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THE GRAPHIC ARTS COMMUNICATIONS PROGRAM
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JAMAICA, NEW YORK

Pogue, William R. and Tom Doherty. How Do You Go to the Bathroom in Space. Associates Book: New York, 1985.

How to Universe Works, A Reader's Digest Book, 100 Ways parents and kids can share the secrets of the universe © 1994, Dorherty Kindersley

Hayden Planetarium On-Line

This Web site is currently under development. Students will be able to submit questions to scientists, participate in on-line quizzes, keep up on astronomy news, and find a large database of information.

Hall of Planet Earth

The Hall of Planet Earth is a new permanent exhibition hall opening in the year 1999. We roughly know the designs at this point although there are liable to be some changes during its development. Classroom visits to the Museum can investigate the following topics while visiting the hall.

- Comparative planetology themes; why Earth's atmosphere makes it habitable.
- Why does Earth have liquid water--pressure, gravity, composition of atmosphere, and temperature.
- Links between surface features of planets and Earth's volcanoes and plate tectonic links
- What presence of liquid water could teach us about life on other planets; black smokers show that water and heat and some chemicals can sustain life; there will be a ball display and web site on black smoker.

Hall of Meteorites

This all is currently open to visitors and would link well to the Life in the Solar System section of the course. Possible fossilized life on Mars in addressed in the exhibit.

Milky Way: Observe the Milky Way and note how it resolves into countless stars invisible to the naked eye. Galileo first observed this diffused band of light broken up into countless stars.

Football Field Solar System:

Use your school football field to create a scale map of the sun and planets; students will research mathematical relationships. Locate scale model solar systems in cities all over the country to give your ideas. If any of the models are nearby, visit them.

Big Bang Visualization

Create an artistic rendition of the Big Bang and discuss visualization as a tool for understanding astronomy. Visit the Big Bang Theater at American Museum of Natural History when it is completed. Discuss what you learned from each visualization. What research was applied to each visualization?

Xerox PARC Map Viewer:
http://pubweb.parc.xerox.com/map

Breathing Earth
http://japan.park.org/Japan/Theme/sware/be/unsw/index.html

PLANETARIA ON THE WEB
http://www.pa.msu.edu/abrams/planetaria.html

SPACE NEWSLETTERS/ADVOCACY

SpaceCast
http://www.spacer.com/

Case for Mars
http://spot.colorado.edu/~marscase/

Films

- Cosmic Voyage (currently at AMNH Imax Theater); discuss scale
- Powers of Ten; watch film and discuss the power of an atom

NASA Resources

All NASA materials are free to teachers.

http://www.vasc.org/erc/
NASA Regional Educator Resource Center

http://www.cea.berkeley.edu/Education/sii/sii_sii.html
Home of the Science Information Infrastructure, a NASA-funded project linking science museums, research centers, and teachers, to produce Earth and space science curricula for K-12 students and teachers using NASA remote sensing data.

Ask the Astronomer
http://www2.ari.net/home/odenwald/qadir/qanda.htm

Other Worlds, Distant Suns
http://garber.simplenet.com/

Views of the Solar System
http://www.fis.uc.pt/astronomy/solar/homepage.htm

Black Holes and Neutron Stars
http://antwrp.gsfc.nasa.gov/htmltest/rjn_bht.html

Constellations
http://www.astro.wisc.edu/~dolan/constellations/constellation_list.html

Earth Rise
http://earthrise.sdsc.edu/

Live from Mars
http://quest.arc.nasa.gov/mars/index.html

OFFICIALDOM/INSTITUTIONS

IAU: Central Bureau for Astronomical Telegrams
http://cfa-www.harvard.edu/cfa/ps/cbat.html

NASA and its field centers
http://www.nasa.gov/

META-REFERENCES:

AstroWeb (NRAO, STScI, CERN)
http://www.stsci.edu/astroweb/astronomy.html

Bill Arnett's WWW Documents (many resources)
http://www.seds.org/billa/offerings.html

NASA's Planetary Photojournal
http://www-pdsimage.wr.usgs.gov/PIA/PIA.html

PLANETARIUM SOFTWARE:
Master list
http://www.seds.org/billa/astrosoftware.html

Distant Suns
http://www.romt.com/products/distsuns/index.html

Voyager II
http://www.carinasoft.com/Voyager.html

Technology Resources

These are just a few of the many Web sites that are available. The list of Astronomy multimedia products and Web sites is endless.

Hands on Universe (HOU)
http://hou.lbl.gov/
Using the Internet, HOU participants around the world request observations from an automated telescope, download images from a large image archive, and analyze them with the aid of user-friendly image processing software. Hands-On Universe (HOU) has developed and piloted an educational program that enables high school students to request their own observations from professional observatories. HOU students download CCD images to their classroom computers and use HOU's powerful image processing software to visualize and analyze their data. HOU also provides comprehensive curriculum that integrates many of the topics and skills outlined in the national goals for science and math education into open- ended astronomical investigations. Last year two high school girls discovered a black hole that scientists had not yet identified.

