite in the southern hemisphere.

After this activity, set up a globe and a light. Use heat sensing tape, thermometers, or an infrared gun to measure the globe in the tropic, temperate, and polar zones. Record the data in one-minute increments and have the students create a line graph on the worksheet.

Assessment Suggestions

- Students will create a diagram showing Earth in the four quadrants of its revolution and write a paragraph that describes the relationship between daylight and dark hours, angle of the sun light, amount of energy being transferred and identify the season.
- Have groups duplicate the activity with different angles and predict the seasonal changes to Earth.

Curriculum Extensions/Adaptations/Integration

- Project Star Hemispheres

Additional Resources

Books

The Real Reasons for the Seasons, by Alan Gould, Carolyn Willard, Stephen Pompea;
ISBN0-924886-45-5

Earth, Sun, Moon, Glen Phelan; ISBN 0-7922-4573-3

Videos

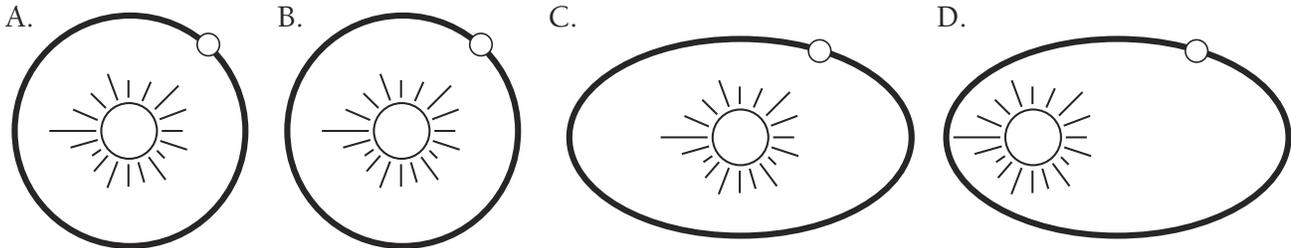
Earth's Seasons, *Bill Nye the Science Guy*, Disney Educational Productions, www.edustation.com

Web sites

<http://www.learningtechnologiesinc.com>

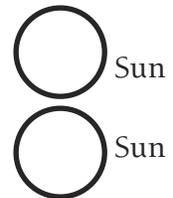
Where is the Sun and Earth

1. Which of the drawings below do you think represents the shape of Earth's orbit around the Sun? (The view is top down.) Circle the correct drawing.



2. Which is the best drawing below to represent the sizes and distances between Earth and the Sun? Circle your answer.

- A. Earth Moon
- B. Earth Moon
- C. Earth Moon



Sun is about 11 page-widths away →

3. Why do you think it is hotter in the United States in July than in January? Circle all correct answers.

- A. The Sun gives off more heat and light energy in July and less in January.
- B. Earth is closer to Sun in July, and farther away from the Sun in January.
- C. The United States is closer to the Sun in July and farther away from the Sun in January.
- D. The United States is facing more toward the Sun in July and away from the Sun in January.
- E. The Sun gets higher in the sky in July, so its rays are more concentrated on the ground.
- F. The Moon blocks out the Sun in January.
- G. In the United States, there are more hours of daylight in July than in December.

Science VI

Activities

Heat & Sound

Heat – It’s as Easy as ONE, TWO, THREE!

Standard IV:

Students will understand properties and behavior of heat, light, and sound.

Objective 1:

Investigate the movement of heat between objects by conduction, convection, and radiation.

Intended Learning Outcomes:

1. Use Science Process and Thinking Skills.
3. Understand Science Concepts and Principles.
4. Communicate Effectively Using Science Language and Reasoning.

Content Connections:

Reading fluency, vocabulary, graphing

Science
Standard

IV

Objective

1

Connections

Background Information

Everything is made up of small particles or molecules. Heat energy is the random movement of these molecules. The molecules in matter are constantly moving, but the hotter something is the faster the molecules move. When fast-moving molecules touch slow-moving molecules energy is transferred. The slow molecules speed up and the fast molecules slow down until the molecules eventually move at the same speed. Heat always travels from hotter to cooler objects. If you were to step barefooted onto a tile floor it might seem as though the “coldness” of the tile transferred into your foot making it cold. The heat energy, however, is actually transferring into the tile from your warm foot making the tile warmer and leaving your foot feeling colder. Heat energy can move from one object to another in three ways: conduction, convection, and radiation.

Conduction is when heat energy travels from one object to another by direct contact between the molecules. Heat is transferred from one molecule to another without the movement of matter itself. Think of a time you may have burned your hand by touching a hot spoon in a pot of hot water on the stove. The heat transfer actually started with the hot burner on the stove. The fast-moving particles of the burner transferred energy by contact into the slower-moving molecules of the cool pan, making the pan’s particles move faster and become hotter. The fast-moving particles in the pan then transferred into the slower-moving particles in the cool water making it hot. The hot water then transferred its heat energy into and up the metal spoon, making it hot to the touch of your hand.

Convection is the transfer of heat by movement of currents within fluids, such as a liquid or gas, causing the fluid matter to move. When

heat is transferred by convection, slow-moving molecules in the fluid began to move faster, and they also move farther apart. As a result, the heated fluid becomes less dense and floats to the top. The more dense (cooler) fluid then sinks to the bottom. Many students are under the misconception that heat rises, but it is actually hot fluids (gas and liquids) that rise. Convection produces global winds that form Earth's weather when air is heated by the Sun. It also produces the ocean currents when warm water meets the cold.

Radiation is the transfer of heat energy by electromagnetic waves and (unlike conduction and convection) does not require a medium in which the energy is transmitted. Students often incorrectly think that radiation radiates only downward because heat radiated from the Sun appears to radiate down. Heat energy actually radiates out in all directions from the energy source, such as radiated heat from a fire moving up to cook a marshmallow held above it. Any object that has more heat energy than another radiates heat to the cooler object. This is the reason a room heats up quickly when it is filled with hot student bodies. Since heat and light travel by electromagnetic waves and do not require a medium, heat and light travel through space to Earth, while sound can not.

Research Basis

Stahl, S., & Hayes, D. (1997). *Instructional models in reading*. New Jersey : Lawrence Erlbaum Associates, Inc.

“Studies have shown that when students work cooperatively, as opposed to competitively or individually, student achievement is increased, attitudes toward learning are better, social bonds between students are more positive, and students' self-esteem is higher (Johnson & Johnson, 1991; Johnson, Johnson, & Holubec, 1990; Slavin, 1990).”

Invitation to Learn

Discuss with the students the common occurrence of items coming in three's. List the ideas the students generate on the board. Examples are: the three bears, three little pigs, three billy goats Gruff, three Stooges, Three Musketeers, three blind mice, etc. Discuss how heat also comes in threes and illustrate by mapping their brainstorm on the board. (Transferred three ways, creates three states of matter, measured in three temperature scales, etc.) Divide the class into groups of three and tell them that you expect them to perform together as the Three Musketeers, not the three blind mice or Three Stooges. Tell the students that during the next three days they are to work together to discover how heat is transferred in three ways.

Instructional Procedures

The Three Sponges – These three heat sponge activities keep students actively engaged during common time wasters, such as class changes, teacher set-up, students finishing early, etc. (These simple strategies can be used by the teacher for any science topic or content area.)

1. Partner Practice Procedure (two minute timed bell work, students work together to learn the big ideas)
 - a. As you enter the room, get your *Partner Practice* (PP) sheet & begin.
 - b. Face your partner & hold the PP sheet between the two partners, so the practicing partner sees the question side.
 - c. The practicing partners ask themselves the questions and then answer the questions.
 - d. The other partner corrects from the answer side as needed.
 - e. Repeat steps b-d with the second partner.
2. Literary Readings (one minute timed read to gain information while increasing reading fluency)
 - a. Read the Literary Reading orally but quietly to yourself.
 - b. Read as fast as you can and try to beat your previous speed.
 - c. Record your gain in words per minute each time.
3. Vocabulary “Bingo” Games (students review critical vocabulary in a fun way)
 - a. Write the targeted vocabulary words randomly in the squares on your “Bingo” sheet.
 - b. Listen to the description of the word and place a marker on the correct word.
 - c. Call out if you have five markers horizontally, vertically, or diagonally.

Activity #1 – The Three Ring Circus – Conduction

1. Pass around the two amazing ice melting blocks, allowing the students to discover that one block seems somewhat cold to the touch, while the other seems warm.
2. Tell the students that today they are going to witness a disappearing act where 3 ice cubes will disappear in a three-ring circus act. Their mission as the Three Musketeers is to predict correctly how much time it will take for each ice cube to melt.

Materials

- Heat Partner Practice
- Literary Reading – Heat
- HEATO Bingo sheet
- HEATO Definition Strips
- Amazing Ice Melting Blocks (set)
- Ice cubes
- Large sheet of drawing paper
- Small Three Musketeers bar



One will be placed on the cold block, one on the warm block, and one on a black square of construction paper placed on the desk. They are to work together as a group and record their predictions in their journals.

3. Place an ice cube inside each rubber ring on the three black surfaces and wait as the students observe. (The ice cube on the aluminum completely melts within two minutes, and the students are always surprised and curious as to why.)
4. Tell the students to compare the actual results with their predictions. They are also to discuss among themselves as to why the ice cube could have disappeared so quickly and record their reasons.
5. Have each group share their explanations with the class and encourage class-wide debate. With guidance the students should discover that because the aluminum block conducts so well, its heat (room temperature) is transferred quickly into the ice cube (0° C). Discuss other forms of heat transfer by conduction and how some materials allow this transfer and others do not.
6. Follow the activity by discussing other examples of heat conduction. Give each group a large sheet of drawing paper and have them illustrate as many examples as they can. The group with the most examples wins the prize (a Three Musketeers candy bar, of course).

Activity #2 – Three Temperatures, When Hot and Cold Meet Warm – Convection

1. Ask the students what happens when hot and cold meet warm. Tell them they are to work together as the Three Musketeers to discover what will happen when hot water and cold water are introduced into warm water. They are to discuss and come up with a prediction of what will happen. Pass each group a copy of the *When Hot and Cold Meet Warm* worksheet.
2. Fill the transparent container with room temperature water.
3. Fill one baby food jar with boiling water and add three drops of red food coloring. Cover the jar with aluminum foil and put a rubber band around the neck.
4. Gently lower it into the container, turning it on its side.
5. Puncture the aluminum foil in the middle and again near the edge with a pencil point so the colored hot water can flow out. If the water doesn't flow out, you may need to put the pencil

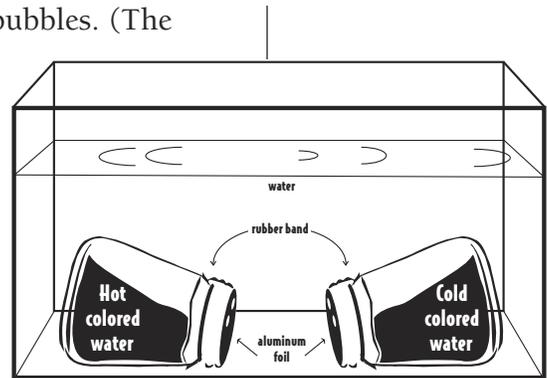
Materials

- Transparent container (small fish aquarium)
- Baby food jars
- Ice water dyed blue
- Boiling water dyed red
- Aluminum foil
- Rubber bands
- When Hot and Cold Meet Warm*



into one of the holes to release any trapped air bubbles. (The hot red water will float to the top of the room temperature water.) Have the students observe and draw what is happening on their worksheet.

6. Fill the other baby food jar with ice water and add three drops of blue food coloring. Cover the bottle with aluminum foil and put a rubber band around the neck.
7. Repeat steps four and five with this jar.
8. Have the students discuss within their groups what happened, compare it to their predictions, and determine why it happened. Have them share their thoughts with the class and discuss how convection works. Discuss other examples of convection. Have each group list as many examples of convection (completely described) as they can on the back of their worksheet. They may use textbooks and other sources, and the group with the most examples wins the prize.



Activity #3 – The Tale of Three Colors– Radiation

1. Previous to the activity make the three colored flat surfaces, the three colored envelopes, and the three-chambered box. To make three chambered box, find a small rectangular box (approximately 5” by 7”) and cut two pieces of heavy paper (oak tag, poster paper, etc.) as long as the inside of the box (lengthwise) and as tall as the box. Place the two pieces in the box and tape them so that they divide the box into three equal chambers.
2. Use the aluminum foil to cover the bottom and all sides of the center section and glue the foil in place. Cover one section with the white paper and the third section with the black paper. When finished, the box will have three chambers: one black, one white, and one silver.
3. Cut 6 pieces of construction paper, four white and two black, that are 6” x 4”. Cover one side of two of the white squares with tin foil and glue in place.
4. Fold one of the black pieces, one of the white pieces, and one of the silver pieces in half. The three folded pieces should now be 6” x 2”. Tape the bottom and long side of each piece to form three envelopes. (Set the remaining three pieces aside.)

Materials

- Gooseneck lamp
- Aluminum foil
- White and black construction paper
- Glue stick
- Small rectangular box (5”x7”)
- Thermometers
- The Tale of Three Colors*
- Heat cluster cards
- Heat* tri-fold brochure



5. Now you are ready for the activity. Tell the students that as the Three Musketeers, they have a special mission to discover how color affects radiated heat. Pass out the worksheets and remind them they will need to be precise in the data they keep.
6. Lay a thermometer on top of each of three squares of paper: a white piece, a black piece, and a silver foil piece. Have the students write down the starting temperature (C) of each thermometer on the worksheet. (Select one Musketeer from each group to witness each experiment and verify the temperatures.) Place the pieces evenly under the lamp so they will all get the same amount of light and turn it on. While waiting for the time to pass they are to predict the outcome. **WARNING:** Do *not* touch the lamp after you have turned it on, as it gets very hot!
7. Check and record the temperature after five minutes and again after 10 minutes.
8. Cool the three thermometers to room temperature and then place them inside each of the three envelopes. Write down the starting temperature (C) of each thermometer on the worksheet. Place the envelopes evenly under the lamp so they will all get the same amount of light and then turn it on.
9. Watch the clock and allow the lamp to shine on the envelopes for five minutes. While waiting for the time to pass have the students predict which envelope will get the hottest. Check the thermometers quickly and have the students record the temperatures of each envelope on the worksheet after five minutes and again after 10 minutes.
10. Take the thermometers out of the envelopes and allow them to cool again to room temperature.
11. Now place the thermometers in the three-chambered box. Place the box under the light so each chamber gets the same amount of light and then check the clock and time the box for five minutes. Have the students record their predictions. Record the temperatures after five minutes and then after 10 minutes.
12. After the students have gathered the data, have them compare the results with their predictions. After they have filled out their worksheets discuss why they think there was a difference between the three placements. Discuss possible applications of the results.
13. On the back of their worksheets have them demonstrate what they have learned and come up with as many applications to life

situations as they can that show an understanding of heat and color. (You wouldn't wear a dark shirt on a hot, Sunny day. You could put a silver lining on your windows to keep the heat out. You could wrap yourself in a silver survival blanket to keep the heat in on a cold day or place it above your head as a canopy to keep cooler on a hot day. You could line a solar oven with silver to heat better and add black to help absorb the heat.) The group with the most heat applications wins the prize.

