

SCIENCE SESSION I

Integrating Science and Math

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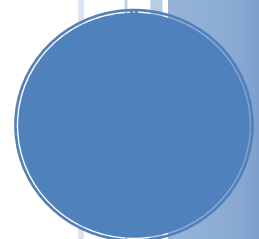


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2002 SERIES GED TEST – SCIENCE OVERVIEW

INTRODUCTION

Science is everywhere. It is a part of our everyday experiences, from the time we turn off the alarm clock in the morning to when we watch the stars twinkle at night. Learning about science helps us to learn about the world around us. Science is the study of everything around us. In fact, the word science comes from a Greek word, “scientia,” which means “knowledge.” Science is a combination of process (how we learn about science) and content (the knowledge, concepts and understandings of science).

In today’s world, with all of the various products of science, scientific literacy has become a necessity for everyone. Everyone uses science on a daily basis, and thus, must be able to make informed decisions about scientific information. In order to make such decisions or choices, individuals need to be able to talk intelligently about scientific issues and understand the scientific world in which they live.

More and more, scientific literacy is a part of everyone’s world. Even the workplace requires that employees be able to learn, reason, critically think through a problem, make an informed decision, and solve the problems that surround them. A thorough understanding of the scientific process, as well as the basics of science, is essential in today’s global economy. Scientific literacy is a necessary goal of all educational systems.

STRUCTURE OF THE TEST

The 2002 Series GED Tests have an increased emphasis on high level thinking skills. These critical thinking and problem solving skills are very evident on the GED Science Test. The GED Science Test requires that students understand or use the information provided to make a hypothesis or prediction and solve a problem or to make a judgment using abstract reasoning and problem solving.

CONTENT OF THE TEST

The GED Science Test measures the major and lasting expected outcomes of a sound, well-rounded high school science education. Test questions focus on the comprehensive, integrated skills typical of what the candidate must know, understand, and be able to perform in order to be scientifically literate. Test questions have been designed to ensure that the candidate recognizes the relevance of science in daily life.

Science questions are based on the content standards for grades 9-12 outlined by the National Science Education Standards (NSES). The *National Science Education Standards* present a vision of a scientifically literate populace. They outline what students need to know, understand, and

be able to do to be scientifically literate at different grade levels. The development of the *National Science Education Standards* was guided by specified principles. Those principles are:

- Science is for all students.
- Learning science is an active process.
- School science reflects the intellectual and cultural traditions that characterize the practice of contemporary science.
- Improving science education is part of systemic education reform.

It is these principles that provided the GED Testing Service with the type of knowledge needed by a scientifically literate individual. GED Science Test questions are based on the NSES content standards for grades 9-12. The test covers three areas of science: physical science (which includes the areas of physics and chemistry), life science, and earth and space science.

Physical Science

The physical science portion comprises 35% of the test questions and includes:

- Structure of atoms
- Structure and properties of matter
- Chemical reactions
- Motions and forces
- Conservation of energy and increase in disorder
- Interactions of energy and matter

Life Science

Life science questions comprise 45% of the test and include:

- The cell
- Molecular basis of heredity
- Biological evolution
- Interdependence of organisms
- Matter, energy, and organization in living systems
- Behavior of organisms

Earth and Space Science

Earth and space science questions comprise 20% of the test and include:

- Energy in the Earth system
- Geochemical cycles
- Origin and evolution of the Earth system
- Origin and evolution of the universe

CONTEXT OF THE TEST

The GED Science Test questions are classified using the *National Science Education Standards*.
<http://www.nap.edu/readingroom/books/nses/html/>.

There are eight categories of content standards. They are:

- Unifying concepts and processes in science
- Science as inquiry
- Physical science
- Life science
- Earth and space science
- Science and technology
- Science in personal and social perspectives
- History and nature of science

Standards in each of the following areas are included on the GED Science Test.

Unifying Concepts and Processes outlines standards that need to be developed over a student's entire education and sets the guidelines for the understanding of the following concepts:

- systems, order, and organization;
- evidence, models, and explanations;
- change, constancy, and measurement;
- evolution and equilibrium; and
- form and function.

Science as Inquiry moves the student to higher level content knowledge and cognitive skills through questioning and reasoning abilities. Processes associated with scientific inquiry include:

- asking questions;
- planning and conducting investigations;
- using appropriate tools and techniques to gather data;
- thinking critically and logically about relationships between evidence and explanations;
- constructing and analyzing alternative explanations; and
- communicating scientific arguments.

The remaining standards build on the student's knowledge of and inquiry about physical science, life science, and Earth and space science. All require the ability to apply scientific knowledge.

Science and Technology focuses on the ability to design technology and understand links between science and technology. These might include decision-making abilities in identifying and stating a problem; and then designing, implementing, and evaluating a solution.

Science in Social and Personal Perspectives addresses the scientific foundation a student needs to evaluate and make decisions about personal and social issues, such as:

- personal and community health;
- population growth;
- natural resources;

- environmental quality;
- natural and human-induced hazards; and
- science and technology in local, national, and global challenges.

History and Nature of Science addresses the ability to apply history to science in order to understand:

- different aspects of scientific inquiry;
- the human aspects of science; and
- the role that science has played in the development of various cultures.

The GED Science Test also emphasizes areas such as health and the environment, genetics, cells, and atoms.

GED 2002 SERIES TESTS – A QUICK OVERVIEW

Content		
Earth & Space Science	Life Science	Physical Science
Comprises 20% of the test and includes: <ul style="list-style-type: none"> • Energy in the Earth system • Geochemical cycles • Origin and evolution of the Earth system • Origin and evolution of the universe 	Comprises 45% of the test and includes: <ul style="list-style-type: none"> • The cell • Molecular basis of heredity • Biological evolution • Interdependence of organisms • Matter, energy, and organization in living systems • Behavior of organisms 	Comprises 35% of the test and includes: <ul style="list-style-type: none"> • Structure of atoms • Structure and properties of matter • Chemical reactions • Motions and forces • Conservation of energy and increase in disorder • Interactions of energy and matter

STRATEGIES FOR TEACHING SCIENCE

OVERVIEW

As with the other tests of the GED, science requires that students use the higher order thinking skills of application, analysis, synthesis, and evaluation. Teachers should assist students in obtaining these types of skills by:

- Incorporating small and large group sessions into the GED classroom, focusing on science concepts and principles that will help students gain core knowledge they will need on the test.
- Using the local newspaper or *USA Today* to provide students with an opportunity to interpret graphic-based material, including graphs, charts, maps, etc. The newspaper is an excellent resource for information related to the environment and health issues. Most newspapers at the very least include a health section once per week. Use articles to discuss issues such as diet, exercise, disease prevention, medical advances, etc.
- Having students conduct surveys about environmental, health, or other science issues that affect their daily lives. Have the students construct graphs to report their results. If students understand when and why they should use line graphs versus bar graphs versus circle graphs, it will help them interpret the graphs included on the test.
- Using the weather map in the local newspaper to track weather trends and changes. Have students make predictions based on the information provided on the maps.
- Using the Internet to expose students to new material. Capture their interest through the exploration of websites that focus on various aspects of science.

SCIENCE VOCABULARY

Understanding science requires understanding the basic concepts of science as well as the vocabulary that is frequently used in the areas of physics, chemistry, life science, and earth and space science.

There are many different ways to teach vocabulary. Realia is the use of real objects and materials to make learning more explicit to the learners. In science this is especially beneficial since a lot of the vocabulary is new to the students.

Research shows that it is easier to learn vocabulary when it is linked to prior or background knowledge. This helps to reach all types of learners including kinesthetic and visual learners as well as auditory learners. Background knowledge is not only important for vocabulary learning, but also for overall comprehension of what is being read.

Rasinski states that “the phrase ‘experience is the best teacher’ is certainly true in vocabulary learning.” In his research, he states that the best way to learn vocabulary is through the use of

indirect, vicarious experiences that are interesting and meaningful to the students (Reutzel & Cooter 2000). This is an excellent approach in science, where many of the activities can be hands-on in order to present new vocabulary that students have little or no prior knowledge.

The use of realia or items in one's daily life is an excellent way to assist students in building a science vocabulary. In fact, science is one of the easiest subjects in which to use realia. With every new experiment, students use new tools and learn new vocabulary that goes along with the lesson. Experiments are "another way to develop background knowledge as a prereading strategy." Students can use the knowledge they gain through experiments to better comprehend texts. This background knowledge also provides motivation for students to read by making the material more meaningful to the students (Peregoy & Boyle 2001).

Ideas to Teach Science Vocabulary

Understanding the diverse vocabulary of science is extremely important to the comprehension of scientific writings and text. Activate your students' knowledge of science terms by having them brainstorm words they know about each subject area or to use the words in a narrative chain. Some basic activities to get you started in teaching science vocabulary are provided.

Before and After Vocabulary Grids

Give each student a list of key words with two blank columns. In the first column, the students write the meaning of each word or what they guess the meaning is for each word. As they come across the word later during the lesson, the students can revise their original definition. At this point, the answers can be discussed and clarified in the whole class.

The benefits of Before and After Vocabulary Grids are that they:

- Focus attention onto key words
- Provide opportunities for students to actively work out word meaning
- Help students become independent learners of new words by using strategies such as context clues

Before and After Vocabulary Grid Template

Word List	What I think the word means	Revised definition

Building Word Lists

Locate lists of words from each of the areas of science that you will be teaching. You may also wish to have students build their own word lists by having students write unfamiliar scientific terms on a chart that is posted in the room.

Analyzing Prefixes and Roots

Sixty percent of English words are formed of roots and prefixes. When your students come across a common prefix and/or root form, write the word on a sheet of paper and generate more words, first from the prefix and then with the root. List them on the paper. Discuss the definitions and the relationship of the words to each other. Science is filled with words that use the same root form, such as acid, which then can be used to writing such words as acids, acidic, and acidity.

Developing the Dictionary Habit

Tell your students to keep a small dictionary handy and use it when an unknown word crops up. Have the students use the word in a sentence or in conversation with you so that they are comfortable talking the “scientific language.”

Find the Words

Provide students with specific letters of the alphabet. Tell them that their task is to create as many words as possible from the letters in the area in which they are studying. They cannot use other letters, but they can repeat letters from the list as often as necessary to create a vocabulary word. If challenged, students should be prepared to state how the word is related to the selected topic.

Science Vocabulary Example

Provide a group of students with the letters: a, c, e, h, j, i, l, m, n, o, p, r, s, t, u. Have them come up with as many vocabulary words in the area of the solar system as possible from the list of letters provided. Remember, they cannot use other letters, but they can repeat letters within words as often as necessary. If challenged, they should be prepared to state how the word is related to the solar system.

Sample Words: solar, planet, sun, star, Jupiter, Uranus, Saturn, Mars, Pluto, earth, moon.

The Narrative Chain

A narrative chain requires that students link words in a list together into a sentence or paragraph. By using the words and associating them they create a firmer connection between the new words and those already stored in their memory.

Science Narrative Chain Example

Provide students with the words: temperatures, southern, glacier, earth, tropical, rainforest, jungle, ice cap, moderate

A sample narrative chain might be as follows:

Although some of the places on the earth experience moderate temperature changes throughout the year, there are also areas where the temperatures are quite drastic. In some of the southern regions, one might experience a tropical rainforest or jungle-like atmosphere which is very hot and humid. Some parts of the earth are very cold all year long and are composed of glaciers or ice caps.

Word Jar

Word Jars are another version of a personal dictionary. However, since the whole class is providing words, they are an excellent resource for activities that assess the students' vocabulary skills. They can even be used as a short review at the end of class period to see how many words students remember or know from the lesson.


The task is that when students see words that are unfamiliar, they should complete a Word Jar slip and put it in the jar in the classroom. The following is a sample slip that can be used.

Word
Name of book and page number
Sentence in which the word was used
Dictionary definition
Student's name

K. I. M. (Key Idea – Information - Memory Clue)

K. I. M. is a great strategy for new words or concepts. Write the term or key idea (K) in the left column, the information (I) that goes along with it in the center column, and draw a picture of the idea, a memory clue, (M) in the right column.