Galileo Project
http://es.rice.edu/ES/humsoc/Galileo/
This site uses the visual metaphor of Galileo's family villa to enable visitors to explore the life and work of Galileo Galilei (1564-1642). Find out about the struggles, triumphs, and lifelong curiosity of the man who set the stage for modern science. It presents information about Galileo and the science of his time to viewers of all ages and levels of expertise.

Project STAR (Science Teachers As Reformers)
http://edap.bgsu.edu/STAR/
Materials for Project STAR were developed by science teachers and scientists and were thoroughly tested by teachers and students from around the country. Simple labs enable

students to use scientific tools in the classroom for exploration. Students can build a telescope that is similar to Galileo's, readily study color and light as well as learn about absorption and emission through personal observation, see the absorption lines in the sun's spectrum, see the spectra of energized elements in gaseous states and the double yellow line of Mercury in the spectrum of a fluorescent lamp, or study light pollution can be studied by checking yellow street lights to see if they are high- or low-pressure sodium lamps. The online activities are abundant.

Welcome to Mars!
http://www.amnh.org/mars/
Offline Activities available on this Web site:

- Mars Math

Offline Activities available on this Web site:

- Do It Yourself Rocketry
- Safe Landings?
- Mapping Unknown Surfaces
- Egg Drop

Nine Planets
http://www.seds.org/nineplanets/nineplanets/
A Multimedia Tour of the Solar System, by Bill Arnett, includes a nice introduction to Mars.

Views of the Solar System
http://bang.lanl.gov/solarsys/
An excellent overview of the entire solar system by Calvin Hamilton. The featured link to Mars includes a chronology of exploration.

Starry Night
http://www.seds.org/billa/StarryNight/sn.html

Windows to the Universe
http://www.windows.umich.edu/

Space Weather
http://windows.engin.umich.edu/spaceweather/

IMAGES

Astronomy Picture of the Day
http://antwrp.gsfc.nasa.gov/apod/astropix.html

The Aurora page
http://www.geo.mtu.edu/weather/aurora/

Regional Planetary Image Facility
http://ceps.nasm.edu:2020/rpif.html
http://ceps.nasm.edu:2020/RPIF/RPIFsources.html

Hubble Space Telescope
http://www.stsci.edu/

The Planetary Data System (PDS)
http://pds.jpl.nasa.gov/

US Geological Survey
http://www.usgs.gov/

Space Science Photography
http://pao.gsfc.nasa.gov/gsfc/spacesci/pictures/spacepic.htm

The NASA Shuttle Web Archives
http://www.stsci.edu/

About the NSSDC Photo Gallery
http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery.html

Jupiter & Moons/animation
http://bang.lanl.gov/solarsys/raw/jup/index.htm

INTERACTIVE MAPS/LIVE FEEDS/etc.

EarthView
http://www.fourmilab.ch/cgi-bin/uncgi/Earth/action?opt=-p

NASA Cameras (slow)
http://www.ambitweb.com/nasacams/nasacams.html

Mars Pathfinder: Welcome to Mars!
http://mpfwww.arc.nasa.gov/default.html
The Mars Pathfinder home page, with all the images and other info from Mars.

Mars Global Surveyor (MGS)
http://mars.jpl.nasa.gov/mgs/
The current status of the MGS mission including the latest images and scientific data from Mars.

Mars Pathfinder Preliminary Results
http://nssdc.gsfc.nasa.gov/planetary/marspath_results.html
A technical summary of scientific findings with many links.

Center for Mars Exploration
http://cmex-www.arc.nasa.gov/
Lots of Marslinks, including "Life on Mars?" and Mars missions.

Live from Earth and Mars: Pathfinder Mission Summary
http://www-k12.atmos.washington.edu/k12/mars/MPF_short_facts.html
A detailed and fairly technical description, including good graphics on the Entry, Descent and Landing sequence.

Live from Mars/Passport to Knowledge
http://quest.arc.nasa.gov/mars/
Lots of Marslinks and educational materials.

Mars Pathfinder Fact Sheet
http://mpfwww.jpl.nasa.gov/mpf/fact_sheet.html
The basic mission specifications, nicely encapsulated.

Mars Pathfinder Project Information
http://nssdc.gsfc.nasa.gov/planetary/mesur.html
Complete summary of the mission, with color images and many links.

Marslink Essays
http://barsoom.msss.com/http/ps/intro.html
Excellent articles on various aspects of Mars, written by Mike Caplinger for the Planetary Society.

PDS Mars Explorer for the Armchair Astronaut
http://www-pdsimage.wr.usgs.gov/PDS/public/mapmaker/
A giant "room sized" global map of Mars, from Viking orbiter images. Starting from a global Mercator map, you can choose any specific spot on Mars and pan and zoom your way across the entire planet.

The Red Planet: A Survey of Mars
http://cass.jsc.nasa.gov/publications/slidesets/msurvey.htmlAn illustrated guided tour, with brief descriptions, prepared by W.S. Kieffer, A.H.Treiman and S.M. Clifford for the Lunar and Planetary Institute.