Assessment Suggestions

The Great Heat Race, a fun cluster activity where students compete in groups to be the first to place the cluster pieces under the correct method of transfer: conduction, convection, or radiation. Through informal observation the teacher is able to discover many student misconceptions.

The Heat Brochure: Students make a tri-fold brochure. On the front they write the three ways heat is transferred and illustrate an example of each. On another side they write and illustrate the three states of matter. On one page they draw the three temperature scales and write the freezing and boiling points for each.

Curriculum Extensions/Adaptations/Integration

- Have students test to see which spoon (wooden, plastic, or metal) conducts heat best by gluing a marshmallow with a dab of butter on each spoon handle and pouring boiling water on the bottom of the spoon to see which marshmallow drops first.
- Have students fly a hot air balloon by filling plastic bags with hot air from a blow dryer or floating a solar bag heated by the Sun's radiation.
- Have students design and construct an Ice House that will prevent an ice cube from melting and have a class-wide Great Ice Race.
- Have a Three Musketeers conduction race. Tie three small candy bars with a string and attach each string to a long copper rod or hanger suspended on two blocks of wood. Attach each string to the rod with a piece of wax, making sure they are at least two inches apart. Have the kids predict what time each musketeer will drop from the rod when a flame is held on the end of the rod.

- Have students predict what will happen when hot water is placed over cold water and cold water over hot water and experiment with the baby food jars and colored water.

Family Connections

- Students could design and construct solar ovens and test their effectiveness by cooking in them.
- Have students keep a log and document examples of conduction, convection, and radiation they observe at home for a week.
- Have students keep a weather log for a week and explain how convection creates weather patterns.
- Have students conduct a home energy assessment to determine where heat energy is being lost in their homes and how heat loss can be lessened.

Heat Partner Practice

1. What are the 2 *kinds of energy* and how do they differ?
2. What is *heat*?
3. Name 3 ways *heat is transferred*.
4. What is *conduction*? by direct contact between particles.
5. What is *convection*?
6. What is *radiation*?
7. What is the difference between an *insulator* and a *conductor*?
8. What is the difference between *contraction* and *expansion*?
9. What is temperature?
10. What are the *boiling and freezing points* of water on the Celsius, Kelvin, and Fahrenheit scales?
1. *Kinetic energy* is the energy of motion and can be transferred. *Potential energy* is stored energy.
2. *Heat* is the movement of thermal energy from a substance at a higher temperature to another at a lower temperature (warmer to cooler).
3. *Heat is transferred* by conduction, convection, or radiation.
4. *Conduction* is the transfer of heat.
5. *Convection* is the transfer of heat by movement of currents within a liquid or gas.
6. *Radiation* is the transfer of heat by electromagnetic waves.
7. An *insulator* is any material that stops or inhibits the transfer of heat, and a conductor allows the transfer of heat.
8. *Contraction* is a decrease in the space between the particles in an object (it gets smaller), and *expansion* is an increase of space between the particles (it gets bigger).
9. *Temperature* is the measure of the average kinetic energy of the particles in a sample of matter.
10. *Boiling point* is 100° Celsius, 373 Kelvins, and 212° Fahrenheit. *Freezing point* is 0° Celsius, 273 Kelvins, and 32° Fahrenheit.

HEATO Definition Strips

Instrument that measures the temperature of a sample of matter	(Thermometer)
Temperature when a liquid changes to a solid - 32 ^o F or 0 ^o C for water	(freezing point)
Temperature when a liquid changes to a gas - 212 ^o F or 100 ^o C for water	(boiling point)
Thermal energy transferred from an area of high temp. to an area of lower temp.	(Heat)
About 70 ^o F or 21 ^o C - a comfortable temperature	(Room Temperature)
98.6 ^o F or 37 ^o C - the average temperature of a healthy human	(Body Temperature)
Material that prevents the transfer of heat from one object to another	(Insulator)
Material that easily transfers heat from one object to another	(Conductor)
Potential energy stored in the nucleus of an atom	(Nuclear Energy)
Amount of heat needed to raise the temperature of 1 g. of a substance by 1 ^o C	(Specific Heat)
Temperature at which a substance changes from a solid to a liquid	(Melting Point)
Energy that an object has due to its motion	(Kinetic Energy)
Measure of the average kinetic energy of the particles in a substance	(Temperature)
Energy that is stored and held in readiness	(Potential Energy)
Transfer of heat by the movement of currents within a fluid (air and liquids)	(Convection)
Transfer of energy by electromagnetic waves	(Radiation)
Increase in the space between the particles in an object, making it larger	(Expansion)
Decrease in the space between the particles in an object, making it smaller	(Contraction)
State of matter that has definite shape and takes up a definite volume	(Solid)
State of matter that has definite volume, but not a definite shape	(Liquid)
State of matter that does not have a definite shape or definite volume	(Gas)
Total energy of all the particles in an object	(Thermal Energy)
Energy of light and other forms of radiation	(Electromagnetic Energy)
Transfer of heat by direct contact between particles within a substance	(Conduction)

HEATO

		Free Space		

Name _____

When Hot & Cold Meet Warm

What do you predict will happen when the 3 temperatures meet?

Observe, draw, and color a picture of the results in the space below.

1. What did you notice happened to the hot water from the baby food jar?

2. Why do you think this happened?

3. What did you notice happened to the cold water from the baby food jar?

4. Why do you think this happened?

5. What are some other examples where hot fluids rise and cold fluids sink?

6. What do you think will eventually happen in the container if the jars are left in it for an hour?

7. What is another way you could demonstrate this process of convection?

The Tale of Three Colors

Focus Question: What difference does color make in absorbing heat?

Predict which color will be the hottest after 10 minutes under a hot lamp.

Hottest color on the 3 flat colored surfaces _____

Hottest color in the 3 colored envelopes _____

Hottest color in the 3-chambered box _____

Colors on 3 Flat Colored Surfaces

Flat Surface	Starting Temperature	Temperature after 5 min.	Temperature after 10 min.
Silver			
Black			
White			

Colors in the 3 Colored Envelopes

Envelope	Starting Temperature	Temperature after 5 min.	Temperature after 10 min.
Silver			
Black			
White			

Colors in the 3-Chambered Box

Chamber	Starting Temperature	Temperature after 5 min.	Temperature after 10 min.
Silver			
Black			
White			

Write the actual results of the experiment.

Hottest color on the 3 flat colored surfaces _____

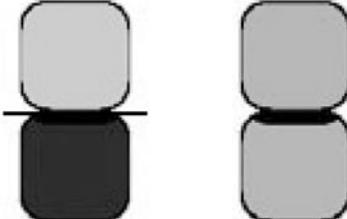
Hottest color in the 3 colored envelopes _____

Hottest color in the 3-chambered box _____

Discuss what happened and answer the following questions:

1. What type of heat transfer is occurring when the lamp shines on the colors?
2. Does the color of paper make a difference in the heat absorption?
3. Why was there a difference in whether the color was on a flat surface, inside an envelope, or in a box?
4. Give an example of how each result (3 examples) could be applied to real life experiences.

Literary Reading - Heat

Heat can move from one object to another in three different ways: conduction, convection and radiation.	14 16
<i>Conduction is the heat transfer through a substance or from a substance to another by direct contact.</i> Everything is made up of small particles. When the particles are moving faster, there is more energy and the temperature is higher. As fast-moving particles touch slow-moving particles, the energy is transferred. This causes slower particles to speed up and the faster particles to slow down. You can demonstrate this by rubbing your hands together very fast for 30 seconds. Now touch them to your ears. Can you feel the heat transfer from your hands to your ears? As your ears warm, your hands will cool until the particles in each are moving at the same speed.	32 47 62 71 83 94 106 118 131 132
	
Another example of conduction is a pan on the stove. The stove is heated by gas or electricity. Then the pan gets hot. <i>Substances that transfer heat better than others are conductors.</i> Can you think of other examples of conductors? Insulators are substances that do not conduct heat easily. Glass, wood, plastic and rubber are all insulators. Pans have plastic or wood handles to keep the pan from conducting heat to your hand and burning it. Can you think of other examples of insulators?	149 164 179 194 212 216
<i>Convection is the heat transfer in liquids and gases as particles circulate in currents.</i> This transfer of energy causes warm substances to rise and cool ones to sink. In heat transfer by convection, the particles in a liquid or gas speed up as they are heated. This causes the particles to move apart and the substance becomes lighter. As the heated substance rises, the cooler, heavier substance moves down. These currents exchange heat through this movement. You can observe convection in a simple experiment. Get two baby food jars. Fill one with hot water and a drop of red food color. Fill the other with cold water and a drop of blue food coloring. Place a card over the mouth of the cold water jar and turn it upside down on top of the warm water. Carefully pull out the card. You should see warm, red water rising and cold water sinking.	231 248 260 271 280 288 298 309 322 335 354 368
	
<i>Radiation is the transfer of heat through space in the form of waves.</i> The heat we receive from the Sun is radiant heat. Radiant heat travels as waves through space. Heat waves hit Earth and cause warming. Our atmosphere traps the warmth. Your house gets warm when the Sun's waves or rays travel through a window and are trapped in your house, warming it. Heat waves are invisible. All warm objects radiate or give off heat waves. Some other examples of radiation are the heat surrounding a fire, the heat given off by an electric heater, and the heat near a hot oven.	386 402 417 434 450 470 471

HEAT

Temperature Scales

States of Matter

Conduction

Transfer of heat by direct contact between particles

A metal spoon gets hot in a pot of boiling water.

An egg on a frying pan sizzles and cooks.

An ice cube held in a hand begins to melt.

A metal cup gets hot when boiling water is poured in it.

A cheek is burned by a hot curling iron.

Convection

Transfer of heat in liquids and gasses through currents

Water in a heated pot begins to boil.

A bird takes advantage of rising warm air by catching an updraft.

Cool air sinks to the ground on a warm night.

A swimmer is caught in a current of cold water and is pulled under.

Air is warmer near the ceiling than the floor.

Radiation

Transfer of heat by electromagnetic waves

Toes are warmed in front of a space heater.

A marshmallow turns brown when held over hot coals.

The Sun melts the ice formed on a frosty lawn.

A Sunbather gets a nasty Sunburn after laying out for too long.

Slices of bread turn brown in a toaster.

Sizing up Sound – STRAW'N & STRING'N

Standard IV:

Students will understand properties and behavior of heat, light, and sound.

Objective 3:

Describe the production of sound in terms of vibration of objects that create vibrations in other materials.

Intended Learning Outcomes:

1. Use Science Process and Thinking Skills.
2. Manifest Scientific Attitudes and Interests.
3. Understand Science Concepts and Principles.

Content Connections:

Measurement

Science
Standard

IV

Objective

3

Connections

Background Information

Sound is a form of energy when vibrations (rapid back and forth movements) travel through a medium. Three things are necessary for the creation of sound: (1) a source of energy or disturbance, (2) vibrations, and (3) a medium for the vibrations to travel. The source of energy could be plucking the string of a guitar, blowing across a reed, or hitting a drum. This disturbance causes the string, the reed, or the drumhead to vibrate rapidly. When the drum is hit, the drumhead vibrates and creates a disturbance in the molecules in the air near it. When the drumhead moves to the right it pushes the air molecules into each other, causing them to become compressed (like a slinky). When it vibrates to the left, the molecules of air move farther apart, creating a rarefaction (the particles are farther apart). These vibrations travel through the air, one particle bumping into another like dominoes, until they reach the ear. Sound, unlike heat and light, cannot travel through space because space has no medium for it to travel.

Sound waves (longitudinal waves) like all waves have four basic properties: amplitude, wavelength, frequency, and speed. Amplitude in a longitudinal wave is a measure of how compressed or rarified the medium becomes. High-energy vibrations (hitting the drum harder) cause the molecules to become more compressed. The greater the amplitude of the wave (intensity) the louder the sound is. Frequency is the number of complete waves (vibrations) that pass a given point in a certain amount of time or how fast the medium is vibrating. The pitch (highness or lowness of a sound) that is heard depends on the frequency of the sound wave. Sound waves of high frequency have a high pitch, while sound waves of low frequency have a low pitch. The frequency of a vibration of a drumhead depends on the material

used, the size of the drumhead, and how tight it is. A tighter or smaller drumhead would create a higher pitch than a looser or larger drumhead. A guitar string that is tighter, thinner, or shorter will have a higher pitch than one that is looser, thicker, or longer. Therefore, size makes a difference in sound. If the shape and material used in two instruments are the same, then the larger instrument will vibrate with a lower frequency and create a lower pitch than the smaller instrument.

Research Basis

NSTA Publications, (1984). Understanding play. *Science and children*, National Science Teachers Association, Arlington.

Wonder, inquiry, curiosity, and mental challenge are all important to the developing young scientist. A review of educational and psychological research suggests that play and science are complimentary in their aspect of problem solving. Research studies have shown that children who play with and manipulate a wide variety of toys and games are flexible in strategies to solve problems.

Kluger, B., (1999). *Inquiry thoughts, views, and strategies, for the K-5 classroom*. Arlington: National Science Foundation.

Good science inquiry involves learning through direct interaction with materials and phenomena.

Invitation to Learn

Discuss the following questions with the students, Does size really matter? What are the advantages and disadvantages of being tall or short? Does size make a difference in sound? Play with the PopToob and ask the students to observe and be ready to share their observations. After a minute or two, have the students share what they observed and heard. Tell them that today they are going to play around with sound and discover if size really does matter.

Instructional Procedures

Activity #1 STRAW'N – That's the Last Straw!

Straw Whistle

1. Lay a ruler alongside the 12 inch jumbo straw and use the pencil to measure and mark the straw in the following lengths: a three inch piece, two and a half inch piece, two inch piece, one and a half inch piece, one inch piece, and a spare piece. Put an X on the spare piece so you can distinguish it from the rest.