The key idea may be a new vocabulary word or a new concept. The information may be a definition or it may be a more technical explanation of the concept. The memory clue is a way for students to fully integrate the meaning of the key idea into their memories. By making a simple sketch that explains the key idea, students synthesize and interpret the new information, making it their own. Then, students can reference their drawings to easily remember new key ideas.

K (Key Idea)	I (Information)	M (Memory Clue)
drought	Little or no rain over a period of time	

Vocabulary for Science

Have students fill in words for each of the science areas that are covered by the GED Science Test.

Physical Science		Life Science	Earth and Space Science
Physics	Chemistry		

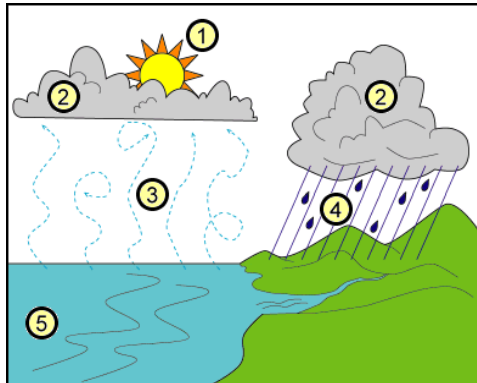
Cloze Activities

Cloze activities are excellent vocabulary builders for students who function at all different levels of reading. Students need to identify an appropriate word that completes a sentence or idea. Teachers may use any text to develop a cloze activity. Teachers may also wish to include a graphic, such as that used below by the Thomas Jefferson Education Lab. Graphics provide visual clues, as well as building graphic literacy skills necessary for the GED Test and real-world situations.

The Water Cycle

Evaporation, Condensation and Precipitation

The evaporates from lakes and oceans. As the air rises, it cools. The water vapor condenses into tiny droplets of . The droplets crowd together and form a . Wind blows the towards the land. The tiny droplets join together and fall as precipitation to the . The water soaks into the ground and collects in . The that never ends has started again!



Use the diagram to identify the different parts of the water cycle:

Answers: the sun, clouds, evaporation, precipitation, the ocean

Thomas Jefferson Lab. Retrieved from the World Wide Web at:
<http://education.jlab.org/index.php>

COMPREHENSION SKILLS FOR SCIENCE

Life is a classroom so it is important to use it. Because science is all around us, one way to use your student's background to better learn about the area of science is to connect what they are learning to what they already know. Sometimes this will result in less than accurate information. However, there is a story about the great Thomas Edison who assessed having to do something more than once as follows.

Mistakes are invaluable if, for no other reason, they **tell us what not to do**. There is a story told of Edison, who made 1,000 unsuccessful attempts before arriving at the light bulb. "How did it feel to fail 1,000 times?" a reporter asked. "I didn't fail a 1,000 times," Edison replied. "The light bulb was an invention with 1,001 steps."

How do you bring a student's background knowledge and vocabulary to the current science topic that you are discussing? Activate their personal knowledge first!

Many students begin to read a selection without thinking about the topic beforehand. This means that they are probably not aware that what they already know is an essential factor in understanding the material to be read. The background or prior knowledge that students bring to the reading of a selection may be the most important factor affecting how well they comprehend a science passage. It is nearly impossible for students to understand material of which they have little or no personal knowledge. The process of interacting with text to construct meaning is largely the process of combining new information with prior knowledge. There are many ways to get a student thinking about the subject and what he/she knows. Samples of forms to support the following techniques are located in this chapter.

ABC Brainstorm

ABC Brainstorm asks students to come up with a word about a specified topic for each letter of the alphabet. This technique can be used prior to the beginning of the actual lesson or reading to assess a student's current knowledge or as a quick assessment at the end of the lesson to see what the student has learned.

KWL

Another technique is KWL. The first column is completed prior to the lesson being taught. A student is asked to list what he/she knows about a topic. Next, the student writes in what he/she would like to know about the topic from the lesson, and finally, after the lesson is completed, the student writes down what he/she has learned.

ABC Brainstorm

Topic _____

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Y

Z

Summary Paragraph

KWHL

What I Know for Sure About This Topic	What I Think I Know, But Am Not Sure About This Topic	What I would Like to Learn About This Topic	Connections Between This Topic and Other Things I Know

Previewing Skills

Just like in any reading process, students must learn to first preview the article or text. With the graphic-intensive texts of science, previewing is highly important to true comprehension. One strategy to use with students is TIPP?. This strategy requires that students skim and scan the reading material similar to the way we may look at the morning newspaper. We often decide what articles we will read after we have quickly previewed the titles, main ideas, and even the pictures or graphics. Students often just begin reading science articles rather than spending a brief time previewing so that they better understand what they will be reading.

Make sure that your students use a previewing strategy before reading in depth that:

- Activates prior knowledge
- Provides a skimming and scanning technique, such as TIPP?

TIPP?	
Title	What do the titles/subheadings and layout tell me?
Introduction	Skim this to get the main idea.
Paragraph	Read the first line of paragraphs/text boxes.
Pictures	What do the diagrams, photos, and graphs show me?
?	Can you come up with any questions?

Sample Comprehension Techniques for Understanding Science Text

There are many different comprehension strategies that can be implemented in the science classroom. Some teachers use KWL, others Cornell Notes, while others set up graphic organizers in which students must take notes. The following are a few of the research-supported comprehension strategies to employ in the science classroom.

The 5 Es

The 5E Instructional Model provides a format for lessons that builds on what students already know. The 5Es sequence the learning experience so that the learners construct their understanding of a concept across time. Each phase of the learning sequence can be described using five words that begin with "E": *engage, explore, explain, extend, and evaluate*.

Engage

Begin each unit or topic with a lesson or activity that engages students with an activity or question as they are introduced to the concept. Students should make connections to prior knowledge and what is to be studied. During this phase, teachers ask questions of students and engage them in the guided inquiry lessons. They use strategies such as KWL or ABC Brainstorm that make connections between the past and present learning experience.

Explore

Have students carry out hands-on activities in which they explore the concept or skill. This phase allows students to acquire a common set of experiences that they can use to help each other make sense of the new concept or skill. Teachers should set up the investigation and guide students in inquiry, asking probing questions to clarify understanding.

Explain

After students have explored the concept or skill, the teacher provides the concepts and terms used by the students to develop explanations for the phenomenon they have experienced. The significant aspect of this phase is that explanation follows experience. Teachers should ask probing questions that encourage students to look for additional information.

Elaborate

Students expand their learning, practice skills and behavior, and make connections or applications to related concepts and in the world around them. Teachers provide learning opportunities for students to apply their knowledge and to gain a deeper understanding. Activities can include reading articles and books, writing, designing other experiments, and exploring related topics on the Internet. Provide opportunities for students to apply what they have learned to new situations. It is important for students to discuss and compare their ideas with each other during this phase.

Evaluate

The final phase provides an opportunity for students to review and reflect on their own learning and new understandings and skills. This is the phase where students provide evidence for changes to their understandings, beliefs, and skills. Teachers should assess students understanding through both formative and summative activities.

An Overview of the 5Es		
Phase	Purpose	Role of Teacher
Engage	<p>Create interest and stimulate curiosity.</p> <p>Set learning within a meaningful context.</p> <p>Raise questions for inquiry.</p> <p>Reveal students' ideas and beliefs, compare students' ideas.</p>	<p>Activity or multi-modal text used to set context and establish topicality and relevance.</p> <p>Motivating/discrepant experience to create interest and raise questions.</p> <p>Open questions, individual student writing, drawing, acting out understandings, and discussion to reveal students' existing ideas and beliefs so that teachers are aware of current conceptions and can plan to extend and challenge as appropriate – a form of diagnostic assessment.</p>
Explore	<p>Provide experience of the phenomenon or concept.</p> <p>Explore and inquire into students' questions and test their ideas.</p> <p>Investigate and solve problems.</p>	<p>Open investigations to experience the phenomenon, collect evidence through observation and measurement, test ideas and try to answer questions.</p> <p>Investigation of text-based materials (e.g. newspaper articles, web-based articles) with consideration given to aspects of critical literacy, including making judgments about the reliability of the sources or the scientific claims made in the texts.</p>
Explain	<p>Introduce conceptual tools that can be used to interpret the evidence and construct explanations of the phenomenon.</p> <p>Construct multi-modal explanations and justify claims in terms of the evidence gathered.</p> <p>Compare explanations generated by different students/groups.</p>	<p>Student reading or teacher explanation to access concepts and terms that will be useful in interpreting evidence and explaining the phenomenon.</p> <p>Small group discussion to generate explanations, compare ideas and relate evidence to explanations.</p> <p>Individual writing, drawing and mapping to clarify ideas and explanations.</p> <p>Formative assessment to provide feedback to teacher and students about development of investigation skills and conceptual understandings.</p> <p>Small group writing/design to generate a communication product (e.g. poster, oral report, formal written report or PowerPoint presentation, cartoon strip, drama presentation, letter) with attention to form of argumentation, genre form/function and audience, and with integration of different modes for representing science ideas and findings.</p>

Elaborate	Use and apply concepts and explanations in new contexts to test their general applicability. Reconstruct and extend explanations and understandings using and integrating different modes, such as written language, diagrammatic and graphic modes, and mathematics.	Further investigations, exercises, problems or design tasks to provide an opportunity to apply, clarify, extend and consolidate new conceptual understandings and skills. Further reading, individual and group writing may be used to introduce additional concepts and clarify meanings through writing. A communication product may be produced to re-represent ideas using and integrating diverse representational modes and genres consolidating and extending science understandings and literacy practices.
Evaluate	Provide an opportunity for students to review and reflect on their own learning and new understandings and skills. Provide evidence for changes to students' understandings, beliefs and skills.	Discussion of open questions or writing and diagrammatic responses to open questions – may use same/similar questions to those used in Engage phase to generate additional evidence of the extent to which the learning outcomes have been achieved. Reflections on changes to explanations generated in Engage and Evaluation phases to help students be more metacognitively aware of their learning.

Predict-Observe-Explain (POE)

There are many events that surprise us. We expect that one thing will happen, and something else happens instead. These events are called discrepant events. In science, students often remember what they think should happen, rather than what did happen.

What's an example of a discrepant event? Ask students which liquid is heavier – vegetable oil or vinegar. Students will generally state that vegetable oil is heavier so vinegar will float on the top. Have students pour the two together. What happens? The vegetable oil floats on the vinegar. This is an example of the phenomenon that "I wouldn't have believed it if I hadn't seen it." However, if students do not have the opportunity to predict, explain, observe, and then explain again, they will often return to their original faulty belief that vinegar is less dense than vegetable oil and will rise to the top.

POE is a strategy often used in science. It works best with demonstrations that allow immediate observations. It can be used for:

- Finding out students' initial ideas
- Providing teachers with information about students' thinking
- Generating discussion
- Motivating students to want to explore the concept
- Generating investigations

How the Strategy Works

Unless students are asked to predict first what will happen, they may not observe carefully.

Writing down their prediction motivates them to want to know the answer.

Asking students to explain the reasons for their predictions gives the teacher indications of their theories. This can be useful for uncovering misconceptions or developing understandings they have. It can provide information for making decisions about the subsequent learning. Explaining and evaluating their predictions and listening to others' predictions helps students to begin evaluating their own learning and constructing new meanings.

What To Do

Set up a demonstration of an event, related to the focus topic, that may surprise students, and which can be observed. Tell the students what you are going to be doing.

- **Step 1: Predict:** Describe to the students what you are going to do. Then ask them to predict what will happen. Have students to explain why they believe what they have just stated. Many scientific beliefs are innate (people are unaware of what they actually believe until they are pushed to describe them). An important part of science teaching is to have students make their ideas and their knowledge of scientific theories explicit. The easiest way to do this is to simply ask students to tell you why they believe what they believe.
- **Step 2: Observe:** Now carry out the activity. Have the students watch as you do what you told them you would do. Students should note what happens.
- **Step 3: Explain:** Have students hypothesize about why things happened the way they did and attempt to construct some sort of new theory for what happened. Debrief the activity with the students.

White, R. T., & Gunstone, R. F. (1992). *Probing Understanding*. Great Britain: Falmer Press.