NASA Educational Resource
http://iita.ivv.nasa.gov/

QUESTIONS:

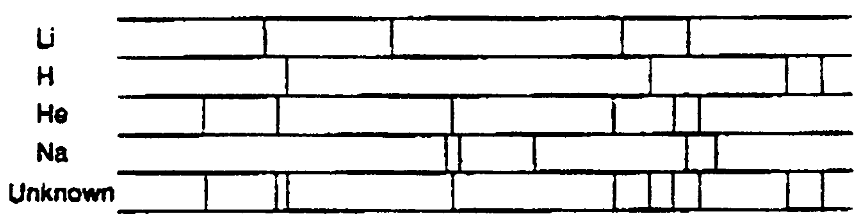
1. (a) What is a continuous spectrum?
   (b) What is an emission or bright-line spectrum?

2. Which type of spectrum does an element produce when its atoms are "excited" with energy? Why?

3. In this investigation, you observed the flame color of lithium (at your desk) and the bright-line spectrum of lithium (at teacher's disk). Keeping in mind that the sun and other stars contain a mixture of **dozens** of elements, which is a more valuable method to determine the elements in a mixture, flame color or bright-line spectrum? Why?

4. All of the solutions used in your flame tests were compounds of chlorine ($LiCl$, $NaCl$, KCl, $CaCl_2$, $BaCl_2$, $SrCl$, $CuCl_2$). Why?

5. The diagram below shows the spectral line pattern of four elements plus an unknown substance. Which pair of elements is in the unknown?



1 lithium and sodium
2 sodium and hydrogen
3 lithium and helium
4 helium and hydrogen

The lines in a bright-line spectrum represent amounts of energy emitted when electrons, which have been "excited" with heat or electricity, move from one energy level to another. These bright lines are the fingerprints of an element since no two elements have atoms with the same arrangement of electrons, and therefore do not produce spectra with the same set of bright lines. In 1868, while looking at the sun, astronomers identified the spectrum of an element that they had never seen before. They called the element **helium**.

Sometimes, solid objects that glow contain more than one element. These glowing solids emit all of the different wavelength as visible light. The resulting spectrum is not a series of bright lines but a continuous bond of colors that looks like a rainbow. It is called a **continuous spectrum.** In this laboratory investigation, you will study the emission spectrum of different elements in two ways:
1) by observing the color flame each produces, and
2) by observing the bright-line spectrum, using a spectroscope. You will also observe a continuous spectrum.

PROCEDURE:

A - **Flame Tests** (Students work cooperatively in laboratory groups.)

1. Get materials.
2. Clean the nichrome loop by dipping it in a beaker of water and than heating it in the Bunsen Burner flame. Repeat until no color is observed.
3. Put 3 drops of different solution in each well of the depression plate. (Label or make a note of where each solution is placed. Seven wells should be filled, each with a different solution.)
4. Dip the clean wire loop in one of the solutions and collect a "bead" of liquid in the loop.
5. Hold the bead over the tip of the Bunsen burner flame. Record the color you see on Table 1.
6. Repeat step 5 with each of the other seven solutions. Be sure to clean the loop between solutions, as instructed in step 2.

B - **Continuous Spectrum** (Students work individually.)

Using your spectroscope, observe the spectrum of sunlight. Record the colors of light you see in their correct order, on Table 2.

8. Write a statement in which you explain the relationship between the distance of the planet from its sun and its speed of motion in its orbit.