- Cut the spare piece off the straw on the mark you have measured. Set the remaining straw aside.
- Flatten one end of the spare piece and use the scissors to cut two sides off the flattened piece to create a sharp point like an arrow.
- Place the pointed end between your lips and blow. If you can not get a sound, try flattening the straw more with your teeth and releasing it slowly as you blow or pull the straw in or out of your mouth as you blow.

Straw Panpipe

- Cut the remaining 12 inch jumbo straw on the marks you have measured. You should have five pieces.
- Flatten one end of each piece of straw and bend it over about one-fourth inch to seal off the straw. Staple the bent over end so no air can pass through the straw. Test each piece by blowing into the straw.



- Lay the ruler alongside the craft stick and make small marks every half inch.
- Lay one end of each piece of straw against the top edge of the craft stick. Line them up (each piece on a different half inch mark) from longest to shortest, as shown. Use the glue gun to make a dot of glue on five of the marks you will use and press a piece carefully into each dot of glue.
- Blow across the top of each straw and listen to the sound. How does the length of the straw affect its pitch? Which straw makes the lowest pitch? Which straw makes the highest pitch? Why? Move your instrument back and forth as you blow across. How does the sound change as you move from the longest straw to the shortest?
- Play a tune with your instrument. Write a code showing how to play the tune. Try to play a tune written by someone else.

Strawbone

- Take the smaller Jumbo straw and cut the tip into a point like an arrow.
- Slide the smaller straw into the wider Super Jumbo straw. Blow on the smaller straw and slide the wider straw up and down the smaller straw. How does the sound change as the straw becomes longer?

Materials

- Pop Toob
- Craft sticks
- 12" jumbo drinking straw
- Jumbo straw and Super Jumbo straw for each student
- Low temp glue guns
- Hand-held hole punch
- Scissors
- Rulers
- Plastic trays
- Pegboard pieces
- Nylon fishing line (30# or thicker)
- Four eyebolts (each)
- Eight washers (each)
- Four wing nuts (each)



Strawzophone

1. Slide the wider straw off the smaller straw and flatten the wider straw. Use the hole punch to make three holes starting two inches from the top. Make sure you only punch a half hole in the form of a C as shown. Unflatten the straw and you should have three round finger holes. (See illustration.)
2. Cut the top of the straw into a point like an arrow. Blow into the straw with no holes covered. Now, cover one hole at a time and blow into the straw? What happened? Why?
3. Allow the kids to play and experiment with the straws. Discuss what they have discovered.



Activity #2 – STRING’N – Pegboard Harp

1. Pass out the following items to each member of the group (Have them place the small items in the plastic tray to keep them from getting lost.): one plastic tray, one pegboard, four eyebolts, eight washers, and four wing nuts. (The pegboard should have four strings already attached: one tied to the last hole in the board, one tied two holes in from the end, one tied four holes in, and one tied six holes from the end.)
2. Place one washer on an eyebolt and put it through the hole at the opposite end of the first tied string. The washer should be on the top surface of the pegboard.
3. Secure the end of the eyebolt on the underside of the pegboard with another washer and a wing nut.
4. Tie the loose end of the string to the eyebolt. (Be careful when tying the strings on the eyebolts because you will have to untie the knots you put in the strings.)
5. Repeat steps two to four with the remaining strings. All eyebolts should run flush left down the pegboard as shown in the illustration.
6. Turn the eyebolts to tighten or loosen the strings. Loosen the wing nut on the bottom before tightening the string. It will be easier to turn the eyebolt to tighten the string and won't cut the string.
7. Pluck one of the strings and listen to the pitch (the highness or lowness of the note). Now, tighten the string and pluck the string again.
 - a. When you turned the eyebolt, what happened to the string?

- b. What happened to the pitch when you tightened the string?
 - c. How do you think the sound would change if you stretched the string tight? Loosened it?
 - d. How many different pitches can the string make?
8. Pluck the strings on your harp.
 - a. Why does each string make a different pitch?
 - b. How does the pitch change when you change the tension of the strings?
 - c. Which strings have the highest pitch?
 - d. What might you do to produce a high pitch from a long string?
 9. Tighten or loosen the strings until you have four different notes. Try to play a tune on the harp.

Assessment Suggestions

- Assign the students to use what they have learned to design and construct a multi-pitch instrument.
- Have the students place cluster pictures of instruments in order from lowest to highest pitch.
- Have the students write an essay on three ways that they could change a string on a guitar to create a lower pitch and then explain which of the three ways would be the easiest change.
- Have students place items (identical except for size) in the order of highest to lowest pitch.

Curriculum Extensions/Adaptations/Integration

- Extend the sound unit into the arts core by creating a rhythm band from instruments created by class members and performing.
- Create bottle xylophones from bottles filled with differing amounts of water that play a tune by tapping the bottles or by blowing across the tops.
- Create a panpipe by filling bullet shells with differing amounts of water and then play a tune by blowing across the tops.

Family Connections

- Keep a log of all the sounds you hear in your home during an hour time span.
- Tell a short story to your family and use sound effects.
- Have students design and construct a telephone using string and test to it to find answers to questions such as:
 - a. How long can the string be and still be heard?
 - b. Is it possible to cross strings from two sets and have a “conference call”?
 - c. Do metal cans or plastic cups work best?
 - d. Does yarn, string, or fishing line work the best?
 - e. Does it matter if the line is loose or tight?
 - f. Do high-pitched sounds or low-pitched sounds carry farther?

Additional Resources

Books

Experimenting with Sound, by Alan Ward; ISBN 0-7910-1511-4

Focus on Sound, by Barbara Taylor; ISBN 1-56924-038-8

Light, Sound & Electricity, The Usborne Internet-Linked Library of Science; ISBN 0-439-44147-1

Light, Sound, and Waves by Robert Gardner; ISBN 0-7660-2126-2

Physical Science Activities for Grades 2-8, by Marvin Tolman & James Morton; ISBN 0-13-669797-6

Primarily Physics: Investigations in Sound, Light, and Heat Energy, AIMS Activities, ISBN 1-881431-46-0

Sound, Noise & Music, by Mick Seller; ISBN 1-57335-149-0

Sound Science, by Etta Kaner; ISBN 0-201-56758-X

Sound, Student Activity Book, National Science Resource Center; ISBN 0-89278-745-7

Videos

Breaking the Silence: An Introduction to Sound, Live Action Video, (Rainbow Educational Media, 1-800-331-4047, <http://www.rainbowedumedia.com/>); Product ID: RB814

Heat, by Bill Nye (Disney Educational Publications, 1-800-295-5010, <http://dep.disney.go.com/educational/index>); Product ID: 68A71VL00

Heat, Temperature and Energy, Live Action Video, (Rainbow Educational Media, 1-800-331-4047, <http://www.rainbowmedia.com/>); Product ID: RB8229

Sound, by Bill Nye (Disney Educational Publications, 1-800-295-5010, <http://dep.disney.go.com/educational/index>); VHS Product ID: 68A99VL00, DVD Product ID: 77A34VL00

Web sites

<http://www.exploratorium.edu/snacks>

<http://www.learner.org>

<http://www.howstuffworks.com>

<http://nyelabs.kcts.org>

<http://scienceow.org>

<http://www.usborne-quicklinks.com>

Additional Media

Sound, Science Court, Tom Snyder Productions, 80 Coolidge Hill Road, Watertown, MA, 1-800-342-0236, <http://www.tomsnyder.com> ; #XSCI SND U 01

Sound Partner Practice

1. How are *sounds produced*?
 2. What is a *medium*?
 3. What are the *4 basic properties of waves*?
 4. What is an object's *frequency*?
 5. What is a *wavelength*?
 6. What does *pitch* mean and what property of sound effects it?
 7. What is an *object's resonance*?
 8. What 3 things *effect an object's timbre (sound quality)*?
 9. How does sound *travel* through the 3 states of matter?
 10. How does the *ear let us hear sound*?
 11. What is *amplitude* and how does it effect sound?
1. *Sounds are produced* when vibrations (rapid back and forth movement) travel through a medium.
 2. A *medium* is any solid, liquid, or gas through which a wave is transmitted.
 3. The *4 basic properties of waves* are amplitude, wavelength, frequency, and speed.
 4. The *frequency of an object* is the number of times the object vibrates in one second.
 5. A *wavelength* is the distance between crests in transverse waves or compressions in longitudinal waves.
 6. *Pitch* is how high or low a musical note sounds. Frequency effects pitch.
 7. An *object's resonance* is the tendency for an object to vibrate at the same frequency as another sound source.
 8. An object's *timbre is effected* by its size, type of material, and shape.
 9. Sound *travels* fastest through solids, then liquids and slowest through gases.
 10. The *outer ear* funnels sound waves, the *middle ear* transmits the waves inward, and the *inner ear* converts the sound waves into a form that your brain can understand.
 11. *Amplitude* is a measure of how compressed the medium becomes. The greater the wave's amplitude (intensity) the louder the sound.

SOUND

Properties of Sound

Things that Make Sound

Amplitude

Effects the loudness or Intensity of sound

A drum is hit harder and sounds louder

The volume on a stereo is turned down

Measure of how compressed the medium becomes

A voice can be heard across the room, but another can't

Frequency

Effects the pitch of the sound

A guitar string is tightened or loosened

Two instruments are the same, except for size

The amount of times an object vibrates per second

Musical notes creates a recognizable tune

Wavelength

Effects the frequency and speed of a wave

Gets longer as the frequency slows

Property of sound that is not used on radios

Measured from crest to crest in transverse waves

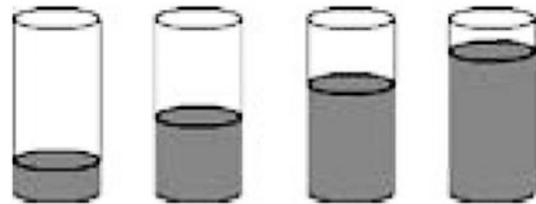
Distance between the compressions of a longitudinal wave

Literary Reading - Sound

If a tree falls in the forest and no one is there, does it make any sound? *Sound is a form of energy that causes particles to vibrate back and forth.* How would you answer the question about the tree falling in the forest?

When the tree hits the ground it causes the particles in the air to vibrate. *Vibration is a rapid movement back and forth.* The tree creates vibrations in the air as it falls. The vibrations spread out in all directions. If the vibrations in the air reach you, your eardrum will vibrate and you will hear the sound of the tree falling.

Have you ever placed your hands over your ears because someone was yelling? The loudness or intensity of a sound depends on the energy used. The more energy used, the louder the sound. You use a lot more energy to yell than you do to whisper. The same is true with all sounds: the more energy expended, the louder the sound.



Do you sing or play a musical instrument? If you do, you understand *pitch, how high or low a sound is.* The pitch of an instrument changes by adjusting its length or width. A trombone’s sound changes from low to high as the slide is moved in. The pitch of musical instruments can also be changed by tightening the strings which increases the speed of vibration. The picture below shows glasses filled with water. The glass on the left will have the lowest pitch when tapped. It has the greatest length of air space to vibrate, thus creating a low sound.

To keep areas quiet, such as libraries, there are materials placed in the rooms such as carpet and upholstered chairs to absorb noise. The *absorption, the ability to take in or dampen,* soaks up any noise so people can study in quiet surroundings.

Science VI

Activities

Light

Bending Beams of Light

Standard VI:

Students will understand properties and behavior of heat, light, and sound

Objective 3:

Describe how light can be produced, reflected, refracted, and separated into visible light of various colors.

Intended Learning Outcomes:

- 1 Use Science Process and Thinking Skills.
4. Communicate Effectively Using Science Language and Reasoning.

Content Connections:

Math III, IV, V

*Science
Standard
VI
Objective
3*

Connections

Background Information

Light rays slow down and may bend when they pass from one material to another. This bending is called refraction. Refraction happens because light travels at different speeds in different materials. Light changes its speed when it passes from one material into another. It travels at lower speeds through dense materials such as water and at higher speeds through materials that are less dense such as air. A beam of light will travel at a slower speed in a denser material. It will maintain that same, slower speed until it exits that material where upon it will resume its original speed. (speed of light: in a vacuum: 186,000 miles/sec, air: slightly less than 186,000 miles/sec, water: 140,000 miles/sec, glass: 124,000 miles/sec, diamond 77,500 miles/sec)

Light refracts only when it hits another substance at an angle. When light impacts the boundary of another substance head-on (perpendicular or 90-degrees) it will slow down but will not refract. When light hits the substance at any other angle, it will refract. The angle of refracted light will increase in proportion to the angle of the entry. The angle at which the light crosses the media boundary and the angle produced after refraction is a very precise characteristic of the material producing the refraction.

Lenses are used to bend light. They are made of curved glass or other transparent material. Light always bends towards the thickest part of the lens. There are two types of lenses. A concave lens is thick on the outside ends and thin in the middle (think of a cave). A convex lens is thin on the outside edge and thick in the middle.

The electromagnetic spectrum (EM) is a name given to a group of different types of radiation. Radiation is energy that travels in waves through empty space as well as through air and other substances. The

length of the wave determines the type of radiation energy it is. At one end of the EM are long, low-energy waves. These are radio and TV waves. At the other end of the EM are very short, high-energy waves which include x-rays and gamma-rays. Near the middle of the EM is a very small area of waves that we can see. This visible, white light is actually made up of all the colors. Each color has a different wavelength which is why our eyes are able to see the different colors. Red light has the longest wavelength (lower energy), and violet the shortest wavelength (higher energy). The Spectrum refers to this series of colored bands that can be seen when passing light through a prism. The major colors are: red, orange, yellow, green, blue, indigo, and violet. (ROY G. BIV)

Misconceptions to avoid:

1. Sound waves and radio waves are not the same thing. Sound waves cannot travel through a vacuum. Radio waves do not need a medium to travel through and they travel much faster than sound waves. Sound travels at speeds on the order of hundreds of meters per second. Radio waves, travel at speeds on the order of hundreds of millions of meters per second.
2. The spectrum is not made up of just seven distinct colors. In reality, there are a large number of color variations in the spectrum and there are no distinct boundaries between them. How many variations we see depends on the viewer's eye and what is refracting the light.

Science language students should use: refraction, angle of incidence, angle of reflection, spectrum

Research Basis

Colburn, Alan. (2004) Inquiring scientists want to know. *Educational leadership*: Sep 2004, Volume 62.1, pp. 63-66.

Inquiry-based instruction is shown to be a realistic middle ground between hands-on verification activities and open-ended discovery learning. Colburn gives examples of how to take incremental steps in moving a bread mold verification activity towards a guided inquiry lesson. The crucial role of assessment is emphasized. This includes assessing the students' abilities to develop further questions to investigate.