Classroom Questioning

Questions are central to the understanding of science. Teachers that use a wide variety of questioning techniques provide for deeper, more meaningful learning for students. There are many categories of questions. The simplest questions center on recall information and ask what-where-when and yes-no. More complex questions focus on guiding and probing learning. Open-ended questions are some of the most complex.

When asking questions:

- Ask clear specific questions. If students have to guess at what you are asking, they are likely to remain quiet and not engage in the thinking you are expecting.
- Use cueing vocabulary that is familiar to students. By using the vocabulary they are use to students can better answer the question.

- Ask follow up questions to get at students' real understandings. Often the student's first response is a parroting of what they think you expect or have remembered. Asking a second question can reveal the difference between a student's accurate understanding and misconceptions.
- Remember "wait time." Provide at least five seconds of thinking time after a question and after a response. Students need time to think and organize their response. Waiting lets students know that you are serious about wanting an answer to your question.
- Create a climate that supports risk taking. Establish eye contact and withhold judgment. Let students know that there is not a single correct answer for some questions.
- Allow students to ask their own questions. This often will further develop a topic and let students know you are interested in their reasoning.
- Listen to the answer.

Sample Questions for Guiding Scientific Thinking

Question Type	Sample Question Starters
Recalling	Who, what, when, where, how ____?
Comparing	How is ____ similar to/different from ____?
Identifying Attributes and Components	What are the characteristics/parts of ____?
Classifying	How might we organize ____ into categories?
Ordering	Arrange ____ into sequence according to ____.
Identifying Relationships and Patterns	Develop an outline/diagram/web of ____.
Representing	In what other ways might we show/illustrate ____?
Identifying Main Ideas	What is the key concept/issue in ____? Retell the main idea of ____ in your own words.
Identifying Errors	What is wrong with ____?
Inferring	What might we infer from ____? What conclusions might be drawn from ____?
Predicting	What might happen if ____?
Elaborating	What ideas/details can you add to ____? Give an example of ____. Summarizing Can you summarize ____?
Establishing Criteria	What criteria would you use to judge/evaluate ____?
Verifying	What evidence supports ____? How might we prove/confirm ____?

The GIST Procedure (Generating Interactions between Schemata & Text)

The GIST Procedure is a strategy that can be used to improve students' abilities to comprehend the gist or main ideas of the text by answering the 5 Ws and H questions and then summarizing the passage by using the information from the 5 Ws and the H. This strategy incorporates reading and writing. Students should use their editing and revision skills for keeping their summary to twenty words or less.

Getting the GIST in Science – 5 Ws and H

Name of Text _____

Complete the following:

Questions	
Who?	
What?	
When?	
Where?	
Why?	
How?	

Write a GIST statement of 20 words or less that summarizes the text.

Using Graphic Organizers in Science

Graphic organizers are ‘mind tools’ that may be used to plan activities and investigations or to assist with reviewing and reflecting on progress in the science classroom. There are many different types of graphic organizers that are useful in the science classroom. In addition to assisting students in better comprehending scientific knowledge, graphic organizers also assist students in being able to read and to develop graphics – a useful skill since approximately 50% of GED Science Test questions use some type of graphic.

Some of the basic graphic organizers are:

- **concept maps** - show relationships between ideas or concepts. A concept map can be used to identify prior knowledge and understandings and to summarize concepts.
- **mind maps** — similar to concept maps, but show ideas branching off from each of the main ideas set out.
- **Venn diagrams** - help make comparisons. The overlapping area ‘contains’ similarities and differences are in the areas that do not overlap.
- **flow diagrams** - sequences ideas, procedures or events. Often called a process diagram.
- **sequencing illustrations**, such as cartoons, and storyboarding, shows pictorially the sequence of ideas, procedures or events.
- **consequence maps** - shows the consequences of a series of actions or events like a ripple effect from a central event. The consequence map is developed in stages from the central event.
- **issues maps** - shows the different categories of issues which relate to a particular event or topic of concern. It is often helpful to have issues phrased as questions.

Following are templates of a few of the types of graphic organizers that are useful in the science classroom.

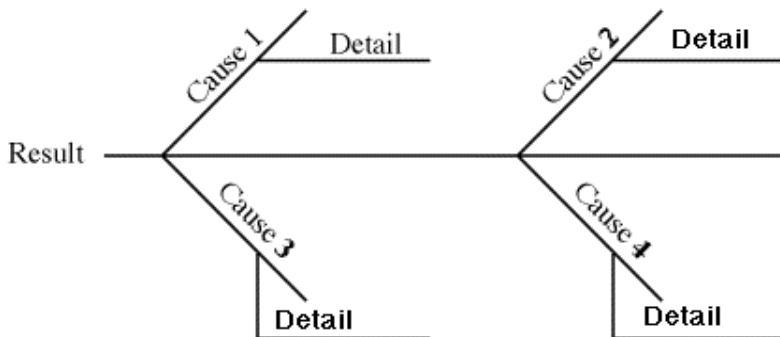
Problem-Solution Summary

Students document the problems that they locate in the text or that they are encountering in a project and identify solutions for the problems.

Problems	Solutions

Fishbone Map - Cause and Effect

A Fishbone Map is used to show the causal interaction of an event. The key questions for a teacher to ask as a student is completing the fishbone map are: What are the factors that cause X? How do they interrelate? Are the factors that cause X the same as those that cause X to persist?



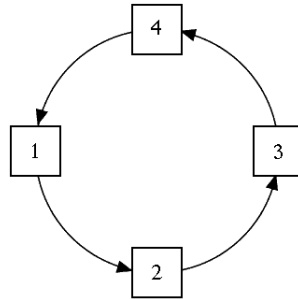
Compare/Contrast

This technique is helpful in science to show similarities and differences. Key questions should be: What are being compared? How are they similar? How are they different?

	Name 1	Name 2
Attribute 1		
Attribute 2		
Attribute 3		
Attribute 4		

Cycling

Cycling is a graphic organizer that shows how a series of events interacts to produce a set of results again and again, such as the water cycle. Key questions to ask when completing this organizer include: What are the main events in the cycle? How do they interact and return to the beginning again?

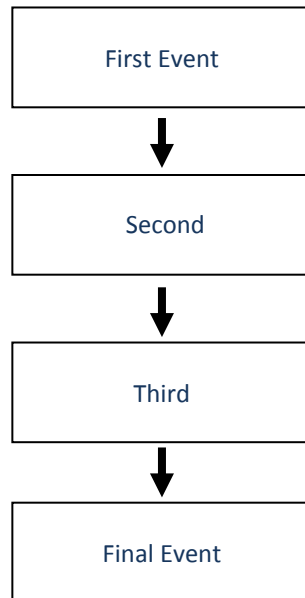


Chain of Events

This graphic organizer is used to describe the steps or stages of an event or action. This is a good prelude to developing a process diagram in science. Key questions to ask students include: What is the first step in the procedure or process? What are the next steps? How does one event lead to another? What is the final outcome?

Chain of Events

Beginning



EARTH AND SPACE SCIENCE

INTRODUCTION

Earth and Space Science – GED Test

Earth and space science comprise approximately 20% of the test questions on the GED Science Test. This portion of the test includes such areas as:

- Energy in the Earth system
- Geochemical cycles
- Origin and evolution of the Earth system
- Origin and evolution of the universe

What Is Earth and Space Science?

Earth and space science play a unique and essential role in today's rapidly changing world. It is an integrated study of the Earth's history, composition and structure, its atmosphere and oceans, and its environment in space. Earth and space science are important because most human activities are related to interaction with the planet Earth.

For the classroom, earth and space science offers experiences in a diverse range of interrelated scientific disciplines; it is closely related to the students' natural surroundings; and offers students subject matter which has direct application to their lives and the world around them. Students only need to step outdoors to observe and find relevance in concepts learned in the science classroom. Because it offers many opportunities to collect data, hypothesize, experiment, and draw conclusions, both within school and outside environments, earth and space science can be taught through a hands-on activity-based process.

A knowledge base of earth and space science is the key to being an informed citizen and scientifically literate in today's world.

TEACHING EARTH AND SPACE SCIENCE CONCEPTS

The teaching of earth and space science allows all students to have a better science background with pertinent information about their surroundings. Daily, society is faced with environmental and economic concerns such as acid rain, water supply, the greenhouse effect, and waste disposal. Our world is absolutely dependent upon the appropriate utilization of Earth's energy, mineral, and human resource. Awareness of natural phenomena such as floods, tornadoes, hurricanes, volcanoes, and earthquakes is also an integral part of earth and space science.

There are many strategies that can be used to teach the area of earth and space science. Because the world is indeed the laboratory for this area, teachers should draw connections with societal issues making earth and space science content relevant to students' life experiences. Students should spend time questioning, data gathering, and interpreting information regarding

topics that are taught. Field trips are vital in connecting the content to a student's knowledge. If field trips are not possible, computerized virtual field trips can be used to help students understand a field area in a larger context and to focus the students' attention on particularly important observations. Multimedia and information technology provide a wealth of information for teachers to use in the earth and space classroom.

Using models is another strategy to communicate concepts in earth and space science. Model building can assist students in assembling their fragmented knowledge about concepts and relationships into more clearly understood constructs. The act of building a model, such as the solar system or a cell, requires the student to ponder and discuss a scientific concept, break it down into pieces or facts, and consider how and why those pieces are related. Creating models assists students in critical thinking and problem solving skills, as well as using their creativity.

Investigations, demonstrations, modeling, and discussion are four tools that can be used by teachers in the science classroom.

Earth and Space Science Topics for the Classroom

Earth and space science is a discipline of study that lends itself to the real-world. Look at the following types of topics that can be discussed in the science classroom.

- Use scientific inquiry to design and conduct scientific investigations to meet a human need, make a decision, solve a human problem, or develop a product.
- Recognize and describe the interrelationship between science and technology.
- Discuss contributions of men and women of various social and ethnic backgrounds to science and technology.
- Apply science concepts to make decisions (weighing risks and benefits) about one's personal health and well-being.
- Assess the energy transfer in the earth system and explain dynamic processes that determine global climate.
- Relate the earth's geochemical cycles (carbon, nitrogen, oxygen, water) to geological processes.
- Critique theories on the origin and evolution of the earth system.
- Compare and contrast theories on the origin and evolution of the universe.
- Identify ways to wisely use natural resources.
- Measure and evaluate the effect of human societies on earth.
- Distinguish between human and natural hazards.

BASIC EXPERIMENTS FOR EARTH AND SPACE SCIENCE

Oil Spill! Clean It Up

When oil tankers accidentally spill their cargo of oil into the ocean they cause a huge environmental danger. Oil is extremely hard to remove from the water and the beaches, and the whole environment is damaged. In this experiment, you can see how hard it is to remove oil from sand. You will need:

- Large plastic cup
- Sand
- 2 tablespoons of vegetable oil

(This experiment can be messy, so you might want to do it outdoors.)

Step 1 – Observe - Fill a plastic cup with sand and oil and mix well. Observe the problem that you have.

Step 2 – Hypothesize - Based on your observations, make a guess at what tools you could use to get the oil off the sand.

Step 3 – Test the Hypothesis - Conduct an experiment. Use a spoon, a straw, paper towel, an old toothbrush, a sponge – anything that you can think of to get the oil off the sand and help save the environment!

Ziplock Bag Water Cycle

In this experiment, "clouds," made up of tiny droplets, form on the inside surface of a plastic bag as a water cycle is simulated.

Carefully place a plastic cup containing some water into the corner of a Ziplock bag, seal it and suspend it by the opposite corner in a window. Water from the cup evaporates saturating the air in the bag. After a day or so, small droplets will condense on the inside of the bag like a cloud. Some larger drops will begin to run down and grow by accumulating small drops. This is analogous to one way in which rain can form. (The other way involves ice that melts before reaching the ground.)

Make up a few bags and hang them in different places - sunny vs. shady, light vs. dark, warm vs. cool ~ and observe the differences.

Make up a bag with food coloring in the water in the cup. The condensation and the water that accumulates in the bottom corner will be colorless (unless some water from the cup is spilled) showing that when water evaporates the food coloring stays behind. This can also be shown by completely evaporating some colored water.

Make up a bag with salt in the water in the cup. The condensation and the water that accumulates in the bottom corner will be pure. This can be tested by removing the cup and giving students two toothpicks to dip in the water in the cup and the water in the bag and taste.