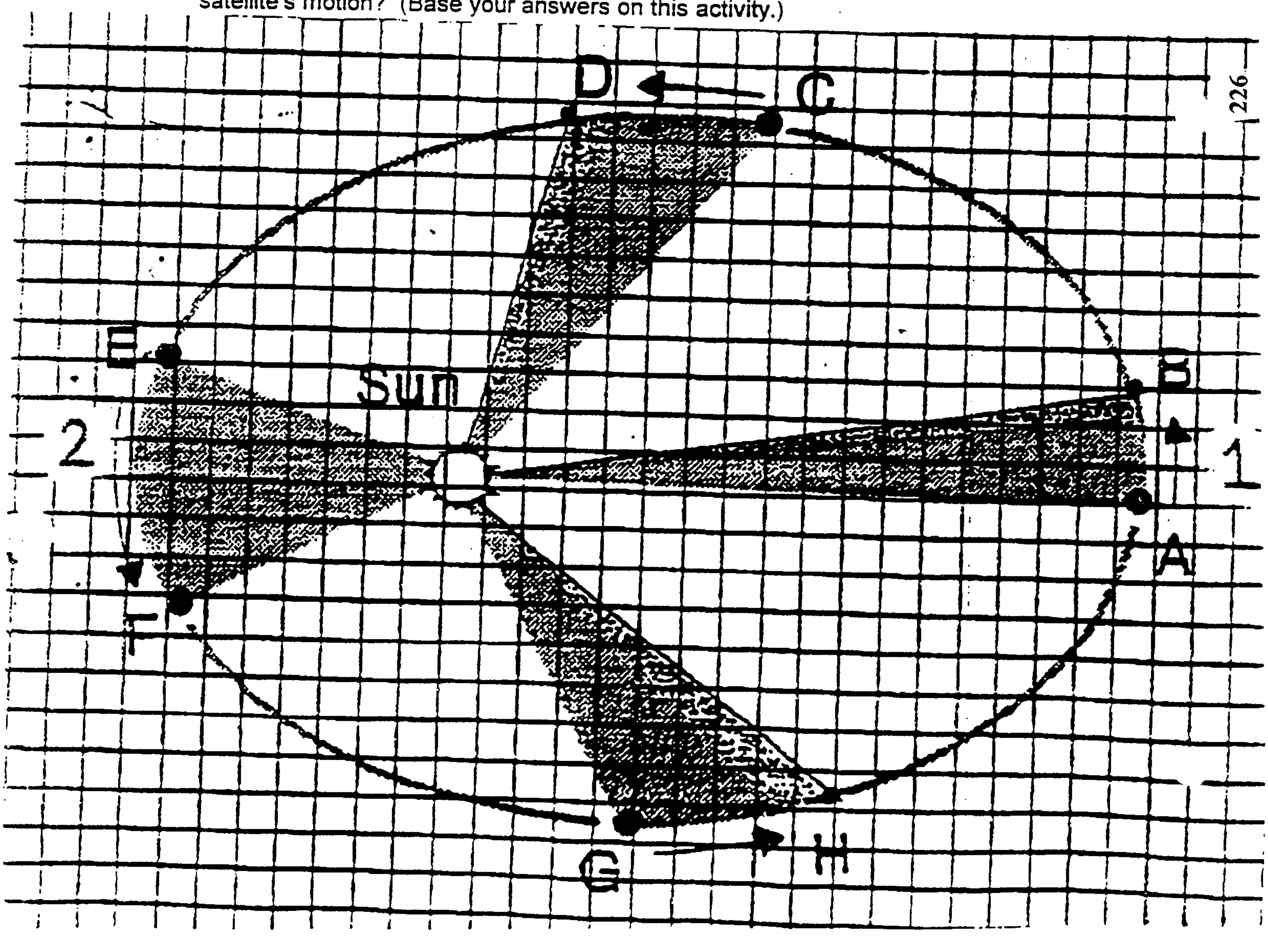
SUMMARY

1. State two very important concepts about planetary motion you have learned from this activity.

2. Using an astronomy text or an earth science text, research Kepler's Laws of Planetary Motion, in particular, the second law. How do the results of your investigation compare with the statement of the second law?

3. Our planet, the Earth, is actually closer to the Sun in January than in July. How would the speed of the Earth in January compare with July?

4. An observation satellite is launched into space into an elliptical orbit around the Earth. When it passes over the United States of America, it is 100 km above the Earth's surface. As the satellite passes over Europe, it is 150 km above the surface. The Earth is located at a focus of the satellite's elliptical orbit. What predictions can be made about the satellite's motion? (Base your answers on this activity.)



PLANET EARTH - BEYOND EARTH, THE SEARCH FOR LIFE

UNIFYING THEME: **Is Anyone Out There?**
TOPIC C: **Life Beyond the Solar System**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
4. For astronomers to discover and study extra-solar planetary systems, technology must improve. - Launch electronic cameras in space to detect a drop in a star's brightness as a planet crosses it, or to detect planet's reflected light. - Launch infrared telescopes in space to detect planet's heat. - Launch a battery of telescopes to be operated in unison over great distances via computer (optical interferometry). It greatly increases resolution.	Students will be able to: 4. discuss new technologies that are needed to improve planetary detection of extra-solar planets. (Discretion of the teacher should be used to decide which technologies to explore from list in *CONCEPTS*.)	4. "Future world" a. Have students devise one future technology not listed that scientists may develop to discover planets orbiting far-off stars. b. Have students discuss the following statement by a Nobel Prize winning scientist: "New truths become evident when new tools become available."
5. The search for extraterrestrial life must be done by detecting E-M radiation. - The distances between stars are too great for conventional space travel. (It would take >25,000 years to reach the <u>Nearest</u> star in our <u>fastest</u> rockets.)	5. explain why the "Search" must be done indirectly-by detecting radio signals from space rather than by traveling to the planets.	5. *Have students explain the following: Aliens on a planet 10 light-years away, doing their own SET I exploration, turn their radio antennas our way. They see the <u>first</u> episode of <u>Seinfeld</u> - live !! *Teacher could use any appropriately popular show. (Elicit that signals indicating intelligent life might be a coded message - a sequence of beeps, or symbols on a screen, rather than a TV or radio show.)
6. The Search for Extraterrestrial Life includes a Search for Extraterrestrial Intelligence (SETI) - Astronomers will be looking for radio and microwave signals produced artificially. This requires an intelligent and technologically advanced civilization.	6. explain why the Search for Extraterrestrail LIfe is, in effect, a search for <u>intellegent</u> life. NASA is working on spectroscopic means of detecting biogenic molecules in atmospheres of extrasolar planets and the rocks of Mars.	