Heber, Richard., Moore, Christopher J. (2002). *A model for extending hands-on science to be inquiry based*. Database: Academic search premier. Retrieved 12/11/2005.

Hands-on activities are typically presented as step-by-step instructions for students to follow to find a pre-determined answer to an assigned question. This model provides structure and guidelines

for extending this traditional approach into a more valuable Strategies include: discrepant events to engage students in inquiry, brainstorming activities to facilitate planning investigations, written job performance aids, requirement for a product – usually including a graph, class discussion and writing activities to facilitate student reflection

May, David B., Hammer, David. (2004) Elements of expertise in the use of analogies in a 3rd-grade classroom discussion. *AIP Conference Proceedings*; Volume 720.1, pp. 149-152. EBSCO Host.

Scientists regularly employ analogies to communicate their knowledge. Using analogies in the classroom, including those generated by students, has been shown to improve student conceptual learning. This article studies how one 3rd grader generated and used an analogy while engaging in an inquiry in a science lesson about earthquakes. The authors identify some of the elements of expertise in analogy use that can be taught.

Jensen, Eric. (2005) Movement and learning, *Teaching with the brain in mind*. ISBN 1-4166-0030-2

“The part of the brain that processes movement is the same part of the brain that processes learning.” Jensen cites many studies and laboratory research showing the relationship between physical activity and increased cognition as well as better memory. In addition to providing for daily recess and physical education, Jensen makes many recommendations for how to incorporate physical activity into the daily curriculum.

Ways to build movement into the school day:

- Drama and role-plays: Have daily or weekly role-plays, play charades to review main ideas, pantomime to dramatize a key point, do one-minute commercials to review content.
- Energizers: use the body to measure things around the room, play a Simon Says type game with built-in content.
- Quick games: use ball toss for review, vocabulary building, rewrite lyrics to familiar songs in pairs or as a team incorporating content. Then have students choreograph and perform them.

Invitation to Learn

Students will experiment with various ways of magnifying objects;

1. Fill round bottles of various sizes with water. Place the bottles over a printed page. The print will appear enlarged. (Students

will observe that print viewed through trapped air bubbles appear smaller.)

2. Make a lens out of an empty can. Remove both ends. Cover one end with clear plastic. Secure with rubber band. Press plastic to form a bowl shape. Fill with water. Place “Tin Can Magnifier” over print and objects.
3. Collect soap bubble wands or make them out of bent paperclips or thin wire. Dip in water. Read print through the bubble.

After students have had time to try out the various magnifiers ask: What is happening? Why does everything look bigger?

Record their ideas on a K-W-L-H Chart – even if they are incorrect. Later, as they discover new information, they can compare the K column (what we know) with the L column – (what we learned). The middle column, What We Want to Find Out, will be used to record more ideas they would like to explore. These will be generated during class discussions. The H column is to be used for brainstorming How students could find the answers to their questions.

Materials

- Bowl
- Coin or washer
- Water
- Glass
- Pencil
- Paperclip or thin wire
- Cans (both ends removed)
- Round bottles filled with water,
- Square bottles
- Concave and convex lenses
- Shoe box top or lens holder
- Flashlights
- Slit blocks
- Protractor
- Compass
- Several round bottles same size (spice bottles)
- Refraction Experiment Log or Journals



Instructional Procedures

Activity #1 Refracting Light – a watery journey

1. Place the slit block at one end of a half sheet of plain paper. Set the water-filled bottle in the center of the paper. Trace the shape of the bottle. Shine a flashlight through the slit block. Move it until two clear lines can be seen from the slit block going into the bottle. Trace those two lines.
2. Observe the two lines exiting the bottle and notice where they cross each other. (The point where they cross is called the Focal Point.) Carefully trace these lines.
3. Remove the bottle. Use a ruler to measure the distance from the bottle to where the lines cross. Use a protractor to measure the angles the two lines form. Compare the angle of incident light (light coming from the flashlight to the bottle) with the angle of incident light (light coming out of the bottle).
4. Light will slow down whenever it enters another medium but it will only bend if it hits that medium at an angle. Experiment with square bottles. Place a square bottle on the same place as the previous bottle. Arrange it so a flat side is parallel to the slit block. Observe that the lines do not bend or refract. Then turn the bottle so that the flat side is at an angle to the slit block.

5. Have students explore light refracting through lenses. Explain what lenses are (see Background). Use the slit block to shine parallel lines of light through each lens. You should see the lines converge through the convex lens and diverge through the concave lens. (You can make a lens holder with the top of a shoe box. Cut a slit in the box top just large enough to stand the bottom part of the lens in.)
6. Explain how light beams slow down in denser materials. Place the chart of speeds of light in various materials (from Background) on the board. Then discuss how analogies can help us understand complicated concepts. Scientists frequently use analogies to help understand and explain complicated events.

Examples of analogies that illustrate light slowing down when entering another substance

- a. Imagine riding your bike on the paved sidewalk. Then the sidewalk ends and you hit a patch of sand. What happens? You will slow down and your bike may not be able to continue in a straight line.
- b. Imagine running through an empty room versus one filled with people furniture? Would you have to slow down in a full room?

An example of analogies that illustrate light only refracts when it enters at an angle.

Imagine pushing a shopping cart across a paved parking lot and onto a grassy area. If you push the cart straight onto the grass, it will slow down because the grass offers more resistance but it will continue in a straight line. However, if you push the cart at an angle onto the grass, the result will be different. If the front right wheel hits the grass first, it will slow down while the left wheel is still on the pavement. Because the left wheel is briefly moving more quickly it will cause the cart to turn to the right. When you move through the grassy medium and back onto the sidewalk on the other side, the wheel that hits the sidewalk will speed up causing the cart to turn in that direction.

Have each group come up with at least one analogy of their own to share. Have each student write their own analogies.

Activity #2 Refracting Light – in heavy liquids

Presenting the Challenge:

Ask: Will different fluids refract light differently? Will the distance from the liquid to the focal point (where the light beams cross) be

different? Will the size of the angles be different? Why do you think that? Refer to the sand analogy. Would a bike act differently in mud, gravel, etc? Have the class brainstorm different liquids they might want to try (dish soap, oil, honey, hand sanitizer, karo syrup, glycerin, etc.) Write their ideas in the W column of the K-W-L-H chart.

Planning the Inquiry

Talk about experimental design. If we are testing liquids, that is the variable. Everything else must be the same, otherwise we cannot be sure what is affecting the beams of light. Have students point out everything that needs to be the same (size and type bottle, quantity of liquid, distance of bottle from light source, and same flashlight). Review the steps that were taken in Activity #1. Tell students that scientists keep detailed, accurate records of their experiments so they can be duplicated. Students may use the Refraction Experiment Log—included at the end of this section—or they may design their own log.

Conducting the Inquiry

Students can be assigned to work in cooperative groups. Depending on time constraints, each group could either experiment with several liquids or each group would choose a different liquid from the list generated earlier and share their results with the rest of the class. Students could use the same paper they used for Activity #1. Use a colored pencil for the new liquid. It will make the comparison easier to see. Follow steps one through three in Activity #1.

Interpreting and Presenting Results

Each group should share their results with the class. If each group just tested one liquid, they could record their results on a large, class chart. A graph could be created which would show the relationship between the distance of the focal point (where the beams cross) from the bottle and the angle it makes.

Questions to consider: How do you know? What was your evidence? What makes you think this was true?

Students should be made to understand that their results and conclusions are valid for the materials they tested. Their sample was very small. Scientists might conduct hundreds of tests on hundreds of different kinds of materials before drawing conclusions.

Considering Implications for Future Research

An important part of the inquiry-based instruction is having students reflect on their activities. Consider the following: If you had to do it over again what would you do differently? Why? Did this inquiry raise new questions? Brainstorm what else we want to

Materials

- Variety of viscous liquids (oil, dish soap, honey)
- Planning Form for Inquiry, Refraction Experiment Log or Journals



know. Write ideas on the K-W-L-H chart. What would happen if we: increased the size of the container? Changed the shape? Tried different temperatures? How did this activity show why scientific knowledge is always subject to change? Visit <http://www.learner.org/jnorth/tm/inquiry/menu.html> . This is an excellent site. A “Menu of Inquiry Strategies” includes lists of questions teachers could pose.

Activity #3 Refracting Light to Make Rainbows

1. Cut a rectangular notch, the length of the equilateral prism, in the middle of the top edge of the narrow side of the box. The prism should fit snugly into the notch with one flat side resting on the cardboard wall. Place a sheet of white paper in the bottom of the box. Position a strong, focused light source about four to five feet from the box.
2. Before starting the lesson, ask the students to draw a rainbow. Ask them to list the major colors in order. Have them show which color they think is on the top. Record their ideas on the K column of the KWL chart.
3. Students should work in their teams with a prism box. They may need to move the light source back and forth until they get a clearer rainbow.

Students should record their observations in their journal or *Prisms and Rainbow* handout. They should be evaluated on thoroughness, accuracy, and neatness.

- a. What colors do you see? Describe as many as you can.
 - b. What is the order of the colors? Draw the spectrum that you see.
 - c. Draw the light box set up from the side. Make note of the angle of the prism to the light source. Draw the path of light from the light source, through the prism and to the paper. Refer back to what they learned in Activity #1 about the necessary conditions for light to refract. (Light does not refract when it enters a substance at 90 degrees.)
4. Place the box in the sunlight. Tilt it, if necessary so that the light goes through the prism and a spectrum is visible inside the box. Make the same observations as in step 3. Are there any differences between the rainbow or spectrum produced by the projector or flashlight and that produced by the Sun? Explain.
 5. This additional activity could demonstrate that each color refracts at a different angle. Trace the spectrum on floor of the

Materials

- Box – the kind copier paper come in is ideal
- Equilateral prism
- Cardboard cutters
- White paper
- Overhead projector
- Slide projector or strong light source
- Yarn or string
- Cardstock
- Compass
- Protractor
- Pencil with point
- Student Journal or Prisms and Rainbows



prism box with colored markers. Use two strings (or a piece of red yarn and violet yarn). Run the strings from the prism to the two outside boundaries of the spectrum—red yarn to the red side, violet yarn to the violet side.

6. Have students measure the width of the different colors. A good way to do this is to tape a ruler onto the wall or screen so that it crosses the colors of the rainbow. Are all the bands of colors the same width?

Experiment with a variety of other ways to break up light into the pattern of colors called the spectrum.

1. Fill a bowl or clear plastic shoebox with water. Place a flat mirror at an angle inside the bowl. Place the bowl in a window so Sunlight shines directly onto the mirror (or use another light source such as a mirror). Hold a white sheet of paper in front of the mirror and move it around until the rainbow spectrum appears. Or move the mirror until the spectrum appears on a wall or ceiling. The wedge, or triangular shape of water between the mirror and surface of the water acts as a prism.
2. Place a glass of water on the edge of a stool or chair. Put a sheet of paper on the floor. Cover the flashlight with cardboard that has a slit cut into it. Hold the flashlight at an angle to the surface of water. Move the flashlight and paper around until you see the spectrum. Shine light from an overhead projector or slide projector through a prism held just a few inches from the light source. Move the prism until the spectrum appears.
3. Shine flashlights through prisms. Have them notice at what angle to the prism the light has to shine in order to see the spectrum. For better effect, mask off most of an overhead projector stage with some cardboard, leaving a narrow vertical strip of light to hit a screen. Hold the prism within the strip of light and a few feet from the screen. A slide projector works well. Convert a slide by covering it – leaving a small vertical slit for light to pass through.
4. Try recombining the spectrum to form white light. Position a convex lens or hand lens between the prism and a screen. You will need to move the lens around to find the right spot for the colored beams to converge.

5. Newton’s Color Disc is one way to demonstrate that white light is made up of all the colors. When spun fast enough our eyes perceive the mixture of colored light as white light. Students can make a color spinner similar to the professional ones.

Directions: Use a compass to make a four or five-inch circle on cardstock. Cut it out. The circle needs to be divided into seven equal sections – the seven main colors of the spectrum. Point out how many degrees a circle is. Ask how do we figure out how many degrees each section will be? (51) Use a protractor to measure the sections. Color each section one of the colors of the spectrum. Color them in the correct order. Make a hole in the center of the disk. Push a pencil through and spin. (If you have an old phonograph turntable with adjustable speed, try spinning your disc on it.)

6. Have students create a mnemonic sentence (other than the common ROY G BIV) to help remember the order of the major colors. red, orange, yellow, green, blue, indigo, violet)

(Adapted from a lesson found at NASA’s Stargazer website.)

Website:

<http://stargazer.gsfc.nasa.gov/educators/activities.htm> This has excellent lessons particularly on prisms and rainbows.

<http://www.howstuffworks.com/framed.htm?parent=exp-> The How Stuff Works site is a great source of information – including all about light.

<http://accept.la.asu.edu/PiN/mod/light/opticsnature/pattLight4.html> This site has good explanation of how rainbows form and other light phenomena

<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/newton/index.html> This includes interactive tutorials that illustrate refraction, prisms, and other light phenomena.

http://www.atozteacherstuff.com/Themes/Shadows_Light/index.shtml A to Z Teacher Stuff includes a variety of science experiments.

http://www.colour-experience.org/teknicolour/teknol_prisms/teknol_prisms5.htm This SDC Color Museum has good background information on prisms and color.

<http://www.exploratorium.edu/IFI/> Learn more about inquiry-based teaching. There are some sample inquiry lessons dealing with light.

<http://www.eskimo.com/~billb/miscon/miscon4.html>

Recurring Science Misconceptions in K-6 Textbooks. This site is designed by a research engineer at the University of Washington who explains and corrects dozens of misconceptions.

Assessment Suggestions

- Use a K-W-L-H chart to record class responses and assess group progress. A large, poster-size chart can be hung on the

wall and fill in during the unit. Individual ones could be used and kept in the students' log books.

- Write analogies that illustrate what happens to light when it enters another medium.
- Pantomime what happens when light is refracted. You could use props to represent different mediums. Have students act out reflected light and have them make comparisons between the two types – refracted and reflected. This is an example of incorporating movement into the class – even into assessment.
- Have groups of students show prism dispersion with yarn. Provide each group with the seven major colors of the spectrum as well as two lengths of white yarn. (Strips of colored butcher or construction paper could be used.) Use one length of white yarn to construct the outline of the prism. The other represents the white entering the prism. Use the seven colored strands of yarn to show what happens. Check for entry angle of white yarn – it should not be perpendicular to the entry face of the prism. The colors should be in order. To include more beneficial physical movement, use longer lengths of yarn. Have the students work in the hall, gym, or outside.
- Inside Outside Circles. Have the class form two circles. The inside circle faces the outside circle. Instruct the inside circle to explain what refraction is to their partners in the outside circle. Ask the outside circle to clarify or make corrections. Have the inside circle move three places to the left and tell their new partner about refraction (or how a prism works, etc.) This activity gives students a chance to move around and explain concepts in their own words. It provides the teacher an opportunity to make informal assessments.
- Student journals or the worksheets included in the activities are good assessment tools.