This can show how water that evaporates from the ocean leaves the salt behind and can lead to relatively pure rain. Salt water can also be completely evaporated to show how the salt stays behind.

Look Out, She's Gonna Blow! – Building a Tornado

Now we're going to get a little messy. In this experiment we build a real working volcano. After mixing just the right amount of ingredients together, we'll add the final item to make our volcano 'blow its top' spewing red lava down the sides.

First we need to create the "salt dough". Mix 6 cups flour, 2 cups salt, 4 tablespoons cooking oil, and 2 cups of water in a large bowl. Work the ingredients with your hands until smooth and firm. Add more water to the mixture if needed.

Stand the soda bottle in the baking pan. Mold the salt dough around the bottle making sure you don't cover up the bottle mouth or drop any dough into the bottle. Take your time on this step and build your volcano with as much detail as you like.

Fill the bottle most of the way with warm water mixed with a little of the red food coloring.

Put 6 drops of the liquid detergent into the bottle.

Add 2 tablespoons of baking soda.

Slowly pour vinegar into the bottle and jump back quick!

Notice the red 'lava' that flows out of your volcano. This happens because of the baking soda and vinegar mixture. Mixing baking soda and vinegar produces a chemical reaction in which carbon dioxide gas is created - the same gas that bubbles in a real volcano. The gas bubbles build in the bottle, forcing the liquid 'lava' mixture of the bottle and down the sides of your volcano.

Homemade Barometer

The air pressure around us greatly affects our weather. Notice how your weatherman always mentions various pressure systems (low pressure system, high pressure system, etc.) and how they will affect tomorrow's weather. In this experiment, we will create a tool that lets you gauge the pressure of the air around you.

- Fill the measuring cup or glass with water and add some colored dye to it.
- Flip the empty soda bottle upside down into the glass measuring cup.
- Make sure that you use a bottle that is just the right size. The thicker body of the bottle should fit snugly in the measuring cup so that the mouth of the bottle does not touch the bottom of the cup.
- Make sure that the level of the water extends into the neck of the bottle.
- Mark a line on the cup to indicate the water level within the bottle.

- Reexamine the bottle in a few days.

Notice the change in the water level? The amount of air within the bottle is fixed and cannot change since the water extended into the bottle acts as a 'plug'. Hence, you can consider the amount of air trapped in the bottle as an indicator of the air pressure on the day you plugged the bottle. The pressure on the surface of the water depends on the current air pressure. When the air pressure increases (as it does in drier weather), the pressure on the surface of the water is greater and the water is forced up into the bottle changing the level of the water. If you see the water level drop, find your umbrella...

Homemade Clouds in a Bottle

The clouds you see in the sky are formed when water vapor is cooled enough to form tiny water droplets. When moist, cool air rises to a higher altitude, it cools, water droplets are formed, and voila - you have clouds. In this experiment we'll duplicate this same process by causing air in a bottle to rapidly cool.

- Put a small amount of water into the jar. Just enough to cover the bottom.
- Place the glove into the jar with the fingers pointing down. Stretch the mouth of the glove over the top of the jar.
- Carefully insert your hand into the glove being careful not to break the seal. Pull your hand (with the glove still on it) outward quickly. Make sure you don't break the seal.
- Now remove the glove and drop a lit match into the jar. Quickly put the glove back into the jar and seal it again.
- Put your hand back into the glove and quickly pull it outward again.

Surprised! The clouds form when you pull the glove outward and disappear when you put your hand back into the jar.

Water molecules are in the air all around us - they're just invisible. So we do indeed have some water particles in the jar. When you pull the glove outwards you make more room in the jar and the air in the jar hence has more room to expand. This process causes the air and water particles in the jar to cool slightly. When the air cools, the water particles begin sticking to each other (just like the formation of clouds).

The match adds another component to this mix - smoke particles, which are solid. Water particles will bunch together more easily if there are some solid particles around to act as a nucleus. The smoke particles serve this purpose well and hence facilitate the formation of the 'clouds'.

When you put your hand back into the jar you compress the air which has the opposite effect of expansion - the air heats up. This may seem a little confusing but just remember expansion causes cooling and compression causes heating.



Advanced Notes: Clouds form from water that has evaporated from lakes, oceans, and rivers, or from moist soil and plants. This evaporated water, called water vapor, expands and cools as it rises into the air. Air can hold only a certain amount of water vapor at any given temperature. Warm air can hold more water vapor than cool air can. When the temperature drops, some of the water vapor begins to condense (change to a liquid) into tiny water droplets.

For water vapor to condense, particles so small they can be seen only through a microscope must be present. These particles, called condensation nuclei, become the centers of the droplets. Many condensation nuclei are tiny salt particles or small particles present in smoke. Most droplets measure from 1/2,500 to 1/250 inch (0.01 to 0.1 millimeter) in diameter.

If the temperature is cold enough, and other conditions are right, water vapor does not condense and form a liquid droplet. Instead, the water vapor turns directly to ice through a process called sublimation. For sublimation to occur at temperatures above -40 °F. (-40 °C), small particles similar to condensation nuclei, with a shape somewhat like an ice crystal, must be present. These particles are called freezing nuclei.

Comparison of Comets and Asteroids

Often it is not an experiment, but rather a simple activity that causes students to think about and discuss their research. For example, they might compare and contrast various objects found in space. Use the following graphic organizer for students to compare comets to asteroids.

Comparison of Comets and Asteroids	
Comets	Asteroids
	

Comparison of Comets and Asteroids – Possible Answers

Comets	Asteroids
Made up of ice and dust	Made up of rocks and metals
Form tails when they pass through the inner solar system	Do not form tails
Typically have orbits that are more elliptical and tilted than the orbits of planets	Typically have orbits that are more elliptical and tilted than those of planets
Usually orbit the sun in two regions: the Kuiper belt (about 30 to 100 AU from the Sun) and the Oort Cloud (extending out to about 50,000 AU from the S=sun)	Usually orbit the sun in the asteroid belt, a region between Mars and Jupiter
Typically remain in the outermost regions of the solar system (beyond the orbit of Neptune), but can pass through the inner solar system if their orbits are elliptical enough	Typically remain in the asteroid belt, a region between Mars and Jupiter
May or may not orbit the Sun in the same direction as the planets	Orbit the Sun in the same direction as the planets
Usually undetectable to the naked eye; may become visible while passing through the inner solar system	Virtually undetectable to the naked eye
Meteor showers usually occur when Earth passes through a stream of particles left behind by a comet in its orbit	Produce meteors (streaks of light) upon entering Earth's atmosphere; produce meteorites if they (either whole or in part) survive the trip through Earth's atmosphere and hit the ground

Weather Proverbs – Fact or Fiction

Retrieved from the World Wide Web at:

<http://inspire.ospi.wednet.edu:8001/curric/weather/hsweathr/solutions.html>

A cow with its tail to the west makes weather best.

A cow with its tail to the east makes weather least.

Is the weather proverb based in fact or just fiction? Explain your response.

When the ditch offends the nose, look for rain and stormy blows.

Is the weather proverb based in fact or just fiction? Explain your response.

When leaves show their backs, it will rain.

Is the weather proverb based in fact or just fiction? Explain your response.

When squirrels lay in a big store of nuts, look for a hard winter.

Is the weather proverb based in fact or just fiction? Explain your response.

Crickets are accurate thermometers; they chirp faster when warm and slower when cold.

Is the weather proverb based in fact or just fiction? Explain your response.

Sea gull, sea gull, sit on the sand; It's a sign of a rain when you are at hand.

Is the weather proverb based in fact or just fiction? Explain your response.

Weather Words Matching Game

Air Mass	a large dome of air, which has similar horizontal temperature and moisture characteristics
Cold Front	the front edge of a relatively cold mass of air
Dew Point	limit to the amount of water air can hold
High Pressure	sinking air, which is generally associated with fair weather patterns
Low Pressure	rising air, which is generally associated with stormy weather patterns
Overrun	during winter, warm air moves above cold air at the surface, creating much of the winter precipitation
Rain	nearly steady and uniform fall of precipitation over an area
Showers	intermittent and scattered rainfall of varying intensity
Relative Humidity	measure of the amount of water in the air compared with the amount of water the air can hold at that temperature
Unstable Atmosphere	result of cold air moving above warm air, which often creates severe weather, including tornadoes
Warm Front	the front edge of a relatively warmer mass of air

Weather Observation Chart

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Temperature							
Humidity							
Clouds							
Wind							
Precipitation							
Air Pressure							

Climate Comparison Chart

Average Monthly Temperatures

Months		
January		
February		
March		
April		
May		
June		
July		
August		
September		
October		
November		
December		

Average Monthly Precipitation

Months		
January		
February		
March		
April		
May		
June		
July		
August		
September		
October		
November		
December		

Important Scientific Formulas

Mathematics is one of the most important tools of science. As you learn about science, you will learn many important formulas. This sheet provides you with a place to record them.

Directions: Whenever you learn a new formula, record it in the chart. Include as much information about each formula as possible in order to help you remember it and use it correctly.

Important Scientific Formulas				
Name of Formula	Purpose and Use	Mathematical Expression	Definition of Terms	Additional Information

Sample Lesson and Activities on the Solar System

Overview of Our Solar System

For thousands of years, people have gazed into the sky at the stars. Ancient astronomers observed points of light that appeared to move among the stars. They called these objects planets, meaning wanderers, and named them after Roman deities - Jupiter, king of the gods; Mars, the god of war; Mercury, messenger of the gods; Venus, the goddess of love and beauty, and Saturn, father of Jupiter and god of agriculture. The stargazers also observed comets with sparkling tails, and meteors - or shooting stars apparently falling from the sky.

Since the invention of the telescope, three more planets have been discovered in our solar system: Uranus (1781), Neptune (1846), and Pluto (1930). Pluto was reclassified as a dwarf planet in 2006. In addition, our solar system is populated by thousands of small bodies such as asteroids and comets. Most of the asteroids orbit in a region between the orbits of Mars and Jupiter, while the home of comets lies far beyond the orbit of Pluto, in the Oort Cloud.

The four planets closest to the Sun - Mercury, Venus, Earth, and Mars - are called the terrestrial planets because they have solid rocky surfaces. The four large planets beyond the orbit of Mars - Jupiter, Saturn, Uranus, and Neptune - are called gas giants. Tiny, distant, Pluto has a solid but icier surface than the terrestrial planets.

Nearly every planet - and some moons - has an atmosphere. Earth's atmosphere is primarily nitrogen and oxygen. Venus has a thick atmosphere of carbon dioxide, with traces of poisonous gases such as sulfur dioxide. Mars' carbon dioxide atmosphere is extremely thin. Jupiter, Saturn, Uranus, and Neptune are primarily hydrogen and helium. When Pluto is near the Sun, it has a thin atmosphere, but when Pluto travels to the outer regions of its orbit, the atmosphere freezes and collapses to the planet's surface. In that way, Pluto acts like a comet.

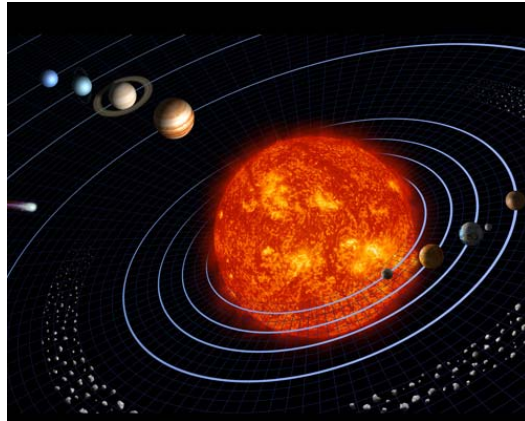
There are 144 known natural satellites (also called moons) in orbit around the planets in our solar system, ranging from bodies larger than our own Moon to small pieces of debris. Many of these were discovered by planetary spacecraft. There are currently 21 recently discovered moons awaiting final approval before being added to our solar system's moon count.