PLANET EARTH - BEYOND EARTH, THE SEARCH FOR LIFE

UNIFYING THEME: **Is Anyone Out There?**
TOPIC B: **Life in the Solar system**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
11. a. Manned space programs require many years to plan and cost billions of dollars. International cooperation helps to share the costs and the work involved in these projects. b. There are pros and cons to all space programs: - knowledge gained - surveillance (identifying asteroids/meteors that may collide with earth) - potential sites and resources for colonization - expense - dangers	Students will be able to: 11. a. list the advantages of cooperating with other countries to plan and carry out a space mission. b. describe controversies concerning space exploration to the planets. c. list and describe the advantages and disadvantages of space programs. d. compare and contrast earlier expeditions to the planets and the more recent ones.	11. a. Ask students why spacecraft to planets beyond Mars are not equipped with solar panels to convert sunlight to electricity. Discuss the controversy over the use of radioactive plutonium on the Cassini craft to Saturn. Point out that this 4 year expedition is a joint effort of NASA and the European Space Agency. b. Some space explorations are expensive (Cassini-mission - $3.4 billion; compare with the Mars Pathfinder -$250 million). Have the students debate whether or not it is a good idea to spend large amounts of money on space missions. What are the benefits of exploring space? How do political decisions impact space programs? What are some other uses for this money? Discuss the concept of cost/benefit. c. Compare the Cassini mission to the first Mariner missions. How has space flight advanced in forty years? A timeline could be used to illustrate the technological advances.
12. Scientists are reasonably certain that there is no life on any other planet in the solar system. However, there may be life on other planets outside of the solar system.		12. Have students poll classmates to see how many believe that life exists outside the solar system. Discuss the results of the poll.

PLANET EARTH - BEYOND EARTH, THE SEARCH FOR LIFE

UNIFYING THEME: **Is Anyone Out There?**
TOPIC B: **Life in the Solar system**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	c. When viewed through a telescope, Mars sometimes appears to have a network of "canals." These observations led Percival Lowell in the early 1900s, to propose that intelligent beings or "Martians" inhabited Mars. Play the audio tape of Orson Welles's 1938 radio broadcast of *The War of the Worlds."* Describe how people panicked and actually believed that Earth had been invaded by Martians. How would people react today if it were done on television and Internet? Why? d. In August of 1996, researchers announced evidence for fossilized microbes in a meteorite from the surface of Mars. This evidence suggests that billions of years ago primitive life may have existed on Mars. American Museum of Natural History Visit: Hall of Meteorites possible fossil life on mars is addressed in this exhibit.
8. Even though no person has landed on a planet, we know a great deal about our neighbors in space.	8. describe how scientists get most of their information about the planets.	
9. a. Most of what we know about the planets comes from information sent to earth by unmanned spacecraft and probes that have landed on some planets. b. Unmanned spacecraft (probes) have been sent to all the planets in the solar system except Pluto.	9. compare the advantages and disadvantages of unmanned and manned space programs.	9. Discuss the advantages and disadvantages of manned and unmanned spacecraft. How risky is space travel?

PLANET EARTH - BEYOND EARTH, THE SEARCH FOR LIFE

UNIFYING THEME: **Is Anyone Out There?**
TOPIC B: **Life in the Solar system**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
1. In the past, astronomers learned about the solar system primarily by using land-based telescopes and spectroscopes to observe planets.	Students will be able to: 1. describe the ways astronomers study the planets.	1-2 Have students work in groups - one group per planet - and use the Internet and other resources to research a planet, including information about space missions to the planet. Each group can make a model of its planet. Images of the planet from the Internet can be used to design the outward appearance of the planet. Welcome to the Planets http://pds.jpl.nasa.gov/planets/welcome.htm Nine Planets http://www.seds.org/nine planets/
2. In the last forty years, astronomers have greatly increased their knowledge about the solar system by: a. sending satellites to fly by or even land on some of the planets. b. placing telescopes in orbit around the earth.	2. explain why knowledge about the planets has increased tremendously in the last forty years.	
3. a. Planetary distances are measured in astronomical units. (A.U.) An A.U. is the average distance between the earth and the sun. b. The nine planets of the sun are very different from each other.	3. a. define astronomical unit (A.U.) b. name the planets in order of increasing distance from the sun. c. construct a model of the solar system and display the planets with their respective distances from the sun.	3. a. Students can use planet diameter and distance data to make a scale model of the solar system. Suggested activities: Use your school football field to create a scale map of the sun and planets or use the Solar System Activity in the Earth Science lab Manual - B.E.S.T. Views of the Solar system. http://bang.lanl.gov/solarsys./ b. American Museum of Natural History Activity: Martian Math http:/www.amnh.org/mars/

UNIFYING THEME: **Is Anyone Out There?**
TOPIC A: **The Race to the Moon - Our Nearest Neighbor**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	15. b. Have students find out what the Apollo 11 crew left behind on the moon. American Museum of Natural History visit the Hall of the Universe to observe a scale model of the back of the moon which we cannot see from the earth.
16. Five more lunar landings were accomplished. Astronauts explored large areas of the moon's surface.		16. Show students the movie *Apollo 13* for an understanding of the problems that can arise without warning. Ask them to critique the film in terms of its scientific accuracy.
17. A lunar buggy was developed for transportation on the moon's surface.	17. list the advantages of a lunar roving vehicle.	17. Apollo 15 was the first mission to use the Lunar Roving Vehicle (the rover). Show pictures of the rover and discuss the advantages of the LRV.
18. Lunar rocks contain many of the same elements found in earth's rocks but in different amounts.	18. compare the lunar surface and rocks with the earth's surface and rocks.	18. A new mineral was discovered on the moon and named **Armalcolite**. Ask students how it got its name?
19. a. The moon's surface is different from the earth's surface because there is no liquid water or atmosphere on the moon. The conditions on the moon cannot support life. b. The lunar surface is covered by a thick layer of dust and small fragments. This layer is called **the regolith**. Meteorites erode the rock on the surface into dust and small fragments.	19. explain why the lunar surface is covered with a thick layer of powder.	19. Have students examine and compare images of the earth's surface and the moon's surface. Why are they different from each other?