Curriculum Extensions/Adaptations/ Integration

For advanced learners:

- Students can research how lenses work in microscopes, telescopes, and prescriptive glasses.

There is an interesting explanation and demonstration of how “motion cards” work using refraction. (The pictures on motion

cards change depending on the angle you hold them.) The How Stuff Works website is one good source of information.

- The color spectrum is actually made up of dozens of colors—not just the main seven. Students could research word colors (teal, cyan, fuchsia, magenta, etc.) find samples and make posters for display. This would be a useful resource for more “colorful” writing. The internet has several good sites with lists of colors and pictorial representations. The site http://www.main.cz/colors/color_names.htm has color names in six different languages.

For learners with special needs:

Post science objectives on a wall along with science words students should use. Have students work in pairs and groups. Strategies to help English Language Learners and other special needs learners are incorporated into this unit. They include: use hands-on activities, work in collaborative groups, model expected behavior and how to complete a task, provide real material to help make concepts concrete, prepare multiple forms of assessment, utilize graphic organizers, and minimize lecture format.

Family Connections

Look for objects at home that bend light and create rainbows or spectrum. One item to consider is, white light reflecting off beveled mirrors. (New vocabulary word—sloping or slanted). Some examples of faceted objects (many small surfaces) are pendants, cut glass bowls, diamond rings, CDs, soap bubbles, and spray from a hose.

Provide a list of websites and encourage families with computers and internet connections to explore some of these excellent sites, other families could visit a local library.

If you have a good color printer, print out one of the color charts from the internet, or find color charts at a paint store. Have students find examples around school and at home. Students might be given just one family of colors such as red and look for items that match the various shades (pink, rose, maroon, etc.).

Additional Resources

Books

Science Alive: Light, by Crabtree Publishing Company ISBN 0-7787-0560-9

The Science Book of Light, Neil Ardley; ISBN 0-15-200577-3

Light and Optics, John Farndon; ISBN 0-7614-1090-2

Videos

Light, Series in Elementary Science. Visual Learning Company, © 2004. ISBN 1-59234-084-0, 1-800-453-8481

Light Optics, Bill Nye, (Disney Educational Productions) Product ID 68A86VL00 1-800-295-5010

Light and Color, Bill Nye, (Disney Educational Productions) Product ID 68C01VL00 1-800-5010

Name _____

Refraction Experiment Log

Question: _____

Prediction: I think that _____
 because _____

Materials needed: _____

Procedure:

Step 1 _____

Step 2 _____

Step 3 _____

Step 4 _____

My variable is: _____

My controls are: _____

Results:

	Liquid #1 water	Liquid #2	Liquid #3	Liquid #4	Liquid #5
Distance of focal point from bottle					
Angle of Focal Point					

Conclusion:

Planning Form for Inquiry-Based Science Exploration

Group Members:

We observed this event:

It made us wonder about:

We are going to investigate this question:

We predict these findings:

To answer this question, we will do these things:

During our investigation we will record the following:

We will use this type of graphic organizer to record our data:

Prisms and Rainbows

Part 1: Using the Prism Box with light from a bulb

Observations:

Describe all the colors you see. Look carefully. You may be able to identify dozens of different colors.

List the 7 major colors in the rainbow in the order they appear.

Which color is on the top?

Which color is on the bottom?

Draw a side view of the Prism box. Imagine one of the side walls has been removed. Include the light source, the path through the prism and out the other side. Make sure you accurately show the angle of the prism to the light source that produced the clearest image of a rainbow.

Define the words:

Refraction

Prism

Spectrum

Part 2: Using the Prism Box with light from the Sun

Position the box so that Sunlight is able to pass through the prism and cast a rainbow on white paper on the bottom of the box. Draw the rainbow.

Describe all the colors you see. Look carefully. There are many more than just the major seven.

List the order of the colors you see starting with the one on top.

Draw a side view of the Prism box. Imagine one of the side walls has been removed. Include the light source, the path through the prism and out the other side. Make sure you accurately show the angle of the prism to the light source that produced the clearest image of a rainbow. Show how high in the sky the Sun was. If you had to tip the box at an angle, measure and record that angle.

Are there any differences between the rainbow from the bulb and the rainbow from the Sun? Explain your answer.

Explain why the angle of a prism to the light source determines whether it is able to cast a rainbow.

K-W-L-H CHART

The concept we are learning _____

What We Know	What We Want to Find Out	What We Learned	How Can We Learn More

Science V

Activities

Microorganisms

And the Bacteria Ran Away with the Petri Dish

Standard V:
Students will understand that microorganisms range from simple to complex, are found almost everywhere, and are both helpful and harmful.
Objective 2:
Demonstrate the skills needed to plan and conduct an experiment to determine a microorganism’s requirements in a specific environment.
Intended Learning Outcomes:
1. Use Science Process and Thinking Skills.
Content Connections:
Mathematics, Health

Science
Standard
V
Objective
2

Connections

Background Information

Bacteria are so small that about 1,000 could fit on the head of a pin. Bacteria are classified into three groups according to their shape: round (cocci), spiral (spirilla), and rod (bacilli) shape. Some round shape bacteria can cause infections in people. Some spiral shape bacteria are used to make cheese. Some rod shaped bacteria have been known to cause food poisoning.

There are more than 10,000 kinds of bacteria and an unknown number still waiting to be discovered. The human body has more bacteria than it has cells. An unborn baby is completely free of bacteria, but the instant they are born they acquire billions of bacteria. Bacteria are essential for a healthy body.

All bacteria have similar characteristics. They are made up of a single cell with a cell wall and do not have a nucleus. Some bacteria can make their own food, but a large majority feed on other organisms. In addition, most bacteria need oxygen to survive.

When people become sick, they go to the doctor’s office expecting a miracle cure. Most often, the best advice often times is to go home, drink lots of fluids and rest. Many people are unsatisfied with that response and demand something to end their suffering. So many of these complaints are viral, yet there is no medication available to combat a viral infection. Doctors may prescribe antibiotics, but it cannot treat the illness at hand. As a result, antibiotics can become overprescribed and misused. Over time, the microbes will become resistant and the antibiotics will become ineffective.

Research Basis

Eick, Charles J. (2002). Science curriculum in practice: Student teachers' use of hands-on activities in high-stakes testing schools. *NASSP Bulletin*, Volume 86, pp. 72-85.

“Hands-on, minds on” teaching methods develop a deeper understanding of science concepts and processes. Studies found that limiting instruction to facts and skills and eliminating hands-on inquiry can place already at-risk students at a greater risk of failure on high-stakes testing. Teachers that used investigative inquiry prompted high-order thinking and questioning, and thus obtained higher test scores. The researchers emphasized an integrated curriculum that incorporated testing objectives into courses of study.

Office of Educational Research and Improvement. (1993) *Transforming ideas for teaching and learning science: A guide for elementary science education*. [Guide]. Washington, DC: Siversten, M.L.

Science education reform is a must. Science education must focus on the big ideas and be taught on a daily basis to all students. The researchers stress that hands-on inquiry based learning and experimentation are extremely effective teaching strategies. Instruction should focus on the essential key concepts or ideas, not the memorization of facts and theories. Teachers should be facilitators of student learning by engaging them in active learning projects.

Invitation to Learn

Display on the overhead *Antibiotics: The Cure All?* Read aloud, and then have the students think, pair, and share their ideas to these questions for three minutes. Share as a class, the key ideas students talked about.

We are going to stimulate bacteria infecting a human and how the treatment of antibiotics effects the bacterial infections.

1. Pass out the materials: three small baggies labeled #1, #2, and #3, a small magnet, and a plastic comb, with every other tooth removed. One set is needed for each partner group or small group of students.
2. Take out the contents in Baggie #1. This is a model of a population of infectious bacteria that is making a human very sick.
3. Hold up one “bacterium” (paper clip) and discuss the plural and singular form of bacteria. Go on to discuss the growth process. Bacteria reproduce by binary fission: one bacterium divides in half to produce two new bacteria, each one is genetically identical to each other. They are clones, unless a

mutation occurs. Have the students model the growth of the bacteria with the paperclips. For example, start with one and it reproduces two bacteria and then those two reproduce to make four. How many times has it reproduced when you get to 32? Record on the board. For example: 1 bacterium= 2 bacteria, 2 bacteria = 4, and so on. Save chart for a later extension activity.

4. The comb represents an antibiotic that has been given to the patient. Move the comb through the bacteria population, hooking the bacteria on its teeth, until no more bacteria can be destroyed. This represents the drug treatment to cure the patient. How many times did you have to use the antibiotic to destroy the bacteria? Are there any bacteria left after the treatment?
5. There is a single bacterium left. It has something in its biological make-up that enables it to resist Antibiotic A. This might be a mutation, although other mechanisms are known by which antibiotic resistance can develop.
6. This lone bacterium begins to reproduce. Take out Baggie #2 and remove the contents. Again discuss how the bacteria reproduce. Have the students discuss binary fission again, if needed. Pass the comb over this new generation of bacteria. What effect does the antibiotic have now?
7. If Antibiotic A is no longer effective, try a new antibiotic (the magnet, which is Antibiotic B). Pass the magnet over the population of bacteria several times until no more bacteria are destroyed. How many times did you have to use the antibiotic to destroy the bacteria? What is left?
8. Again, there is one survivor of the antibiotic treatment—it is resistant to Antibiotic A and Antibiotic B.
9. Baggie #3 now represents the new offspring. Empty the contents on the table. Try to kill these bacteria with both Antibiotic A and Antibiotic B. What happens?
10. Discussion: This brief activity illustrates how antibiotic resistance evolves in a population. Due to this evolutionary process, many strains of bacteria have become resistant to one or in some cases several of the antibiotics that formerly used to control them. How will this affect future generations?



Materials

Per small group or per student:

- Antibiotics: The Cure All?* (Overhead)
- Plastic comb
- Small magnet
- Plastic baggie #1 (31 small vinyl-coated paperclips, each with one end bent upward, and 1 normal, unbent paperclip)
- Plastic baggie #2 (30 (unbent) vinyl-coated paperclips and one plastic paperclip)
- Plastic baggie #3 (31 plastic paperclips)

Whole Class

- Hot plate
- Beef bouillon cubes
- Unflavored gelatin
- Petri dishes
- Sterile swabs (Q-tips work)
- One tablespoon
- One cup
- What? There are How Many?*
- Mold: It is Lovely to Behold, but not to Hold*
- Bread Mold Data Sheet*
- Directions for Making a Mini Lab Booklet*

Instructional Procedures

Day One:

1. Model how to make a cheap and easy Culture Medium:
Makes six Petri dishes. Adjust the recipe to fit the size of your classroom.

RECIPE: Use a hot plate to heat water. Stir one tablespoon of plain, unflavored gelatin and one beef bouillon cube into one cup boiling water. Stir constantly until the gelatin and cube dissolve completely. Pour a thin layer of the liquid in each Petri dish. Cover each Petri dish quickly to avoid contamination. Wait until gelatin sets before adding bacteria.
2. Make enough for each student to have one set aside for Day two's lesson.
3. Brainstorm in science journal of all the places that bacteria can be found.
4. Have a class discussion about the numerous places that bacteria could be found. Tell the students that we are going to conduct an investigation on bacteria. We are going to focus on two different locations and compare the bacteria growth in these locations. Each student must come up with a different location to test. Model an idea for the students. For example, test your hand and a student's hand. Write the question on the board: Which will cause more bacterial growth: the teacher's hands or the student's? Write a hypothesis: I hypothesize that a teacher's will have more then the bacteria growth because of the numerous people and objects she comes in contact with everyday and she only gets a break to wash her hands at lunchtime.
5. Record ideas on the whiteboard. Examples of ideas: bathroom door handle, light switches in different aged classes, class computer versus lab computer, and different aged classes' desks. Be ready with ideas. Give the students think time to come up with creative ideas. It is fun to compare classes and grade levels.
6. After recording all the ideas on the whiteboard. Develop a question and a hypothesis as a class for one of the student's ideas. Then, students will write their own question and hypothesis in their science journal. Model repeatedly if needed. Have the groups review over their questions and hypotheses for improvements and clarifications.

7. Take Home Assignment: Students need to take home their science journal and discuss their question and hypothesis with their parents. Together, the student and the parent can write predictions.

Day Two

1. Discuss the at-home assignment and the questions and hypotheses.
2. Pass out Petri Dishes and have the students divide the Petri Dishes into two parts and then label the with student name and locations of samples to be taken.
3. Demonstrate the procedure to swab the Petri Dishes. Choose two different playground balls: soccer and basketball. Swab them with a Q-tip in about a two-inch square area and open the Petri Dish and gently make streaks on the plate's surface. Use firm, but gentle pressure and do not retrace your previous streaks. Discard the Q-tip. Repeat the same procedure with the other ball and swab on the other side of the Petri Dish. Completely seal the Petri dish with four pieces of clear tape. Store the Petri Dish in a dark, warm, and dry place.
4. Have the students complete their experiments. Store the Petri Dishes with the other modeled Petri dish. A copy paper box is a great holder.

Day Three to Eight

1. Each day for five days, take about 15 minutes to have the students record their data. See handout for recording. It turns into a great mini-booklet. Students record observations. Which streaks have more microbes? Do you see a pattern? How do your result compare to other results? How can you describe your findings accurately, with a ruler, comparing to another object, or by color and shape.
2. Have the students create a mini-poster of their findings.

Assessment Suggestions

- Make a mini-poster.
- Completing a five day observation journal of Petri Dishes.
- Active participation in class discussions.

Curriculum Extensions/Adaptations/ Integration

- Research the development of antibiotics.
- Invite a doctor or science specialist to give a presentation.
- Mathematics Story Problem: Complete *What? There are How Many?*

Family Connections

- Discuss possible experiments and precautions to take prior to sending the activity home. Grow mold samples at home. See handout *Mold: It is Lovely to Behold, but Not to Hold*.
- Send home the *Bread Mold Data Sheet* for the students to share information with family while they're performing their experiments.