Some of moons have atmospheres (Saturn's Titan); some even have magnetic fields (Jupiter's Ganymede). Jupiter's moon Io is the most volcanically active body in the solar system. An ocean may lie beneath the frozen crust of Jupiter's moon Europa, while images of Jupiter's moon Ganymede show historical motion of icy crustal plates. Some moons may actually be asteroids that were captured by a planet's gravity. The captured asteroids presently counted as moons may include Phobos and Deimos, several satellites of Jupiter, Saturn's Phoebe, many of Uranus' new satellites, and possibly Neptune's Nereid.

From 1610 to 1977, Saturn was thought to be the only planet with rings. We now know that Jupiter, Uranus, and Neptune also have ring systems, although Saturn's is by far the largest. Particles in these ring systems range in size from dust to boulders to house sized, and may be rocky and/or icy.

Most of the planets also have magnetic fields which extend into space and form a magnetosphere around each planet. These magnetospheres rotate with the planet, sweeping charged particles with them. The Sun has a magnetic field, the heliosphere, which envelops our entire solar system.

Ancient astronomers believed that the Earth was the center of the Universe, and that the Sun and all the other stars revolved around the Earth. Copernicus proved that Earth and the other planets in our solar system orbit our Sun. Little by little, we are charting the Universe, and an obvious question arises: Are there other planets where life might exist? Only recently have astronomers had the tools to indirectly detect large planets around other stars in nearby solar systems.



Myth or Reality?

Which of the following is a myth and which is a reality? When you are done, check your answers.

1. The Earth is the largest object in the solar system.
2. The Earth is the center of the solar system.
3. Earth and Venus are identical.
4. Earth and Mars are similar in size.
5. The Sun is a burning ball of fire.
6. Spacecraft can land on the surface of Jupiter, Saturn, Uranus and/or Neptune.
7. Pluto is the most-distant and last object in the solar system.
8. Comets are composed of the same material as asteroids.
9. Meteors are falling stars.
10. Other stars and galaxies are part of the solar system.

The Solar System: Myth or Reality?

Answers to Sample Misconceptions

1. The Earth is the largest object in the solar system.

The largest object in the solar system is the Sun. It contains 99 percent of the mass of the solar system. Jupiter is the largest planet in the solar system, and Earth is the fifth largest.

2. The Earth is the center of the solar system.

The Sun is at the center of the solar system, and the planets, asteroids, moons, and comets orbit the Sun. The Earth is the third planet from the Sun.

3. Earth and Venus are identical.

Earth and Venus have a couple of things in common: they are rocky planets and are about the same size. But Venus is different in many ways from Earth. Venus has a harsh environment, is very hot, and has a poisonous atmosphere with “acid clouds.”

4. Earth and Mars are similar in size.

Mars is about half the size of Earth.

5. All the planets are the same size as Earth.

The planets are different sizes. From smallest to largest they are: Mercury, Mars, Venus, Earth, Neptune, Uranus, Saturn and Jupiter. Jupiter is roughly 10 times larger than Earth. Mars is about half the size of Earth. Venus and Earth are roughly the same size.

6. The Sun is not a star because it doesn't shine at night.

The Sun is the closest star to the Earth and provides us with most of our energy and light. Earth turns on its axis once every day. When we experience darkness, we are facing away from the Sun. When we experience daylight, we are facing the Sun. We can't see other stars during the day because the Sun's light illuminates the Earth's atmosphere.

7. The Sun is a burning ball of fire.

The Sun is glowing, not burning like a fire. The Sun glows because its temperature is about 5,500 degrees Celsius (about 10,000 degrees Fahrenheit). This heat is not produced by burning (a chemical reaction), but rather by fusion (a nuclear reaction). This nuclear fusion takes place deep in the Sun's core at a temperature of about 15 million degrees. As the heat travels out through the Sun's layers, it becomes much cooler, but still hot enough to glow in visible light. For comparison, the temperature of a wood fire is less than a thousand degrees Fahrenheit.

8. Spacecraft can land on the surface of Jupiter, Saturn, Uranus and/or Neptune.

These giant planets are made mostly of gas. They may have solid cores, but the temperature and pressure of the gas would increase as the spacecraft moved toward the core. It would be destroyed before it reached that solid surface.

9. The rings of Saturn are solid disks.

Thousands of rings, made of pieces of ice, orbit the planet. The pieces of ice are about one meter apart, and can be as small as dust specks or as big as a house. The ice pieces collect into ring shapes because of gravity. The rings are usually divided into seven regions, labeled A to G. The total mass of the rings is that of a 100-kilometer-sized comet.

10. Pluto is the most-distant and last object in the solar system.

No, Pluto is not the last object in the solar system. Pluto, a dwarf planet, resides within a region of icy objects called the Kuiper belt. The Kuiper belt extends from Neptune's orbit outward. Beyond Pluto's orbit is another region of icy objects called the Oort cloud, which is home to comets.

11. The planets are evenly spaced.

The inner planets (Mercury, Venus, Earth and Mars) are closer together than the outer ones (Jupiter, Saturn, Uranus, and Neptune). The inner planets are closest to the Sun; the outer planets are farthest away from the Sun. The distance between planets generally increases as one looks farther from the Sun. The planets in the inner solar system are tens of millions of kilometers apart; the planets in the outer solar system are hundreds of millions of kilometers apart.

12. The solar system is made up of only the Sun and eight planets.

The solar system also contains the planets' moons, scattered gas and dust, asteroids, and comets. Comets occasionally visit the inner solar system –the region closest to the Sun – from their home in the Kuiper belt or Oort cloud.

13. Comets are composed of the same material as asteroids.

Although comets and asteroids are both tiny objects that orbit in the solar system, their composition is different. Asteroids are mostly rock with some ice, while comets are mostly ice with some rock.

14. Comets always have tails.

Comets do not always have tails. They develop a fuzzy, shell-like cloud called a coma, and one, two, or three tails when near the Sun. Comets have no coma or tail when far away from the Sun.

15. Comets come from regions outside the solar system.

Comets are part of the solar system. Scientists believe they come from one of two locations within the solar system: the Kuiper belt and the Oort cloud. The comets that we see often – every 100 years – come from the Kuiper belt, and comets that we see rarely – every few thousand years – come from the Oort cloud.

16. Meteors are falling stars.

Meteors are the bright flashes of light seen in the night sky. They are caused by meteoroids, small, solid objects moving through space that have entered Earth's atmosphere. Usually, the meteoroids burn up in the atmosphere and never reach the ground. A meteorite is the chunk of material that does reach the ground.

17. Meteors are solid objects.

A meteor is a bright streak of light in the sky caused when a meteoroid (a small chunk of rock or ice) enters the Earth's atmosphere and heats up.

18. Asteroids are very close to each other.

Asteroids are not close to each other. They are roughly 1 million miles from each other.

19. Other stars and galaxies are part of the solar system.

There is only one star, the Sun, in the solar system. Besides the Sun, the solar system consists of planets, moons, asteroids, and comets. The solar system resides in the Milky Way galaxy. Many

other stars are outside our solar system, but part of our Milky Way galaxy. About 50 billion galaxies are outside our galaxy. Galaxies contain from tens of millions to trillions of stars.

20. Scientists know all there is to know about the solar system.

Scientists are sending out spacecraft and pointing telescopes to learn more about the solar system.

Among the many questions scientists are trying to answer are whether Mars has liquid water and how the solar system was formed.

21. Our solar system is composed of eight planets and a large number of smaller bodies.

Our solar system is composed of: the Sun; the eight official planets, at least three "dwarf planets", more than 130 satellites of the planets, a large number of small bodies (the comets and asteroids), and the interplanetary medium.

Space Science: Using Math to Explore Characteristics of the Solar System

The Solar System – The solar system consists of a star – the Sun – and everything that revolves around it. It’s called the solar system because solar means “of the sun.”

Directions: Use appropriate resources to complete the following graphic organizer

The Solar System		
Major Planets	General Characteristics	Planet: Distance from the Sun: Characteristics:
		Planet: Distance from the Sun: Characteristics:
		Planet: Distance from the Sun: Characteristics:
		Planet: Distance from the Sun: Characteristics:
		Planet: Distance from the Sun: Characteristics:
		Planet: Distance from the Sun: Characteristics:
		Planet: Distance from the Sun: Characteristics:
		Planet: Distance from the Sun: Characteristics:
Asteroid Belt	Definition:	Description:
Dwarf Planets	General Characteristics	Planet: Distance from the Sun: Characteristics:
		Planet: Distance from the Sun: Characteristics:
		Planet: Distance from the Sun: Characteristics:
Comets	Definition:	Description:

How Much Would You Weigh on Other Planets?

Science Skill: Space science – exploration of characteristics of different planets

Math Skill: Multiplication of decimals

Your weight on a planet = your Earth weight times the surface gravity of that planet. Thus, if you wish to know what your weight would be on Mars, you need to multiply your Earth weight by the surface gravity of Mars.

Example: How much does a person who weighs 130 pounds on earth weigh on Mars?

Earth weight times surface gravity of planet = weight on that planet.

130 lbs. x .38 =

Planet (includes Pluto and the moon)	Surface Gravity Compared to Earth's
Mercury	0.37
Venus	0.88
Earth	1.00
Mars	0.38
Jupiter	2.51
Saturn	1.07
Uranus	0.93
Neptune	1.23
Pluto	0.04
Earth's moon	0.17

If a person weighs 130 pounds on earth, how much would that person weigh on each of the planets/moons listed above?

How Far Is It?

Science Skill: Space science – exploration of characteristics of different planets

Math Skill: Conversion of measurement units from astronomical units to miles to kilometers.

Distances in our solar system are so tremendous that units of measurement, such as miles, meters, and kilometers are too small to be helpful. Thus, scientists have developed a unit of measurement based on the distance between Earth and the sun called the astronomical unit (AU). Using geometry we can see that the average distance between Earth and the sun is 93 million miles or 149,600,000 km.

1 AU = 93 million miles – 149,600,000 km.

Complete the following table to determine how many miles and how many kilometers each of the following planets are from the sun.

Planet	Distance from Sun in AU	Distance from Sun in Miles	Distance from Sun in Kilometers
Mercury	0.387		
Venus	0.723		
Earth	1.000		
Mars	1.524		
Jupiter	5.203		
Saturn	9.539		
Uranus	19.182		
Neptune	30.214		

Extension Activity: The average distance from the Earth to the Sun is 1 AU or 92,960,000 miles. How would you write this distance in scientific notation?

How would you write 149,600,000 km in scientific notation?

Can you use scientific notation to indicate the distance of each of the above planets from the sun?

Distances in the Solar System

Even in our own “cosmic neighborhood,” distances in space are so vast that they are difficult to imagine. In this activity, we will build a scale model of the solar system using a roll of toilet paper.

Materials

- Planetary distances table
- Roll of toilet paper
- Gel pen or felt tip pen to write on toilet paper

Doing the Activity

Take one sheet of toilet paper as a test sheet for the pens. Make sure the ink is not too wet, that the pens don't easily tear the paper. Make a dot on the seam between the first two sheets of toilet paper. This is the Sun. Write the word Sun beside the dot.

Use the table of numbers to mark off the distances to each of the planets. The number in the table is the number of sheets of toilet paper needed to reach the orbit of each planet. It is important to realize that the counts in the table are starting from the Sun, not from the previous planet. (Thus, after you get to Mercury, you need 1.7 more sheets to get to Venus.) Make a dot and write the appropriate planet name on the toilet paper at the distance indicated. Ceres, the largest asteroid, is used to represent the asteroid belt.

Note:

- Keep a running count as you work on this. Each distance is from your starting point, the Sun
- 200 sheets of toilet paper stretch out to nearly 84 feet. Make sure you have room for your model before you start.
- Use colored pens to mark the distance to the planet's orbit from the Sun and label the orbit with the planet's name on the toilet paper.