UNIFYING THEME: **Is Anyone Out There?**
TOPIC A: **The Race to the Moon - Our Nearest Neighbor**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
7. The lowest speed at which a rocket would be able to overcome the continuous gravitational pull of the earth and travel into space is called **the escape speed**.	Students will be able to: 7. a. define escape speed. b. explain the relationship between escape speed and the earth's gravity.	7. The Saturn V Launch Vehicle Home Page: http://www.calweb.com/~ccorway/saturn-v/saturn-vhtml
8. A rocket uses its own fuel to push against. The backward rush of exhaust gases causes an equal and opposite push on the rocket itself.	8. explain how a rocket works.	8. American Museum of Natural History Activity: Balloon Rockets http://www.amnh.org/mars/ (Science Grade 9: See References)
9. Rocket travel is based on Newton's Third Law of Motion: For Every Action There is an Equal and Opposite Reaction.	9. a. describe Newton's Third Law of Motion. b. explain how astronauts walk in space.	9. Cooperation Learning: Have students list the problems an astronaut faces during a space walk. Have them design a unit that enables the astronaut to move around in space. Students should demonstrate how they applied Newton's Laws of Motion to plan their system.
10. Astronauts in the Apollo spacecraft needed the proper environment in which to live and work - proper air pressure, temperature, humidity and oxygen.	10. describe living conditions inside the Apollo spacecraft.	10. Have students study the design of the lunar module and the command module. How were they designed to provide the proper conditions for space travel. How are they similar or different?
11. The spacecraft had special shielding to provide protection against harmful radiation in space.	11. explain why the spacecraft has special shielding.	11-12 Set up a "living in Space" question box for students to ask any question they have about living in space. Groups of students can research and answer questions. (Resource: *How Do You Go to the Bathroom in Space?* By William R. Pogue)

PLANET EARTH - BEYOND EARTH, THE SEARCH FOR LIFE

UNIFYING THEME: **Is Anyone Out There?**
TOPIC A: **The Race to the Moon - Our Nearest Neighbor**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
1. Landing a person on the moon was one of the most difficult technological efforts ever undertaken by humans.	Students will be able to: 1. state the goal of the Apollo Space Program.	1. a. In 1959, the Soviet Luna 3 radioed back the first photographs of the moon's far side. How did Americans feel about the Soviet Union's accomplishment? How did the President respond? What was the political climate at the time. b. Have students model the rotation and revolution of the moon and explain why we only see one side of the moon.
2. NASA was instructed by President Kennedy to develop the technology to send a man to the moon and back to earth safely. NASA began the Apollo Space Program to achieve this goal.	2. explain how political decisions affect scientific endeavors such as the space program.	2. Have students read an excerpt from John F. Kennedy's May 25, 1961 speech in which he challenged the United States and directed NASA "to land a man on the Moon and return him safely to the Earth" by 1970. Why did this goal become one of national importance and interest? How did the "race to the moon" become a race between two superpowers- the Soviet Union and the United States? (NASA Resources are free to teachers.) http://www.vasc.org/erc/
3. a. Apollo 11 was the mission that first landed astronauts on the moon. b. The important stages of the mission included: - liftoff from the earth - flight to the moon - orbit around the moon - moon landing - liftoff from the moon to rejoin the command module. - flight back to earth	3. identify and describe the events of the Apollo 11 mission.	3. a. Have students draw or label a diagram illustrating the events of a typical Apollo mission from liftoff to splashdown. b. <u>Apollo Manned Space Program</u> http:/www.nasm.edu:80/APOLLO/apollo. html. This site provides detailed descriptions of the Apollo missions including video clips.

PLANET EARTH - BEYOND EARTH, THE SEARCH FOR LIFE

UNIFYING THEME: **New Truths Become Evident When New Tools Become Available**
TOPIC D: **The Space Telescope**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
1. It is difficult to study stars with earth-based telescopes because the earth's atmosphere: a. blocks radiation given off by stars. b. blurs the visible images of stars and galaxies. c. radiates and reflects light.	Students will be able to: 1. explain how the atmosphere interferes with the observations of stars from the earth's surface.	1. Have students collect newspaper and magazine articles about the latest discoveries in astronomy. In small groups, the students can analyze each article and list the instruments that were used to make the discovery. Astronomy Picture of the Day http://antwrp.gsfc.nasa.gov/apod/astropix.htm/
2. The Hubble Space Telescope was launched in 1990 and was designed to orbit above the interference of the earth's atmosphere.	2. list the advantages of a space telescope over a land-based telescope.	2. a. Show students images from the Hubble Space Telescope. b. Have students research the December, 1993 space mission to repair the Hubble. Video: The Hubble. c. Hubble Space Telescope Activities section hhp://Quest.akc.nasa.gov/hst/index.htm/
3. a. The Hubble Space Telescope sees farther into space and provides greater detail than any land-based telescope. b. Our knowledge of the universe has greatly increased because of the images provided by the Hubble. Newborn stars emerging from clouds of gas and dust, colliding galaxies and dying stars have been observed.	3. explain why the Hubble Space Telescope is more powerful than any land-based telescope.	3. Ask the students why the Hubble, which is smaller than the largest telescope on earth, provides the clearest images. (Hubble mirror is 2.5m in diameter.) **Activity**: Cover a lamp with a colander, allow students to view "points of light" through several thicknesses of tissue, then without. Have them describe the advantages of the Hubble Telescope over a land based telescope.
4. Radio telescopes collect and focus radio waves from space. Unlike visible light, radio waves pass through clouds, can be detected at night and are least affected by gas and dust in space.	4. compare and contrast visible light waves and radio waves.	4. Have students compare pictures of radio telescopes with optical telescopes.