Additional Resources

Books

Bill Nye the Science Guy's—Great Big Book of Tiny Germs, by Bill Nye; ISBN 0786805439

The Demon in the Freezer, by Richard Preston; ISBN 0345466632

Germ Killers—Fighting Disease, by Sally Morgan; ISBN 1588106993

Germs Make Me Sick! by Melvin Berger; ISBN 0060242507

Guide to Microlife, by Kenneth G. Rainis; ISBN 0531112667

Gross But True Germs—A Scientific Inquiry Into The Exciting World of Viruses, Fungi, and Bacteria, by Luann Colombo; ISBN 068981495

The Hot Zone, by Richard Preston; ISBN 0385479565

Intimate Strangers- Unseen Life on Earth, By Needham, C.; Hoagland, M.; McPherson, K.; Dobson, B.; ISBN 1555811639

Invisible Allies- Microbes That Shape Our Lives, by Jeanette Farrell; ISBN 0374336083

Kingfisher Knowledge—Microscopic Life, by Richard Walker; ISBN 0753457784

Microbes By Kids Discover; ISBN 1054-2868

Micro Monsters—Life Under the Microscope, by Christopher Maynard; ISBN 0789447568

Mysterious Microbes—Microscopic Monsters and Vile Monsters! by Steve Parker; ISBN 0811423441

The Smallest Life Around Us—Exploring The Invisible World of Microbes with Eight Easy At-Home Experiments, by Lucia Anderson; ISBN 0517532271

Videos

Body Story Out of Control, by Discovery Channel Video, VHS#763813

Articles

Evolution of Antibiotic Resistance, by Alan Gubanich, Science News

Before the Next Epidemic Strikes, By L.W. Winik, Parade Magazine

Web sites

Antibiotic Resistance

http://www.fda.gov/fdac/features/795_antibio.html

<http://whyfiles.org/038badbugs/>

<http://www.niaid.nih.gov/factsheets/antimicro.htm>

Bacteria

<http://www.cellsalive.com/ecoli.htm>

<http://www.cellsalive.com/howbig.htm>

http://www.virology.net/Big_Virology/BVHomePage.html

Free Video- <http://www.foodsafety.gov/~fsg/teach.html>

<http://www.ucmp.berkeley.edu/bacteria/bacterialh.html>

<http://www.amnh.org/exhibitions/epidemic/>

<http://www.amnh.org/nationalcenter/infection/>

<http://microbeworld.org>

Organizations

Centers for Disease Control and Prevention

1600 Clifton Road

Atlanta, GA 30333

(404) 639-3534

(800) 311-3435

<http://www.cdc.gov>

National Immunization Hotlines

(800) 232-2522 (English)

(800) 232-0233 (Spanish)

Antibiotics: The Cure All?

- 1. Have you taken any antibiotics in the past year? Why were antibiotics prescribed for you? Did you or your doctor know that you had a bacterial infection?**
- 2. Did you take the medication at the dosages and intervals prescribed and take it for the entire recommended course of treatment? If not, why not?**
- 3. Do you know why it is important to finish all prescriptions, even if your symptoms have cleared up?**

What? There are How Many?

When bacteria have ideal growing conditions- moisture, temperature, and food- it reproduces (splits into two microbes) every twenty minutes. This is called bacterial fission.

***REMEMBER our experiment of antibiotic resistance, how does this relate? ***

At 12:00 one infectious bacterium reproduces, now there are 2.

At 12:20 two bacteria each reproduce and now there are 4.

- Interesting Note: When a microbe grows to a certain predetermined size, it divides itself into two microbes instead of growing into a bigger animal with many cells.

How many bacteria will they be in 12 hours? 24 hours? 2 days?

Show all work. Please sure to include a written description of your answer.

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Show all work. Please sure to include a written description of your answer.

Mold: It is Lovely to Behold, but not to Hold

A FAMILY ACTIVITY

For Your Information: Microscopic mold spores are EVERYWHERE including the air, water, and soil. Molds are microscopic plants. Molds grow from tiny particles called spores, which travel through the air. Food additives are substances added to foods during processing to either help preserve them, improve color or flavor, or make their texture more appealing. Chemists have also devised food additives that inhibit (slow down) the growth of molds.

YOUR QUEST IS TO COME UP WITH AN EXPERIMENT INVOLVING BREAD MOLDS!

Materials needed:

- Bag of Bread
- Plastic Ziploc Baggies

IMPORTANT NOTE: Once you have begun bread mold growth in the plastic bags, DO NOT OPEN the plastic bags again.

Sample Question: What affect will *temperature* have on bread mold growth?

Sample Hypothesis: Use the “if, then, because” model to write your hypothesis, if possible.

I hypothesize that if the temperature of bread is increased, then bread mold growth will increase because mold grows better in warm places.

Sample Ideas to Explore: BE CREATIVE AND TRY TO COME UP WITH YOUR OWN!

- Affects of light/dark
- Affects of moisture/dry
- Affects of temperature cold/hot
- Affects of different surfaces sink/carpet

Write your own question:

Write your own hypothesis:

BREAD MOLD DATA SHEET:

For your information
Share with your family and find out more!

Visit this website to see a video about bread mold:
<http://www.Flowersbakeries.Com/kidsbreadmold.Html>

Are bread molds plants?

- Yes, there are! Strangely, even though bread molds are plants, they DO NOT have chlorophyll. Most green plants use chlorophyll to make food during photosynthesis. Without chlorophyll, mold uses food made by others.

What does bread mold look like?

- Bread mold looks like small black dots connected with silky white threads. The white threads spread around and develop the small dots. The dots are spore-producing organs. As the organs mature, thousands of tiny spores from each dot are spread around by the movement of air, like a dandelion.

How does mold digest food?

- Mold digests food different than you and I do. The digestive fluids spread out in the food and break it down into simple nutrients. Then the simple nutrients pass through the cell membranes of the mold. Mold breaks down dead organisms into raw materials, so plants can use it in their food-making process.

Why are blue-green bread molds important?

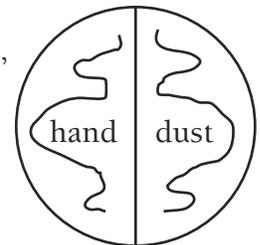
- Well, they have been around for awhile. Professor Alexander Fleming of London used the molds to make a wonder drug called penicillin in 1928. He was studying microorganisms that caused boils and other infections in people. In one of his Petri dishes a blue-green mold colony grew by accident. He was surprised to find that the boils were killed by the blue-green mold. A product of the blue-green mold destroyed the microorganism. Professor Fleming named the product that kills microbes penicillin. Penicillin kills many common bacteria.

Directions for Using Bacterial Petri Plates

1. The plates are reasonably sterile but it is always a good idea to have a control plate to show student that the agar (jelly-like stuff on the plates) will not grow bacteria without be exposed a source of bacteria. Pick one plate and do not open it. Label the bottom of the plate “control” with a water-proof marker. Tape the plate shut. Place it in the same location as the other plates.
2. To expose the agar to bacteria it is important to open the lids for as short a time as possible and no wider than needed. The agar is soft and its surfaces should not be broken during the exposure. A gentle rub with a q-tip or fingertip will be all that is needed. The following types of exposures are recommended:
 - The pad of a finger, not washed
 - The pad of a washed finger
 - A minute or two of exposure to the air
 - Dust from a corner
 - A wet Q-tip rubbed across the surface of a desk, floor or door handle.

The following are NOT recommended:

- Spit or mouth swabs,
 - Skin, ear or foot swabs (any body surface other than fingers)
 - Toilet swabs
3. The bottom on the plate should be labeled and if a large plate is used, a line may divide two different exposures.



4. The beef broth nutrient agar used for the plates typically does not grow harmful bacteria. Avoid using blood agar plates. They are red in color and can grow harmful bacteria. To be safe with any agar, do not open the dish once it has been exposed. All observations can be done looking through the lid. Dispose of the plates by placing them in a plastic bag, securing it shut and placing in a dumpster. If a dumpster is not available, heat the plates for 15 minutes in a pressure cooker before disposing in a trash can.

Once Upon a Pond

Science
Standard

V

Objective

1

Connections

Standard V:

Students will understand that microorganisms range from simple to complex, are found almost everywhere, and are both helpful and harmful.

Objective 1:

Observe and summarize information about microorganisms.

Intended Learning Outcomes:

1. Use Science Process and Thinking Skills.

Content Connections:

Health Education, Writer's Workshop

Background Information

Microorganisms thrive in every ecosystem on Earth. They range in complexity from simple to multi-cellular organisms. Microorganisms require food, water, air, ways to dispose of waste and an environment to thrive in. There is an abundance and variety of microscopic life found in pond water, even frozen pond water and geysers. A healthy pond may have from 500 to 1,000 different species of microscopic organisms. These organisms are essential to the balance of the pond ecosystem.

Pond water is an excellent place to investigate single cells that behave as independent organisms. These organisms seem relatively unchanged from ancient times. Yet, the environment of a pond is ever-changing and no two ponds are ever exactly alike. Some major types of organisms found in ponds are algae, amoebas, and paramecium.

Some students struggle to find these microorganisms in pond water. It is highly advisable to view your samples of pond water prior to the class. Pond water can be collected all year, but be sure to include soil, pond scum, and small plants to insure success. Iodine makes the microorganisms easier to identify. Within a cell, sugar is changed by a chemical process into starch. Dilute iodine stains the starch to a blue-black color.

Research Basis

Harlen, Wynne. (2001). Research in primary science education. *Journal of Biological Education*, 35 (2), Pages 61-5.

Brain research on learning has provided the strongest arguments for including hands-on science in the primary curriculum. Science instruction can take many forms, but the key components need to include: hands-on experimentation, higher order questioning, and

inquiry. Children have many misconceptions on scientific topics, researchers found that formulated key questions were able to clarify misconceptions and expand knowledge during and after a lesson.

Huber, Richard A. (2001). A model for extending hands-on science to be inquiry based. *School Science and Mathematics*, 101.1 pp. 32-42.

Discrepant events are excellent springboards to engaging students and promoting full inquiry investigations in the class. Many teachers felt overwhelmed trying to create hands-on lessons. The researchers found the situation was improved when the entire school bought into the idea, time was made for grade level collaboration, and teacher training was made available. Simple strategies were used that dramatically improved the learning, i.e., brainstorming as a class on inquiry ideas.

Invitation to Learn

Place a small amount of Glo-Germ on your hands and shake the hands of every student in the class as they enter. Important reminder: a small amount goes a long way. Variation: Pass out a small amount to each student and have them rub it their hands (e.g., fingernails, palms and tops of hands)

Have a piece of chart paper with the question written on it: When was the last time you washed your hands? What have you done since the last time? Have the students conduct a quick pair share conversation about hand washing for two minutes. Then, ask the class to share whole class some ideas. Record ideas.

Finally, pass around the ultraviolet light. Have the students look at your hands on what to their hands to see how germs were spread by simply shaking hands. Glo-Germ Products are made of tiny plastic particles that are only visible under an ultraviolet light. The fluorescent glowing particles are to simulate “germs.” Discuss findings. Have the students think about what would remove more of the powder and what would be the most effective procedure for washing hands.

Critical Thinking Questions: How much time is needed for effective hand washing? How hand washing affects microbes? Can the microbes on your hands have a serious effect on your personal health? How will your hand washing habits change?

Share with class if it wasn’t brought up in the discussion: Hand washing is the easiest way to prevent the spread of diseases and infections. Studies have found that only 68% of Americans wash their hands after using the restroom. There are millions of microbes on your hands. Many are harmless, but some are disease causing. Hand washing

with plain soaps suspends the microbes and allows them to be rinsed off. Antibacterial soaps inhibit the growth of microbes. Many studies have found that washing hands with soap and vigorous rubbing for as long as it takes you to sing Happy Birthday is the very effective in removing harmful bacteria.

Instructional Procedures

Materials

- Glo-Germ Liquid
- Ultraviolet Light
- Chart paper
- Once Upon a Pond #1*
- Various samples of pond water
- Microlife Mix Dry Culture
- Small containers for pond water
- Using Your Microscope: Procedure to Make Wet-Mount Slide (Overhead)*
- Pond Life Identification*
- Microscopes
- Pipettes
- Cover slips
- Microscopic slides
- Diluted Iodine (10 droplets to one cup)
- Powerpoint Presentation (created from pictures found in websites-site source)
- Once Upon a Pond #2*
- Do Science With Your Family*
- Family Activity Discussion Points*
- Rubric for Science Journal*
- Rubric for Microorganism Brochu*

Two to three days prior to the lesson: Collect water from a pond in a wide-mouthed glass jar. Scoop up the scum and algae on top of the water. To insure success include a small bit of Microlife Mix Culture. It is a specially formulated mixture that contains a variety of microhabitat materials, including bacteria and nutrients to support microlife growth. It will help grow bacteria and other single-celled organisms in 24 hours and larger microinvertebrates will appear within a week. The Microlife Mix Culture can be safely stored for years without special handing.

Borrow or check out microscopes for your class from your school or district media center. It is optimal for each pair of students to have a microscope.

Begin Lesson: It works best to have the student move the desks into groups of four and organize materials prior to beginning the lesson. This will lessen the chances of pond water being spilled or microscopes being knocked over.

1. Pass out *Once Upon a Pond Worksheet #1*. Discuss what the worksheet is asking the students to do.

OPTION: Use the prepared worksheets or have the students record in their science journals. Use the Worksheets as guidelines to what needs to be in the science journal. Make the worksheets into overheads. Some students do better with freedom to express their findings.

2. After working for two minutes by themselves, stop them and ask for a table discussion about what is in the pond water. Give them two minutes to discuss as a group. Then, have the students resume working individually or in partners (whatever is your comfort level).
3. Give the students five to seven minutes to complete the activity worksheet, *Once Upon a Pond Worksheet #1*.
4. Have a short class discussion about findings. Chart predictions and post.



5. Have a short discussion and display the Utah State Standard, we are trying to achieve. Give an overview of what students will be doing and show the rubric of what is expected of the students. Review over lab rules.
6. Model the procedure for making a wet mount slide prior to the students experimenting. Model for the students how to make a wet mound slide. Refer to *Using Your Microscope: Procedure to Make Wet-Mount Slide Overhead*. *Important note:* Wait until after modeling, to pass out materials or students might be distracted by materials on desk and have a hard time focusing on the discussion.
7. Place a microscope at each group. Then, have one student gather the materials (paper towels, pipettes, slides, cover slips, small container of diluted iodine, *Once Upon a Pond* Worksheet #2, and a *Pond Life Identification* chart). HINT: It is easiest to place a note card of how many each partner group will need.
8. This is a large portion of the lab. Each class will take varying amounts of time. Some students may become frustrated with locating microorganisms in the microscopes. It is important to be actively monitoring the students to assist as needed. Have students record their findings on *Once Upon a Pond* Worksheet #2 or in their science journal. Important Note: Students may find cool things and want to share with other students. Have a set procedure for viewing others student’s microscopes.
9. After ten minutes, stop the students and show them a Powerpoint presentation of varying pond organisms. They are amazing pictures on the Internet that can be used in the classroom, see references. This will help focus students on their findings.
10. After other 10-15 minutes, reconvene as a class. Have the students discuss their most interesting, weird, or important findings.
11. Pair students in partners and have them choose a microorganism to study. The topic choices will be the major groups of organisms: bacteria, fungi, or viruses. Students will do research to find out about the microorganism’s requirements, (e.g., food, water, air, waste disposal, temperature of environment, reproduction). They will create a mini-microorganism brochure about their organism. Give the students one week to complete the project.