Planet	Distance from the Sun (km)	Squares of Toilet Paper from the Sun
Mercury	57,910,000 km	2.0
Venus	108,200,000 km	3.7
Earth	149,600,000 km	5.1
Mars	227,940,000 km	7.7
Ceres	414,436,363 km	14.0
Jupiter	778,330,000 km	26.4
Saturn	1,429,400,000 km	48.4
Uranus	2,870,990,000 km	97.3
Neptune	4,504,000,000 km	152.5
Pluto	5,913,520,000 km	200

Cartography and Math

Objectives/Learning Goals

Students will:

- Practice using the terms associated with the coordinate plane: *x-axis*, *y-axis*, quadrants, coordinate points, ordered pairs, origin, negative numbers, positive numbers
- Graph ordered pairs, in the form (x, y) in all quadrants
- State the location of points within all quadrants by giving ordered pairs in the form (x, y)
- Draw a picture on the coordinate plane using all quadrants and then create a set of directions such that, when followed, will recreate the image they originally drew
- Apply their knowledge of coordinates to the real-world skill of map making

Prerequisite Knowledge

Students should be able to:

- Identify the *x* and *y* axis
- Recognize positive and negative values on a coordinate plane grid
- Identify the four quadrants on a coordinate plane grid
- Locate coordinates in each of four quadrants

Content/Cognitive Skills

This lesson focuses on how to grid coordinates onto either graph paper or a coordinate plane grid using each of the quadrants. Students should also be able to identify coordinates and provide clear directions in order for others to draw a figure or map based only on charting and connecting the coordinates provided.

Materials/Resources/Internet Sites/Handouts

- Grid paper (or coordinate plane grid)
- Pencil
- List of coordinates for each activity
- Copy of maps to compare student work
- Copy of maps showing cartography (complete a search to locate maps to share with class)

Activity Procedure

Introduction to Lesson/Activity Starter (5 minutes)

Show students a copy of an old map that used cartography. Maps such as this are easily located on the World Wide Web. Many maps are free for use in the classroom. Discuss with students that in today's world obtaining a map is as simple as completing a search on the computer and clicking on the icon to view the map of your choice. Thanks to satellites, Geographical Information Systems (GIS), and other technologies, creating and distributing accurate maps is much easier than in earlier days. For centuries, map making, or cartography, was a time-consuming and painstaking effort that blended mathematics, geography, and even art. New lands had to be carefully surveyed with precise measurements taken. Simple coordinates had to be skillfully transformed on paper into land masses and waterways.

Review the parts of the coordinate plane grid. Share with students that they will be completing a process very similar to that used by ancient mapmakers.

Key Words

- Coordinate plane
- Origin
- Coordinate (ordered) pair
- x -axis
- y -axis
- Quadrant
- Point
- Line
- Longitude
- Latitude

Question Starters

- Before satellites and computers, how were maps drawn? (Answers may vary)
- Who has seen a coordinate plane grid?
- What can you graph on the coordinate plane grid? (Answers can include: points, lines, circles, shapes, etc.)
- What is an axis? (A reference line from which distances are measured in a coordinate system)
- Where does the middle of the coordinate plane lie? (0, 0)
- What does the prefix "quad" mean? (Four)
- What is a quadrant on the coordinate plane grid? (One of the four areas on the grid)

Instructional Outline (30 minutes)

- Have students try their hand at old-fashioned cartography.
- Give each student a pencil and a sheet of graph paper or a coordinate plane grid.
- Have students locate 0 on the grid and identify the y axis (bottom to top) and the x axis (left to right).
- Provide students with worksheet and have them locate the coordinates (x, y) on the grid and mark them with a small dot. (A worksheet is provided at the end of this lesson.)

Evaluation (10 minutes)

After students have completed the activity, have them compare their results to actual maps of the states that they have drawn. Debrief the activity. Did students follow the directions completely? Were their maps similar to those provided? What error patterns were made? How were the gridded maps similar/different from the pictures? Why or why not?

Extension Activity

Access the following website to obtain an outline map of your state. Print the map and have students develop the coordinates in order to reproduce the map as accurately as possible. Compare and contrast the different coordinates students developed.

NetState. Retrieved from the World Wide Web at: <http://www.netstate.com/states/index.html>.

Provide students with a blank coordinate plane grid sheet with at least positive 10 and negative 10 as its maximums and minimums. Have students draw a picture on their grid and on a separate sheet of paper write directions using ordered pairs and some guiding words. Develop specific stipulations for students regarding their drawing, such as:

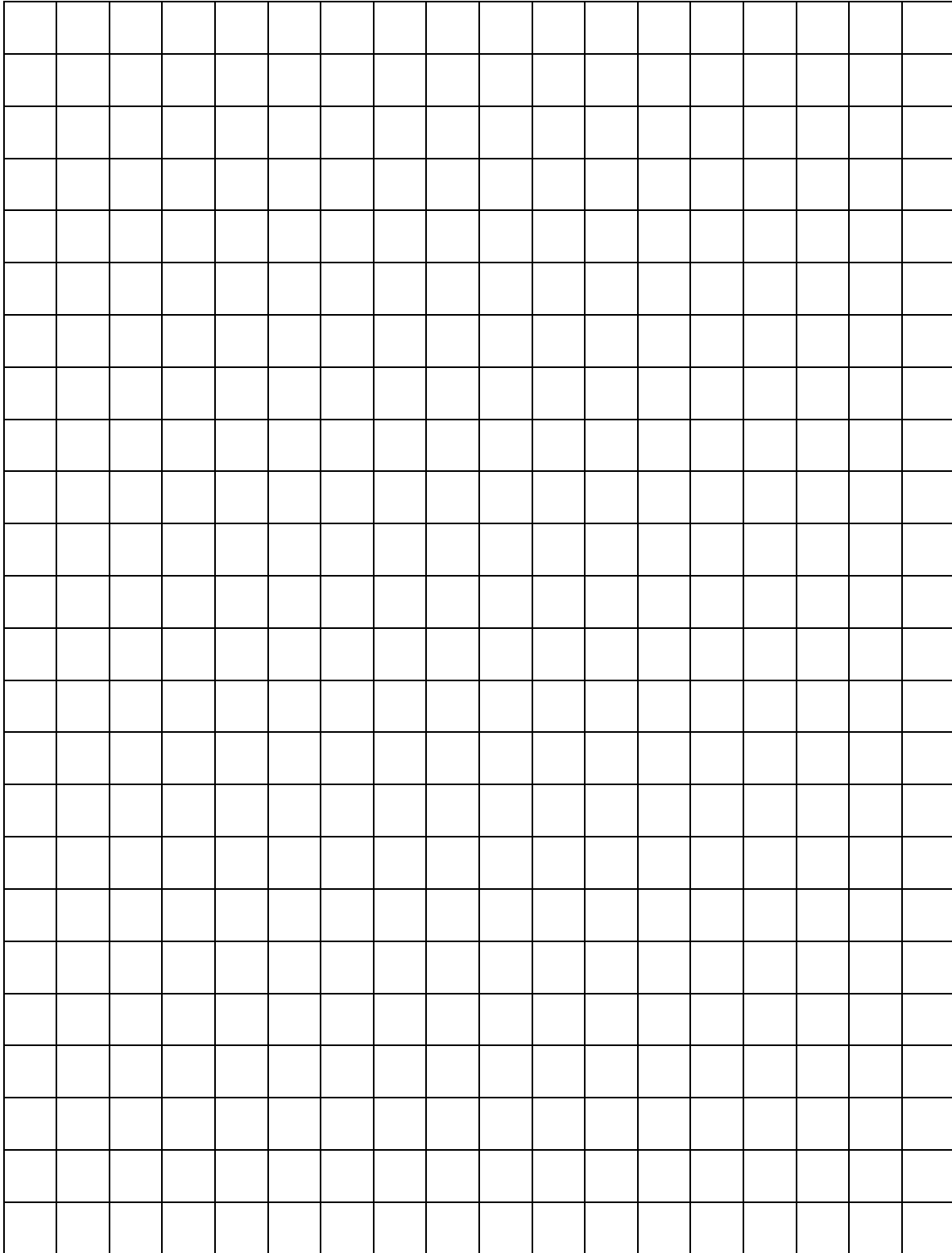
The drawing must include each of the quadrants

The drawing and subsequent directions must include at least 30 separate ordered pairs (dependent on the class)

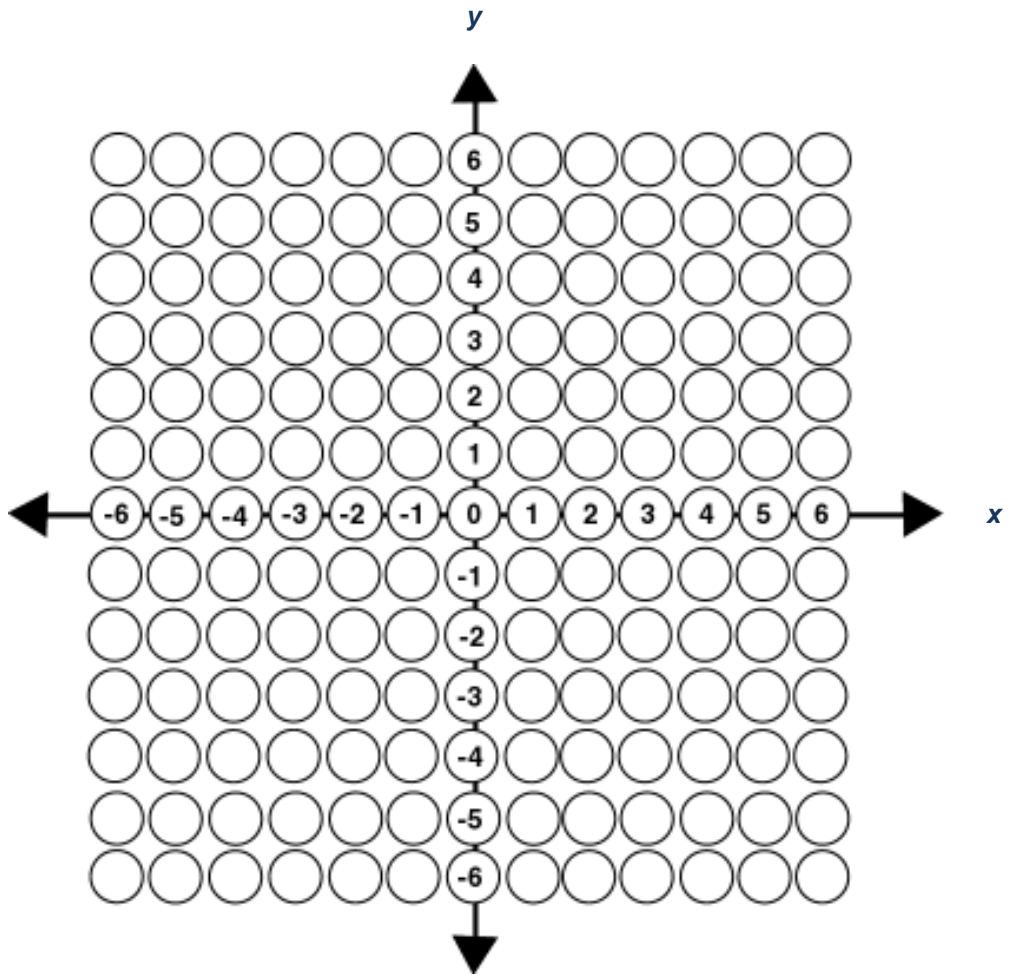
The directions must be written on a different piece of paper than the drawing. For example, a student might have in their directions: "Draw a point at $(4, 5)$ and label it A. Next, draw a point at $(8, -2)$ and label it B. Now, connect A to B."

Have students exchange their directions with other students, along with a blank coordinate plane grid. Provide students with time to complete their drawing. The students should confirm with their classmates if their drawing is correct. When finished, debrief the activity by having students discuss what was easy or difficult about specific directions. Assess the activity by determining from the student's original drawing, his/her directions, and the drawing completed by another student based on the directions, the accuracy of the drawing and directions and whether the drawing included all requirements.

Grid Paper



Coordinate Plane Grid



Where in the World Am I?

Directions: Identify each of the following coordinates with a dot on your grid. Then connect them in order. If completed, correctly you will be able to identify a map of a familiar geographic location.

1. (-3, 0)
2. (-4, -2)
3. (-3, -3)
4. (-4, -4)
5. (-4, -8)
6. (0, -7)
7. (5, -7)
8. (5, -1)
9. (4, -2)
10. (2, -2)
11. (1, 0)
12. (0, 2)
13. (-1, 4)
14. (-2, 5)
15. (-2, 8)
16. (-4, 8)
17. (-4, 2)
18. (-3, 1)
19. (-3, 0)

The name of the place is: _____

Let's try one more. Place each coordinate on the grid and then connect the dots.