PLANET EARTH - BEYOND EARTH, THE SEARCH FOR LIFE

UNIFYING THEME: New Truths Become Evident When New Tools Become Available
TOPIC C: The Spectroscopic View

<table>
<tr><th>CONCEPTS</th><th>PERFORMANCE OBJECTIVES</th><th>TEACHING STRATEGIES</th></tr>
<tr><td></td><td>Students will be able to:</td><td>
<table>
<tr><th>GALAXY</th><th>DISTANCE LIGHT YEARS</th><th>SPEED LIGHT YEARS / YEAR</th></tr>
<tr><td>A</td><td>30,000,000</td><td>0.002</td></tr>
<tr><td>B</td><td>60,000,000</td><td>0.004</td></tr>
<tr><td>C</td><td>90,000,000</td><td>0.006</td></tr>
</table>
</td></tr>
<tr><td>14. A light year (l-y) is the <u>distance</u> light travels in one year.</td><td>14. define light year.</td><td>14. a) Have students calculate the distance of one light year in Km and miles. How old is sunlight?
b) "Old Light" - discuss the concept of intelligent beings on a planet 70 million light years away, looking our way, would see dinosaurs roaming the Earth.</td></tr>
<tr><td>15. There are many galaxies beyond the Milky Way.</td><td>15. describe how the great distances of apparent "dust clouds" led to the discovery of other galaxies.</td><td>15. Have students:
a) use 'inflating balloon" model of the expanding universe to facilitate understanding of distance and age. The farther out something is, the longer it has been expanding and the older it is.
b) using data from table in #13, have students calculate the age of galaxy A, B and C, using the formula: age = $\frac{\text{distance}}{\text{Speed}}$</td></tr>
</table>

UNIFYING THEME: New Truths Become Evident When New Tools Become Available
TOPIC C: The Spectroscopic View

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
6. The spectrum of an element is based upon the structure of its atom; spectral lines are produced when electrons change energy levels. An element may be identified by its spectrum.	Students will be able to: 6. a. draw a model of an atom, identifying the nucleus and energy levels (electron shells). b. compare and contrast electrons, protons, and neutrons. c. define ground state, excited state, atomic number, and mass number.	6. a. Show different atomic models and discuss their differences and similarities. b. Have students explain the statements: "atomic spectra are the fingerprints of the elements." c. Laboratory Activity Ask students how we know what the sun and stars are made of. Using different gas discharge tubes (or colored flames from metallic salts or diffraction gratings), a spectroscope and chart of bright-line spectra, have students identify the element inside each tube. (Las Vegas Nights -NSTA SS&C)
7. The chemistry of the universe is the same everywhere: - The sun and other stars have the same chemical composition. - The elements of Earth are found throughout the universe.	7. a. identify hydrogen (H) and helium (He) as the main components of all stars. b. identify the elements in the sun (and other stars) as elements found on Earth as well.	7. a. Compare a table listing all of the sun's elements and the Periodic Chart of the elements. Have students identify that all of the sun's elements are found on Earth as well. (Activity - Fingerprints of the Elements NSTA SS&C) b. American Museum of Natural History. Visit the Hall of the Universe to see that spectra are the key codes to unlocking the mysteries of the universe.
8. The Doppler effect or shift (DE) is the change in the observed λ of light (or sound) due to the motion of the source, observer, or both.	8. define Doppler effect.	8. Whirl an air whistle on a rope and have students hear the change in pitch.

PLANET EARTH - BEYOND EARTH, THE SEARCH FOR LIFE

UNIFYING THEME: **New Truths Become Evident When New Tools Become Available**
TOPIC B: **The Telescopic View**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
26. The achievements of science have been possible because scientists build on the work of other scientists.	Students will be able to: 26. describe how our view of the universe has changed over the years.	26. Isaac Newton said "If I have been able to see farther than other men it is because I was standing on the shoulder of giants." Who are the giants? What did Newton mean when he said he stood on their shoulders? Video: *Stephen Hawking's Universe Part I* (PBS)