Assessment Suggestions

- Pre-assessment - Monitoring students and discussing their predictions of what might be found in pond water.
- Completing all the activities: Keeping a detailed record of the science experiment in their science journal. Use rubric, *Rubric for Science Journal* for grading.
- Here are some journal prompts for journal writing: The most interesting part of the experiment was; Today, I experimented with..., Today I observed..., My hypothesis was..., I concluded that..., My next experiment will be..., Today, I learned about..., Another question that I have is...
- Informal assessment: Recorded correctly how to make a wet-mount slide in science journal and is able to demonstrate how to make a wet-mount slide with materials.
- Completed Brochure: Student evaluated rubric, Rubric for Microorganism Brochure.

Curriculum Extensions/Adaptations/Integration

- Language Arts: Read about amazing world microorganisms, see additional resources for materials.
- Writing: Work on descriptive writing and improve vocabulary to describe microorganisms. Complete the writer's workshop on their microorganism report.
- Create a decomposition chamber. Read *Bottle Biology*, by Mrill Ingram; ISBN 084028601.
- Develop a pond ecosystem in the classroom in an aquarium, add snails and other organisms.

Family Connections

- Bring samples of pond water, or other water at found at home or with their parents to view under the microscope.
- At Home Project, *Do Science With Your Family: The Making Of A Windgradski Column*
- Work on microorganism brochure with the family.
- Share with family their findings from the hand washing experiment.

Additional Resources

Books

The Adventures of Micki Microbe, by Maurine Burnham Guymon; ISBN 0961865008

Bottle Biology, by Mrill Ingram; ISBN 084028601

Germ Killers—Fighting Disease, by Sally Morgan; ISBN 1588106993

Germs Make Me Sick! by Melvin Berger; ISBN 0060242507

Guide to Micro life, by Kenneth G. Rainis; ISBN 0531112667

Intimate Strangers—Unseen Life on Earth, by Needham, C; Hoagland, M; McPherson; Dobson, Bert; ISBN 1555811639

Kingfisher Knowledge- Microscopic Life, by Richard Walker; ISBN0753457784

Micro Monsters—Life Under the Microscope, by Christopher Maynard; ISBN 0789447568

Mysterious Microbes—Microscopic Monsters and Vile Monsters! by Steve Parker; 0811423441

The Smallest Life Around Us—Exploring The Invisible World of Microbes with Eight Easy At-Home Experiments, by Lucia Anderson; ISBN 0517532271

Web sites

Hand washing:

<http://www.washup.org/>

<http://www.cdc.gov/ncidod/op/handwashing.htm>

<http://www.glogerm.com/worksheet.html>

Pond Organisms

http://www.hants.gov.uk/sparsholtschoolscentre/ponddatabase/virtual_pond_dip.htm

<http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/pond/>

<http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/pond/index.html>

Additional Media

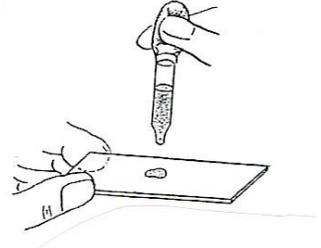
Glo-Germ P.O. Box 189 Moab, Utah 84532 Phone: 800-842-6622 Fax: 435-259-5930

Microlife Mix Culture P.O. Box 22729, Rochester, NY 14692 Phone: 800-526-6689 Item#: E2-80-2001

USING YOUR MICROSCOPE GUIDE

Procedure to Make Wet-Mount Slide

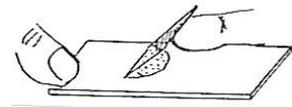
1. Prepare your lab area and organize your materials.
2. Using a pipette, collect a small sample of pond water and place a droplet on a microscope slide.



3. Place one edge of the cover slip on the slide against the side of the droplet of pond water.
4. Add a drop of diluted iodine. Lower the cover slip over the pond water and iodine slowly. If air bubbles are present, gently tap the cover slip with a pencil eraser.

5. Place the slide over the hole in the stage on the microscope.
6. View the slide at the lowest magnification.

7. Look through the eyepiece of the microscope with both eyes open.



8. Slowly focus.
9. Repeat process at a higher magnification.
10. Record observations.

Once Upon a Pond Worksheet- #1

1. Observe the container of pond water. Record what you see.

2. Is there anything living in the pond water? Yes or no, justify your answer.

3. BRAINSTROM: What would you expect to see if you looked at a sample of water under the microscope? Draw your prediction.

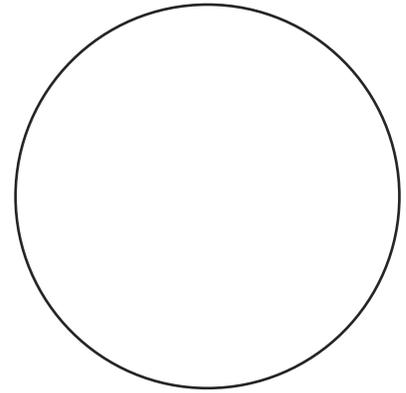
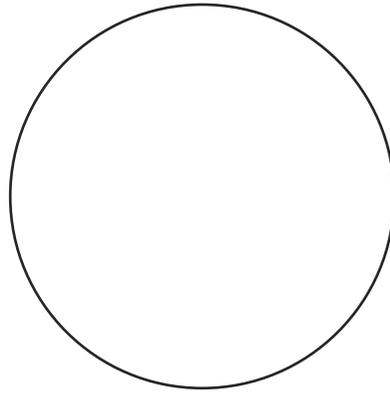
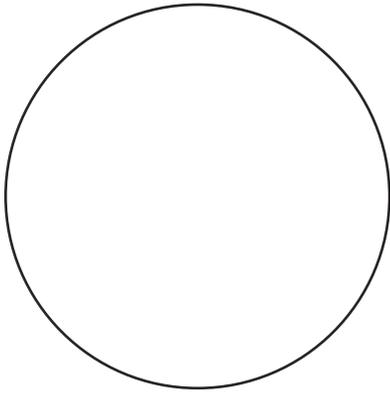
Once Upon a Pond Worksheet #2

Sample #1 Label any of the organisms that you can find using the identification sheet.

_____Magnification

_____Magnification

_____Magnification



Written Description of Findings on size, shape, color, population, and movement:

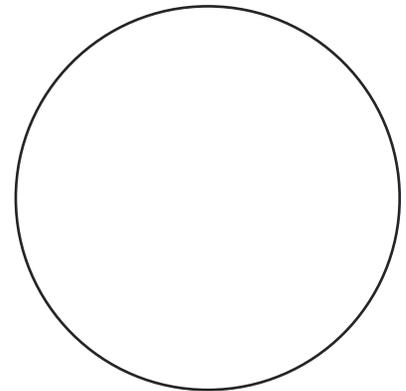
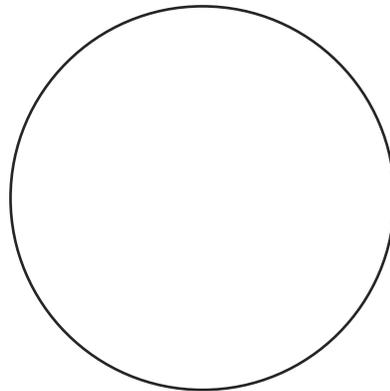
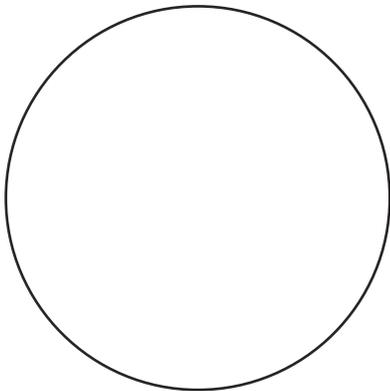
Compare and contrast two microorganisms found in the pond by size, shape, and/or movement.

Sample #2 Label any of the organisms that you can find using the identification sheet.

_____Magnification

_____Magnification

_____Magnification



Written Description of Findings on size, shape, color, population, and movement:

Compare and contrast two microorganisms found in the pond by size, shape, and/or movement.

Name _____

Rubric for Science Journal

This lab journal is completed to the best of my ability.

X _____

(Student Signature)

Standard V: Students will understand that microorganisms range from simple to complex, are found almost everywhere, and are both helpful and harmful.

Objective 1: Observe and summarize information about microorganisms.

<u>Teacher</u>	<u>Criteria</u>	<u>Student</u>
0, 5, 10	Completed all journal questions and wrote down information accurately	0, 5, 10
0, 5, 10	Provided detailed descriptions using scientific terms	0, 5, 10
0, 5, 10	Illustrations are clear and labeled	0, 5, 10
0, 5, 10	Described how to make a wet-mount slide	0, 5, 10
0, 5, 10	Demonstrated correct lab procedures and remained on-task	0, 5, 10
0, 5, 10	Overall Appearance-Neatness, Grammar, Organization	0, 5, 10
Total	FINAL GRADE	Total

Review what you learned today:

Name _____

Rubric for Microorganism Brochure

This lab journal is completed to the best of my ability.

X _____

(Student Signature)

Standard V: Students will understand that microorganisms range from simple to complex, are found almost everywhere, and are both helpful and harmful.

Objective 1: Observe and summarize information about microorganisms.

<u>Teacher</u>	<u>Criteria</u>	<u>Student</u>
0, 5, 10	Completed all journal questions and wrote down information accurately	0, 5, 10
0, 5, 10	Provided detailed descriptions using scientific terms	0, 5, 10
0, 5, 10	Illustrations are clear and labeled	0, 5, 10
0, 5, 10	Described how to make a wet-mount slide	0, 5, 10
0, 5, 10	Demonstrated correct lab procedures and remained on-task	0, 5, 10
0, 5, 10	Overall Appearance-Neatness, Grammar, Organization	0, 5, 10
Total	FINAL GRADE	Total

What have you learned from doing this report?

What are you proud of on this report?

What would you improve for next time?

Have you ever noticed that when you dug in soil it is different colors? WHY?

DO SCIENCE WITH YOUR FAMILY

THE MAKING OF A Windgradski Column

TIME REQUIRED: This activity will take 4 to 8 weeks to complete.

MATERIALS:

- 2-liter clear soda bottle
- Full sheet of newspaper
- Bucket
- 1 Tablespoon of crushed chalk
- Funnel
- Small piece of foil
- 4 cups of mud from pond
- 4 cups of mud from another source (i.e., lake, garden, stream, forest, yard)
- Paint stick stirrer

WHAT TO DO:

1. Shred a newspaper into very small pieces. Set aside.
2. In a small bucket add 8 cups of soil. Remove all the sticks, leaves, and rocks.
3. Slowly add water until it is like thick cream. (Different soils will require varying amounts of water)
4. Add newspaper and 1 tablespoon of chalk.
IMPORTANT: Keep mixing until it can be easily pour through a funnel.
5. Remove all the labels from the 2 liter bottle.
6. Using a funnel add approximately 1 centimeter of the mixture.
7. Tap the bottle to settle the mixture evenly.
8. Continue adding soil and tapping every few centimeters until you reach about 5 centimeters from the top.
9. Cover with foil.
10. Place it in a warm, well lit place, but NOT in direct Sunlight. DO NOT move it!
11. BE PATIENT! It takes about six weeks to notice any change.
12. Observe and record changes. What questions arise from your results?
13. Draw and label your column each week. Keep a lab journal of your findings.
14. If your soil dries up, add 3 tablespoons of water. Check to make sure it is not getting direct sunlight or extreme heat.

CHALLENGE: can you think of a scientific investigation with your column.

Interesting Facts:

- The Winogradsky column is named about the Russian microbiologist who studied how bacteria recycle sulfur in nature.
- Photosynthetic bacteria are found in soil. They need light to grow.
- Different substances added to the column change the microbe growth.

FAMILY ACTIVITY DISCUSSION POINTS

Introduction of Home Project: Model a fresh made column and an old column. Possible questions to explore.

- Are there living organisms in water? Mud?
- Do the bottles look like they contain the same material?
- If they contain the same materials, why do they look different?
- What do you think the different colors in the bottles represent?
- What is the difference between the two bottles?
- What is the same?
- How would you test the hypothesis that light is essential for photosynthetic microorganisms?

Possible Experiments Results after 6 weeks

Why are there different colors in the bottle? What causes the red, orange, green, white and black colors?

Red and orange patches are purple photosynthetic bacteria. Green patches at or near the surface of the mud are bacteria and algae. Olive-green patches in the middle or lower part of the jar are green sulfur bacteria. The black patches are iron sulfide, a chemical formed by certain bacteria.

Why do some colors appear in one part of a bottle and not another?

The patchiness you see is the result of the formation of microenvironments--that is, different communities of bacteria that live in different specific conditions.

What would happen if you kept the bottle in a dark closet?

A jar or bottle kept in the dark will not show any growth of bacteria because light energy is critical to the development of photosynthetic creatures. That does not mean there are no living microbes in the jar, however. Not all microbes need light to grow.

What would happen if you kept your bottle in direct Sunlight? Extreme heat?

A bottle kept in direct Sunlight may not show any growth because the high light intensity retards photosynthesis and the extreme heat can stifle growth.

A jar or bottle kept in intense heat will not show growth, unless the soil you collected came from a hot spring. That's because most living things can't survive temperatures hotter than 120 degrees Fahrenheit (50 degrees Celsius). For comparison, your body temperature is 98.6 degrees Fahrenheit.

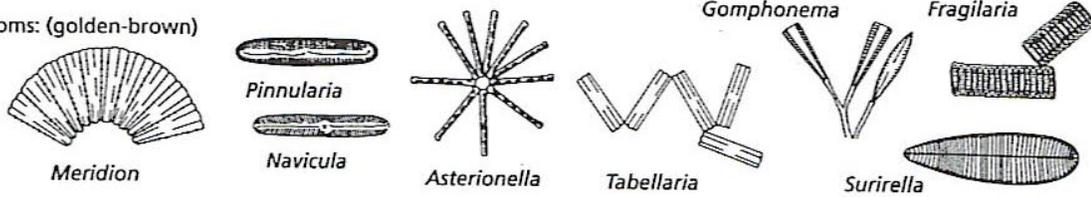
What would happen if you covered you bottle with different colored plastic wrap?