1. (0, -3)
2. (1, -5)
3. (2, -6)
4. (3, -7)
5. (4, -7)
6. (4, -5)
7. (5, -3)
8. (7, -2)
9. (8, -1)
10. (9, -1)
11. (9, 0)
12. (8, 1)
13. (8, 2)
14. (8, 3)
15. (7, 5)
16. (6, 6)
17. (5, 5)
18. (4, 5)

19. (3, 5)
20. (2, 6)
21. (1, 6)
22. (0, 6)
23. (0, 9)
24. (-4, 9)
25. (-4, 6)
26. (-4, 3)
27. (-9, 3)
28. (-6, 0)
29. (-5, -2)
30. (-4, -3)
31. (-3, -1)
32. (-2, -1)
33. (-1, -2)
34. (0, -3)

The name of the place is: _____

RESEARCH ARTICLES

Mathematics and Science Literacy for All Americans

by Frank X. Sutman, Rowan University, Glassboro, New Jersey

Before It's Too Late, the report from the National Commission on Mathematics and Science Teaching for the 21st Century, makes very clear the urgent need for all Americans to develop a higher level of mathematics and science literacy than presently exists:

From mathematics and the sciences will come the products, services, standard of living, and economic and military security that will sustain us at home and around the world. From them will come the technological creativity American companies need to compete effectively in the global marketplace.

As a regular reader of *ENC Focus*, you are aware of the evidence indicating that we have a long way to go in attaining mathematics and science literacy. And you know about the many instructional resources available for mathematics and science. Likewise, as an *ENC Focus* reader, you are aware of the variety of professional development opportunities for teachers to learn how to use these materials.

Yet, there is a fundamental problem that prevents us from meeting the goal of mathematics and science literacy for all Americans. This problem is that teachers, themselves, are unclear about what is meant by literacy in these fields. This term, like so many other educational terms, has a vague and theoretical meaning for too many teachers and school administrators. Understanding is further obscured by education professionals who interchange literacy with acquisition of facts or who argue that no clear definition is possible.

One holder of the latter position is George DeBoer, a well-known science education researcher. In his article "Scientific Literacy: Another Look at Its Historical and Contemporary Meaning," DeBoer states, ". . .scientific literacy is undefinable and perhaps this is for the best" (2000).

DeBoer's history of the evolving understanding of science literacy quotes Morris Shamos, another well-known science educator, who expressed the opinion that "efforts to achieve scientific literacy among students are futile" (1995). Despite this, DeBoer supports the position taken by Shamos that "unless we (science educators) do develop and use a working definition (or description) for science literacy, we are in jeopardy of not reducing (but increasing) the continuing flood of books and articles deploring the sad state of this overall goal of science instruction."

Describing Mathematics and Science Literacy

Another position taken by DeBoer precipitated my own description of scientific literacy, which my professional judgment indicates can be expanded to include mathematics literacy. DeBoer stated that "science literacy is limited to non-scientists, excluding practical scientists from the literacy requirement." I disagree. Scientists (and mathematicians), like all other citizens, have an obligation to become mathematics and science literate so they comprehend the significance of their knowledge to the issues that challenge society and can work with others in putting into practice the processes that lead to solutions.

Recognition of the need for a definition led me to develop a three-level description for mathematics and science literacy. Here it is, beginning with the simplest:

- The ability to learn and to repeat learned mathematics and science content.
- The ability and willingness to learn additional mathematics and science content on one's own.
- The ability and willingness to develop and use mathematics and science processes to expand learning, to communicate with others about that learning, and to involve others in applying that which has been learned to address societal issues.

Each level of complexity subsumes the simpler levels, and there is no sharp line of distinction between one level and the next. There is, however, a "readiness" at which students are able to advance from one level of literacy to the next. This readiness varies from student to student.

This description for mathematics and science literacy is both realistic and functional. It overcomes the vagueness of the past and sets the stage for creating realistic standards for student learning. This is illustrated in the following example about inquiry learning.

The ability to practice inquiry (better stated as student inquiry or discovery) is a goal that pervades both national and state mathematics and science curriculum standards. The fact that younger children naturally inquire but later lose this skill tells us that this process must be encouraged through practice at a reasonably early age and continued throughout schooling. At the same time, the development of this skill needs to be supported through opportunities to participate in mathematics and science processes that lead to discovery.

These process skills include those associated with hands-on math and science but also must include the basic language skills of reading, listening, and writing. Without basic language skills, student inquiry and discovery will be ineffective. In fact, involving students in hands-on activities to answer their inquiries should serve to motivate students to read and write about mathematics and science and to be willing to learn from knowledgeable professionals in those fields.

Not until teachers attain at least the second level of mathematics and science literacy will they understand and begin to practice the tenets of the reform movement in mathematics and

science instruction as proposed by the National Science Education Standards, the Project 2061 Benchmarks, the Principles and Standards for School Mathematics, and other standards that have evolved from these. Nor will teachers be able to implement these standards effectively unless they have developed their own mathematics and science literacy at the third level.

Cautions

Higher levels of mathematics and science literacy for both teachers and students will occur when the education culture allows both to be actively involved in investigations that lead to answers to their own questions. Teachers must be very careful not to ask too many of the questions so that students have ample opportunity to do so. To strengthen students' levels of mathematics and science literacy, teachers must allow adequate opportunity for students to make mistakes that the students themselves can then correct through their own inquiries.

The perception that it is possible for students to attain the highest level of mathematics and science literacy quickly is not accurate. To attain the highest level of literacy requires a concerted, conscious effort on the part of the entire education community to offer students sustained opportunities to develop it. Few upper-grade students practice literacy at the highest level because its development has not been a conscious goal throughout the grades.

Another reason that the highest level of mathematics and science literacy is rarely attained is because mathematics instruction is historically separated from science instruction. This separation results in the loss of wonderful opportunities to enhance both mathematics and science literacy. The teaching of mathematics by itself, solely through written word problems, may unconsciously integrate mathematics with language but does little to develop mathematics/science literacy. A commitment to combine the two disciplines will increase literacy for more students in both academic areas.

Finally, the increasingly popular "quick and dirty" approach of using special study sessions to improve performance on high-stakes mathematics and science tests may pay off over the short haul, but sustained higher test scores will result only when teachers work to enhance their own level of literacy and that of their students. It will take a clear understanding of the meaning of mathematics and science literacy as well as reform in how teachers approach instruction, at all school levels, to enable the next generation of citizens to be adequately prepared to meet the demands of the *Before It's Too Late* report.

Development of Mathematics and Scientific Literacy

Teachers can observe a number of clear-cut indicators that students are increasing their level of mathematics and science literacy. Examples of these indicators are included as questions below.

- Do my students refer to sources of information beyond the teacher and the textbook, such as handbooks, magazines, and the results of their own investigations, to discover answers to their inquiries?

- Do my students interact with their peers concerning mathematics and science concerns?
- At early grade levels, do my students willingly describe in writing to a friend the mathematics and science activities that they have completed and indicate what they learned?
- Do I (the teacher) share my positive mathematics and science experiences with peers?
- Am I integrating mathematics and science with each other and with other areas of study such as reading, writing, and social studies?
- Over several years, do my students' scores on high-stakes tests in mathematics and science, on average, improve?

Practices indicating a lack of support for mathematics and science literacy:

- Do I insist that all of the content in the textbook be covered?
- Do my students complain when asked to organize collected data into tables and graphs and then use these data in reports?
- Do I ask almost all of the questions?
- Are my students' questions limited to procedural questions?

References and Suggested Readings

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Math and Science Illiteracy in the News

Educators, mathematicians, and scientists would be wise to overcome misgivings about media coverage of complex math and science issues and recognize the role of the press in educating the public.

by Carolyn Hamilton

Time was when many of us could say, "Oh, I can't do percents" or "I never understood any of that genetics stuff" with no fear that anyone would think we were illiterate. The next generation will not get off so easily.

Math and science illiteracy is coming under the microscope now. The news media, politicians, policymakers, and educators warn that the need for math and science literacy is no laughing matter. Nor are the dire warnings of what will happen to the United States as a major player in the world if its people are not knowledgeable or at least conversant with fundamental scientific issues. A widely perceived need to equip all children with math and science competency is much in the news.

A recent article in an Ohio State University newspaper describes one professor's approach to reaching young people who take his Biology 101 course to fulfill a graduation requirement. Steve Rissing requires the nonbiology majors to subscribe to the *New York Times*. Weekly he assigns articles and gives quizzes. His intent:

"I don't want to give my students a vocabulary test. I want to know if they understand some of the basic principles of science.... One way to help give some meaning to the jargon is to show relevancy, to show the students that science means something to their lives." (The Times is A-changing, 2001)

While newspapers can be a resource for enhancing literacy, they are also a source of warnings about the dangers of illiteracy.

The Oregonian (February 6, 2001), interviewed what it called "nonmath-related" professionals about their use of math on the job. The conductor of the state symphony said, "Math is the fundamental underpinning of all music, from understanding acoustics to reading music and figuring out tempo."

In the same article, a novelist recalled that he "fell off the train at story problems" and regretfully could not help his children with their math homework. A math specialist for the Portland schools reports that the district is being told by local businesses that math is "a gatekeeper of opportunity."

Organizers of an effort to spotlight the value of math and science education report that 16 percent of the U.S. adult population know the difference between a gene and a chromosome and thus can be called scientifically literate, according to an article in the *Washington Post* (In

science, U.S. adults, 2000). Surprisingly, the researchers claim that this rate puts the United States in the top rankings worldwide.

Some people who tried to avoid math and science when they were in school find that they now have to play catch up to succeed in professions once thought far removed from those subjects. *The Christian Science Monitor* reports that the U.S. Supreme Court requires federal trial judges to determine if evidence "is sufficiently grounded in scientific principles to be introduced at trial. Many state courts have adopted similar standards." This has sent trial judges back to university campuses for summer courses in subjects as diverse as toxicology and statistics. There is even a nonprofit organization that educates judges about genetics.

The Washington Post points to actions by a Florida court justice in the infamous 2000 election recount trials that show he quoted but misinterpreted mathematician and author John Allen Paulos's comments about margins of error. (See article on page 24.) When the public suffers from math illiteracy, according to the reporter's conclusions, "Money is wasted, bad policy is made, health and physical risks are taken based on faulty information" (Strauss, 2001).

Educators would not be alone in their battle against illiteracy if Stanford faculty members Lucy Shapiro and Michael Riordan are successful in getting scientists to share their expertise with the news media. They believe scientists should overcome any misgivings about press coverage of complex scientific issues and join the press in trying to educate the public. Riordan says, "The press is the conduit to a large and influential audience" (*Science Daily Magazine*, 2001).

There's no denying that reporters will be highlighting the math and science literacy issue for some time to come. Teachers can take advantage of this attention to illustrate the relevance of mathematics and science to their students' lives. The classroom is also a good place to model ways to find and use accurate media coverage of new mathematics and science information.

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It's About Relevancy

A chat with high school students reveals that they really do understand why it is important to become literate in mathematics and science.

by Carol Damian

Why do I have to learn this? When will I ever use it?

How many times have you been asked these questions? When I think about students becoming adults who are literate in mathematics and science, it occurs to me that we should be asking our students to answer their two big questions. I've found that young people will respond, citing important, interesting, and relevant reasons for their studies. Literacy in math and science is about relevancy.

Recently, I was chatting with 15 young people and asked them why a person should study math and science in school. They gave reasons such as becoming well-rounded, getting into college, challenging oneself, needing to "take something" (no other interesting courses-or no choice), being with friends in classes, and choosing courses taught by teachers they like.

Then I probed further by paraphrasing the students' two big questions: "Do you think you'll ever use that stuff? Why should you have to learn all that science and math?" Some of them mentioned things like balancing checkbooks, converting liters to gallons at the gas pump, and learning how to make slime.

"Well," I asked, "do you suppose anything you're learning in math and science will ever come up in your everyday lives or in your future jobs?"

"Yes," one girl answered, "like when you charge a bunch of stuff on your credit card and find you'll never be able to pay it off at the humongous interest rate." I asked them if any of their classes prepared them for that kind of real-life shock. Girls and boys chimed in, offering that some classes do-the ones where they actually get to do real things, like simulate stock market investing, plan a model city, or role-play deciding about an organ transplant. They all said they were not sure about the value of other classes because the lessons seemed disconnected from anything real.

I asked the two big questions again, "When will you ever use that stuff? Why learn all that math and science?" They thought awhile, talked among themselves, then started rattling off these "reasons": banking/borrowing money, product consumer, family planning, waste disposal, car purchases (and energy/pollution concerns), transportation systems, global warming, safety, medicines, genetic engineering, politics, defense issues, earthquakes, usable water, food supplies, weather changes, materials for building and clothing, disabilities, understanding numbers and problem-solving, communication, computers, information gathering... Seemingly disconnected answers, these "reasons" are a mirror of the issues adults face today.

The conversation went on for some time. I was fascinated. These students were quite capable of answering their own questions. More than that, they were defining what it means to be

literate in mathematics and science. They were closing in on what is relevant in math and science to their lives now and in the future.

When students ask you their two big questions, ask them to help you think through the answers. As they respond, they will realize how important mathematics and science literacy is to all of us.

Carol Damian has 25 years experience as a high school physics teacher. Currently, she serves as ENC's science education specialist.

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Vocabulary Words for Science

There are many “subject specific” words that students need for science, as well as some general words that are very helpful when students are trying to finding meaning in a scientific text. The following two lists provide sample science vocabulary words and a signal word list.

Sample Vocabulary List for Science

Fry, Edward, Kress, J. E., Fountoukidis, D. L. *The Reading Teachers' Book of Lists*. (2000). 4th Edition. pp. 145-149 & 425 & 426. Jossey-Bass. San Francisco: CA.

Absolute zero
Absorb
Acceleration
Acid rain
Acoustics
Adaptation
Adrenal
Air current
Air pressure
Algae
Allergy
Alloy
Amino acid
Amoeba
Ampere
Amplify
Amplitude
Anaphase
Amphibian
Anatomy
Antibiotic
Antigen
Aorta
Artery
Asexual
Astronomy
Atmosphere
Atom
Atomic mass
Atomic number
Atrium
Aurora
Bacillus
Bacteria
Bacterium
Balance
Benign
Binary fission

Biology
Biome
Biotechnology
Boiling point Buoyancy
Calcium
Calorie
Calorimeter
Capillary
Carbohydrate
Carbon dioxide
Carcinogen
Cardiac
Cardiovascular
Carnivore
Cartilage
Catalyst
Cell
Cell membrane
Celsius
Cellulose
Centimeter
Cerebellum
Cerebrum
Chemical bonding
Chemical equation
Chemical reaction
Chemical symbol
Chemistry
Chloroplast
Cholesterol
Chromosome
Cilium
Circuit
Circuit breaker
Circulatory system
Classification
Cleavage
Coefficient
Cold-blooded
Collision theory
Colorblindness
Combustion
Communicable
Competition
Compound
Compression
Concave
Concentrated

Condensation
Conduction
Coniferous
Connective tissue
Conservation
Constellation
Consumer
Convection
Conversion factor
Convex
Corrosion
Covalent bonding
Crest
Cross-pollination
Crystal lattice
Cytoplasm
Deceleration
Deciduous
Decomposition
Dendrite
Density
Dependence
Depletion
Depressant
Dermas
Desert
Diatom
Diffraction
Diffusion
Digestive system
Dilute solution
Diode
Distillation
DNA
Dominant
Doppler effect
Drag
Drug
Drug abuse
Dry cell
Ecology
Ecosystem
Efficiency
Effort
Electrochemical cell
Electrode
Electrolyte
Electromagnetic

Electron
Element
Embryology
Endangered species
Endocrine system
Endothermic
Energy
Enzyme
Epidermis
Erosion
Estrogen
Evaporation
Evolution
Excretion
Exothermic
Extinction
Fallopian
Fahrenheit
Fermentation
Fertilization
Fetus
Fiber optics
Flammable
Fluorescent
Focus
Food web
Force
Formula
Fossil
Fracture
Freezing point
Frequency
Fulcrum
Fungus
Fuse
Galvanometer
Gamma ray
Geiger counter
Gene
Generator
Genetics
Genotype
Genus
Geothermal energy
Germination
Glacier
Glucose
Grassland

Gravity
Grounding
Half-life
Hallucinogen
Halogen
Hazardous waste
Heat transfer
Hemisphere
Hemoglobin
Herbivore
Hertz
Heterogeneous
Hologram
Homeostasis
Homogeneous
Homologous
Hormone
Horsepower
Host
Hybrid
Hydrocarbon
Hydroelectric
Hypertension
Hypothalamus
Hypothesis
Igneous
Illuminate
Immune
Immunity
Incandescent
Inclined plane
Incubate
Induction
Inert
Inertia
Infectious
Inflammation
Infrared ray
Ingestion
Inhale
Inorganic
Insoluble
Intensity
Interference
Interferon
Interphase
Intrusive
Invertebrate

Invisible spectrum
Ion
Ionic bonding
Ionization
Isomer
Isotope
Jet stream
Joule
Kelvin scale
Kidney
Kinetic
Kingdom
Large intestine
Larva
Larynx
Laser
Leaching
Lever
Lichen
Life span
Lift
Ligament
Liver
Lubricant
Luster
Lymph
Machine
Magma
Magnetic field
Magnetism
Malignant
Malleable
Marrow
Marsupial
Mass
Mechanical
Medulla
Meiosis
Meniscus
Metabolism
Metallic
Metamorphosis
Metaphase
Microbiology
Microorganism
Migrate
Mitosis
Modulation

Molecule
Momentum
Monoclonal
Motion
Multicellular
Mutation
Neon
Nerve tissue
Nervous system
Neutralization
Neutron
Newton
Niche
Noble gas
Node
Nomenclature
Nonmetal
Nonrenewable
Nuclear energy
Nuclear fission
Nuclear fusion
Nuclear waste
Nucleic acid
Nucleolus
Nutrient
Ohm
Omnivore
Opaque
Orbital motion
Ore
Organic
Organic rock
Osmosis
Ossification
Ovary
Over-the-counter
Ovulation
Oxidation number
Ozone
Pancreas
Parallel circuit
Parathyroid
Particle accelerator
Pasteurization
Periodic table
Peripheral
Peristalsis
Permafrost

Permanent magnet
Petroleum
Phase
Pheromone
Photoelectric effect
Photon
Photosynthesis
Phylum
Physics
Pistil
Piston
Pituitary
Plasma
Plateau
Platelet
Polarity
Polarized light
Pollen
Pollution
Polymer
Precipitation
Prescription drug
Primary coil
Primate
Probability
Projectile
Property
Prophase
Proton
Protoplasm
Pseudopod
Psychological
Puberty
Pulley
Quark
Radar
Radiation
Radioactive
Radioactivity
Rarefaction
Reactant
Receptor
Recessive
Recombinant
Reflection
Reflex
Refraction
Regeneration

Renewable
Replication
Reproduction
Resistance
Resonance
Respiration
Respiratory system
Retina
Reverberation
Rhizoid
Rhizome
Ribosome
RNA
Saturated
Savanna
Scavenger
Scientific method
Sedimentary
Seismic
Seismograph
Self-pollination
Semiconductor
Sensory neuron
Series circuit
Sex chromosome
Sex-linked trait
Sexual reproduction
Slope
Small intestine
Smog
Smooth muscle
Solar energy
Solubility
Soluble
Solvent
Sonar
Species
Specific gravity
Sperm
Sphygmomanometer
Spinal cord
Stamen
Static electricity
Stimulant
Stoma
Stratosphere
Structural formula
Subatomic particle

Sublimation
Subscript
Supersaturated
Suspension
Symbiosis
Symptom
Synapse
Synthesis reaction
Synthetic element
Taiga
Taxonomy
Telophase
Temperature inversion
Terminal velocity
Testosterone
Theory
Thermal expansion
Thermocouple
Thermostat
Thrust
Thyroid
Tolerance
Toxin
Trachea
Trait
Transfusion
Transistor
Translucent
Transmutation
Transpiration
Transverse wave
Tropical rain forest
Trough
Tumor
Tundra
Ultrasonic
Ultraviolet wave
Unicellular
Universal gravitation
Uterus
Vaccine
Valence electron
Valley glacier
Valve
Vaporization
Variable
Velocity
Ventricle

Vertebrate
Virus
Viscosity
Visible spectrum
Vocal cord
Voltage
Volume
Warm-blooded
Water table
Watt
Wavelength
Wheel and axle
White blood cell
Zygote

Signal Words

Science is filled with signal words. In fact, signal words tell a student what to do or what may come next. Understanding signal words is a major key to comprehension. Sometimes signal words are also called transition words or relationship words since they guide the reader from one thought to another.

Think about a typical science experiment. If students are to successfully complete the experiment, they need to be able to understand the vocabulary of signal words. Such words as - last of all, second, conversely, last of all, opposite – are all important in understanding what a text is telling a student to do. As part of science vocabulary, ensure that students understand signal words. The following is a list of common signal words used in text:

Signal Words*

1. Continuation Signals (Warning—there are more ideas to come.)

and	also	another
again	and finally	first of all
a final reason	furthermore	in addition
last of all	likewise	more
moreover	next one	reason
other	secondly	similarly
too	with	

2. Change-of-Direction Signals (Watch out—we're doubling back.)

although	but	conversely
despite	different from	even though
however	in contrast	instead of
in spite of	nevertheless	otherwise
the opposite	on the contrary	on the other hand
rather	still	yet
while	though	

3. Sequence Signals (There is an order to these ideas.)

first,	second,	third	A, B, C
in the first place	for one thing	then	next
before	now	after	while
into (far into the night)	until	last	
during	since	always	o'clock
on time	later	earlier	

4. Time Signals (When is it happening?)

when	immediately	now
lately	already	little by little
at the same time	final	after awhile
once	during	

5. Illustration Signals (Here's what that principle means in reality.)

for example	specifically
for instance	to illustrate
such as	much like
in the same way	as similar to

6. Emphasis Signals (This is important.)

a major development	it all boils down to
a significant factor	most of all
a primary concern	most noteworthy
a key feature	more than anything else
a major event	of course
a vital force	pay particular attention to
a central issue	remember that
a distinctive quality	should be noted
above all	the most substantial issue
by the way	the main value
especially important	the basic concept
especially relevant	the crux of the matter
especially valuable	the chief outcome
important to note	the principle item

7. Cause, Condition, or Result Signals (Condition or modification is coming up.)

because	if	of
for	from	so
while	then	but
that	until	since
as	whether	in order that
so that	therefore	unless
yet	thus	due to
resulting from	consequently	without

8. Spatial Signals (This answers the “where” question.)

between	below	about	left	alongside
here outside	around	close to	far	
right over	away	side	near	
near in	into	beside		
middle next to	beyond	north		
east on	opposite	over		
south there	inside	in front of		
under these	out	behind		
across this	adjacent	above		
toward west	by	upon		

9. Comparison-Contrast Signals (We will now compare idea A with idea B.)

and	or	also
too	best	most
either	less	less than

more	than	same
better	while	though
even	then	half
much as	like	analogous to
but	different from	still
yet	however	although
opposite	rather	

10. Conclusion Signals (This ends the discussion and may have special importance.)

as a result	consequently	finally
from this we see	in conclusion	in summary
hence	last of all	therefore

11. Fuzz Signals (The idea is not exact, or the author is not positive and wishes to qualify a statement.)

almost	if	looks
maybe	could	some
except	should	alleged
nearly	might	reputed
seems like	was reported	purported
sort of	probably	like

12. Non-word Emphasis Signals

exclamation point (!)

underline

italics

bold type

subheads, like The Conclusion

indentation of paragraph

graphic illustrations

numbered points (1, 2, 3)

very short sentence: Stop war.

“quotation marks”

Retrieved from the World Wide Web at: <http://www.nifl.gov/readingprofiles/signalwords.htm>.
Original document by Fry, E. B., Kress, J. E., & Fountoukidis, D.L. (1993). The reading teacher's book of lists, 3rd edition. Englewood Cliffs, NJ: Prentice Hall, pp.185-187.