If the bottles or jars are covered with colored cellophane, different microbes will grow because different ones need different colors of light to thrive. For example, purple sulfur bacteria need red to near infrared light, while green sulfur bacteria need green to red light. And bacteria need blue to green light.

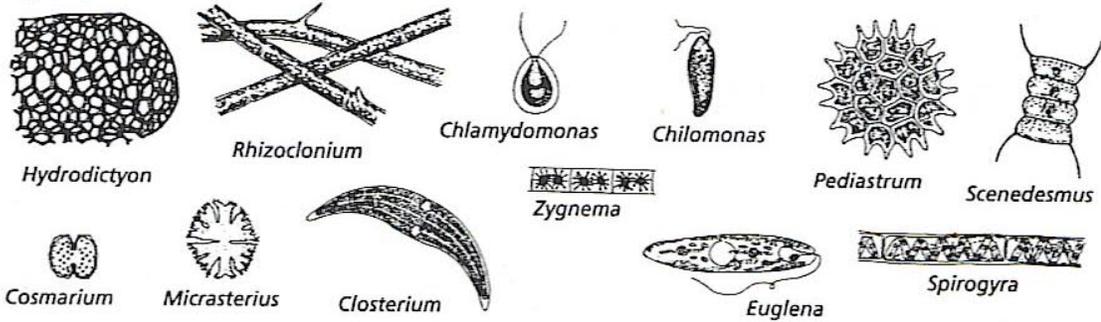
Adapted from Keepers of the Biosphere.

Pond Life Identification

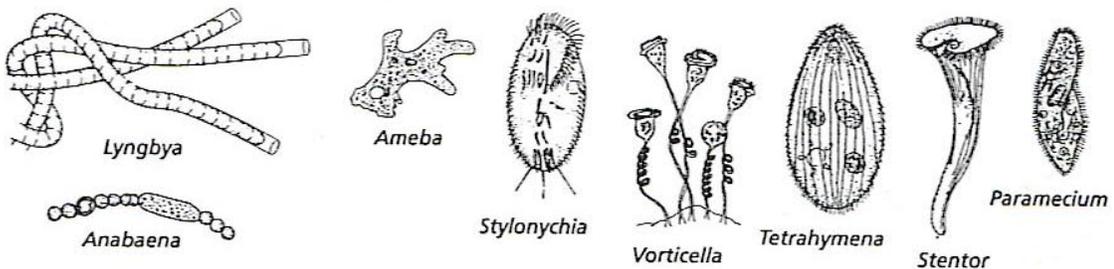
Diatoms: (golden-brown)



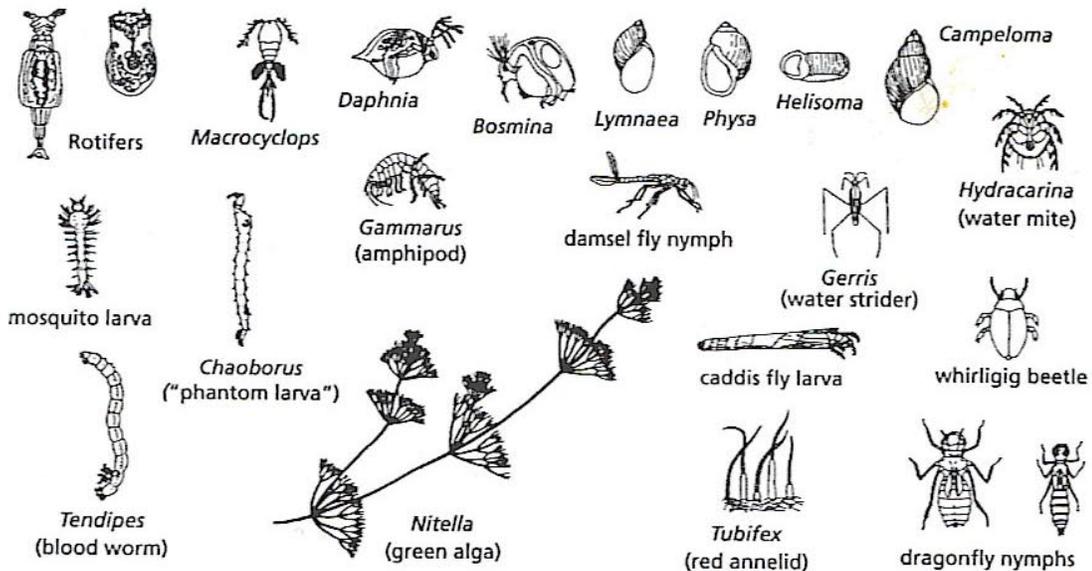
Algae: (green)



Single-celled forms, attached or swimming:



Larger organisms:



Provided by Utah State University Extension and Utah Agriculture in the Classroom, www.agclassroom.org/ut

Appendix

Where to Put the Moon

Your group has a marble representing Earth, a metric ruler, and at least one calculator.

Your group also has three objects of different sizes. Please choose the object whose size best represents the Moon's size using the scale that the marble represents planet Earth. After selecting the object whose size best represents the Moon, place that object at a distance from the marble (Earth) that is true to the same scale.

Share with the whole group which object you selected and the distance separating Earth and the Moon at the scale that we are using.

Your teacher will provide the information about the real sizes of Earth and the Moon, and the real distance separating them. As a group, decide if you want to change the object representing the Moon and/or its distance from the marble. Be prepared to justify why your group did not make changes, or the changes you made.

Scale Model of the Solar System

Your group has a variety of objects to represent the planets of the solar system. We are all using a yellow beach ball that is 20 cm in diameter to represent the Sun. The Sun is actually 1,400,000 km in diameter.

We are going to create a scale model of the solar system that accurately represents the sizes of all the planets and the distances separating them. We are using the same scale for the planets as for the Sun. Using the Table below, calculate the scaled sizes for all the planets, and select an object to represent each of the planets.

Planet	Actual Diameter in Kilometers	Diameter in Scale Model	Object Representing Planet in Scale Model
Sun	1,400,000 km	20 cm	Yellow beach ball
Mercury	5,000 km		
Venus	12,000 km		
Earth	13,000 km		
Mars	7,000 km		
Jupiter	143,000 km		
Saturn	120,000 km		
Uranus	51,000 km		
Neptune	49,000 km		
Pluto	2,200 km		

We will share as a whole group our scaled diameters and the objects selected to represent the planets. Then, we must decide how far to place these model planets from the yellow beach ball. Using the Table below and the same scale, calculate the distances for all the planets.

Planet	Actual Distance in Kilometers	Scaled Distance Between Planets	Scaled Distance of Planet from the Sun
Mercury	58,000,000 km from Sun	N/A	
Venus	50,000,000 km from Mercury		
Earth	41,000,000 km from Venus		
Mars	78,000,000 km from Earth		
Jupiter	550,000,000 km from Mars		
Saturn	649,000,000 km from Jupiter		
Uranus	1,443,000,000 km from Saturn		
Neptune	1,627,000,000 km from Uranus		
Pluto	1,404,000,000 km from Neptune		

Groups share the objects they have chosen for the different planets, and the distances for each planet. We will write the name of each planet on an index card. As a whole group, we will decide how many large steps to take from the Sun to Mercury, with each large step being one meter. We will write that number of steps on the Mercury card. For Venus, we will decide how many large steps to take from Mercury to Venus, and write that number on the Venus card. We will continue for the rest of the planets.

Everyone goes outside to set up one class model of the solar system using the beach ball Sun and the objects that have been chosen. We will pace off the steps from the Sun, and look back from each planet towards the Sun. Of course, we will remember that the planets do not line up in a straight line from the Sun.

Proxima Centauri, the star closest to our solar system, is 40,000,000,000,000 (40 trillion or 40×10^{12}) km away. Where would it be using the same scale as we just used for the solar system?

The distance from our solar system to the center of the Milky Way galaxy is about 30,000 light years which is approximately 30×10^{16} kilometers. How far away would it be in our model using the same scale as we have used previously for the solar system?

Light Years and Crawling Seconds

The speed of light is 300,000 km/second. How long is a light second?

Show how you would calculate the distance of one light year:

How many kilometers is one light year?

The distance from Earth to the Sun is 150,000,000 kilometers. Is the light year a convenient measuring unit for describing the distance from Earth to the Sun? Explain your answer.

The diameter of the Milky Way galaxy is approximately 100,000 light years. The observable universe is about 15 billion light years, but that might only be a small part of our physical universe or all that exists. People often have difficulty understanding that a light year is a measure of distance since the word year is a measure of time, not distance. You can practice using other units of distance that include a unit of time.

How far is the longest distance from one end of the room to the other in:

Crawling seconds:

Crawling minutes:

Walking seconds:

Running seconds:

Make up one or more units of measurement to describe the three distances in the Table below:

Name of your unit of measurement	Distance home to school	Distance home to friend's house	Distance bedroom to refrigerator

Dina the Monster Bee

PART A: Making a Model of Sweeta the Honeybee

Working as a group, you will make a model of Sweeta the Honeybee. Use heavy construction paper (card stock, manila, cardboard, etc) to make the bee model. Sweeta is the approximate size of a natural honeybee. Her body is made of four rectangular strips 3 cm x 2 cm that are taped together to form a rectangular cylinder with openings at either end.

Cover one end with a 2 cm x 2 cm piece that represents her head (okay, she has a flat head, but you can draw on it to make it more realistic). Tape it to cover the opening

Cover the other end with a 2 cm x 2 cm piece that represents her tail (okay, she has a flat tail, but that's better than getting stung). Tape it to cover the opening.

Attach two wings made of paper each 2 cm by 3 cm.

Insects breathe through holes in the surface of their bodies. To do this, they need to have more surface area than volume (more places for air to come in than all the places in the body that need to get air). To make sure that Sweeta can live, we will need to calculate the ratio of the surface area of Sweeta's body to the volume of her body.

Measure the total surface area of the bee, not including the wings. Enter your measurements and calculations here:

Sweeta's total body surface area =

Calculate the volume of Sweeta's body. Enter your measurements and calculations here.

Sweeta's total body volume =

Divide the surface area by the volume:

If your answer is greater than 1, then Sweeta has enough surface area to bring in air for her body. If your answer is less than 1, Sweeta is in trouble.

Will Sweeta have enough air?

Sweeta also has to fly. The surface area of her wings has to be large enough to generate the lift to raise her body. Measure the total surface area of Sweeta's wings. Enter your measurements and calculations here:

Sweeta's total wing surface area =

To be able to fly, the ratio of the surface area of the wings to the volume should be at least 0.5.

Divide the wing surface area by the body volume:

If your answer is greater than 0.5, then Sweeta has enough surface area in her wings to lift her body and fly. If your answer is less than 0.5, Sweeta cannot fly.

Will Sweeta be able to fly?

PART B: Making Dina the Monster Bee

Working as a group, you will make a model of Dina the Monster Bee. Use heavy construction paper (card stock, manila, cardboard, etc) to make the bee model. Dina is ten times size of a natural honeybee in every direction. Her body is made of four rectangular strips 30 cm x 20 cm that are taped together to form a rectangular cylinder with openings at either end.

Cover one end with a 20 cm x 20 cm piece that represents her head. Tape it to cover the opening

Cover the other end with a 20 cm x 20 cm piece that represents her tail. Tape it to cover the opening.

Attach two wings made of paper, each 20 cm by 30 cm.

Insects breathe through holes in the surface of their bodies. To do this, they need to have more surface area than volume (more places for air to come in than all the places in the body that need to get air). To see if Dina can live, we will need to calculate the ratio of the surface area of Dina's body to the volume of her body.

Measure Dina's total surface area, not including the wings. Enter your measurements and calculations here:

Dina's total body surface area =

Calculate the volume of Dina's body. Enter your measurements and calculations here.

Dina's total body volume =

Divide the surface area by the volume:

If your answer is greater than 1, then Dina has enough surface area to bring in air for her body, and she will have enough energy to attack us. If your answer is less than 1, we are safe from Dina the Monster Bee.

Will Dina have enough air?

Dina also has to fly. The surface area of her wings has to be large enough to generate the lift to raise her body. Measure the total surface area of Dina's wings. Enter your measurements and calculations here:

Dina's total wing surface area =

To be able to fly, the ratio of the surface area of the wings to the volume should be at least 0.5.

Divide Dina's wing surface area by the body volume:

If your answer is greater than 0.5, then Dina has enough surface area in her wings to lift her body and fly. If your answer is less than 0.5, we don't have to worry about the Dina the Monster Bee.

Will Dina be able to fly?

Do you think that scaling up in size just involves getting bigger and bigger, or do other things change when you scale up in size? Explain your answer.

Name _____

When Hot & Cold Meet Warm

What do you predict will happen when the 3 temperatures meet?

Observe, draw, and color a picture of the results in the space below.

1. What did you notice happened to the hot water from the baby food jar?

2. Why do you think this happened?

3. What did you notice happened to the cold water from the baby food jar?

4. Why do you think this happened?

5. What are some other examples where hot fluids rise and cold fluids sink?

6. What do you think will eventually happen in the container if the jars are left in it for an hour?

7. What is another way you could demonstrate this process of convection?

The Tale of Three Colors

Focus Question: What difference does color make in absorbing heat?

Predict which color will be the hottest after 10 minutes under a hot lamp.

Hottest color on the 3 flat colored surfaces _____

Hottest color in the 3 colored envelopes _____

Hottest color in the 3-chambered box _____

Colors on 3 Flat Colored Surfaces

Flat Surface	Starting Temperature	Temperature after 5 min.	Temperature after 10 min.
Silver			
Black			
White			

Colors in the 3 Colored Envelopes

Envelope	Starting Temperature	Temperature after 5 min.	Temperature after 10 min.
Silver			
Black			
White			

Colors in the 3-Chambered Box

Chamber	Starting Temperature	Temperature after 5 min.	Temperature after 10 min.
Silver			
Black			
White			

Write the actual results of the experiment.

Hottest color on the 3 flat colored surfaces _____

Hottest color in the 3 colored envelopes _____

Hottest color in the 3-chambered box _____

Discuss what happened and answer the following questions:

1. What type of heat transfer is occurring when the lamp shines on the colors?
2. Does the color of paper make a difference in the heat absorption?
3. Why was there a difference in whether the color was on a flat surface, inside an envelope, or in a box?
4. Give an example of how each result (3 examples) could be applied to real life experiences.