PLANET EARTH - BEYOND EARTH, THE SEARCH FOR LIFE

UNIFYING THEME: **New Truths Become Evident When New Tools Become Available**
TOPIC B: **The Telescopic View**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
17. The force that keeps the earth moving in orbit around the sun is gravity.	Students will be able to: 17. predict what would happen to the orbit of the earth without the force of gravity.	
18. The force of gravity exists between any two bodies. The amount of force pulling the bodies together depends on two things: a. The mass of the bodies. b. The distance between the two bodies.	18. a. describe the force of gravity. b. identify the two factors that affect the amount of gravitational pull between two bodies.	18. Stress gravity as a qualitative concept. Students should be able to identify the two factors that affect gravitational force but calculations are not necessary. The mathematical formula may be introduced here, if appropriate.
19. The greater the mass of the two bodies, the greater the gravitational force between them.	19. state the relationship between mass of objects and gravitational force.	19. **Laboratory Activity:** Students support different masses on spring balances to discover the relationship between mass and gravity. Collect data and graph results. (The gravitational force between you and the earth is your <u>weight</u>. Spring balances measure weight.)
20. The greater the distance between the two bodies, the smaller the gravitational pull between them.	20. state the relationship between distance of objects and the amount of gravitational force.	20. **Homework Activity:** Tell students to take a bathroom scale into an elevator and stand on it. Have them note what happens to their weight when the elevator first descends and then ascends. Have them report back to class. How can this be explained?
21. The earth's orbit is a result of the combined force of gravity and inertia. There is a balance between gravity and inertia.	21. identify the factors that control the movement of the earth around the sun.	

UNIFYING THEME: **New Truths Become Evident When New Tools Become Available**
TOPIC B: **The Telescopic View**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
10. Galileo was forced to recant his belief in the heliocentric model.	Students will be able to: 10. explain why Galileo recanted his belief in the heliocentric model.	10. Have students read and respond to the newspaper article about Galileo's exoneration by the Roman Catholic Church (*New York Times*, Oct 31, 1992)
11. Science is not separate from society but rather science is part of society.	11. distinguish between scientific ideas and other types of explanations regarding the nature of the universe.	11. a. Have students find out how different cultures tried to explain the nature of the universe. These explanations, based on myth, religious values, personal beliefs and superstitions, are not scientific. Why? Scientific ideas depend upon experimental and observational confirmation. This approach is called **the scientific method**. b. When teaching this section, it is important to be sensitive to the religious and cultural beliefs of students. c. Mock Trial - Put Galileo on trial for his scientific belief. Assign roles to students.
12. Isaac Newton's laws of motion and gravity explain the movement of planets around the sun.		12. a. Students should be aware that Galileo was unable to answer the questions: If the earth rotates, why don't we fall off? What keeps the earth in its orbit around the sun? Galileo knew about gravity. But he didn't have the law that describes how it works. b. Isaac Newton (1642-1727) is born the same year Galileo dies. He answers Galileo's questions.

PLANET EARTH - BEYOND EARTH, THE SEARCH FOR LIFE

UNIFYING THEME: **New Truths Become Evident When New Tools Become Available**
TOPIC B: **The Telescopic View**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
4. Light bends,or refracts, as it passes through a lens. A refracting telescope uses convex lenses to collect and focus visible light.	Students will be able to: 4. a. distinguish between reflection and refraction. b. identify the type of lens that focuses light.	4. Have students examine plate glass, convex and concave lenses, a plane mirror, and convex and concave mirrors. What happens to light when it strikes each of these objects? How can we determine which of these objects will focus light?
5. Light bounces off or reflects off the surface of a mirror. A reflecting telescope uses concave mirrors to collect and focus visible light.	5. a. identify the type of mirror that focuses light. b. construct diagrams to show how convex lenses and concave mirrors focus light. c. explain how a telescope works. d. compare and contrast refracting and reflecting telescopes.	5. a. Have students demonstrate how convex lenses and concave mirrors focus light, one by refraction, the other by reflection. (Use a blackboard optics kit, if available.) b. Students can construct and use their own refracting telescope. (Project Star) c. Have students compare diagrams of reflecting and refracting telescopes. d. Allow students to set up three test tubes. Place a penny in each. Fill the first ½ way with water, second up to the brim, and third empty. Have students view the penny. Describe and explain the observations. (Science Grade 9: See References)
6. The amount of light gathered by an optical telescope increases as the size of the mirror or lens increases.	6. state the relationship between the diameter of a concave mirror or convex lens and the amount of light it can gather.	6. Students graph convex lens or concave mirror diameter vs light gathering power and determine the relationship between these variables. Allow students to use convex lenses and concave mirrors to produce images and project them. Have them compare the position of an object and its image.

PLANET EARTH - ASTRONOMY UNIT: THE EARTH IN SPACE

UNIFYING THEME: **New Truths Become Evident When New Tools Become Available**
TOPIC A: **The Naked Eye View**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
16. Using new and better observations of planets, Kepler modified Copernicus's model by proposing that each planet moved around the sun in an orbit called **an ellipse.**	Students will be able to: 16. describe the shape of planetary orbits.	16. **Reading:** Tycho Brahe: The Man with the Golden Nose. (Project Star) It was Brahe's precise measurements of the planets over 20 years that provided data for Kepler's model.
17. An ellipse is an orbit whose shape is determined by two points within the figure. These points are called **foci**. The sun is at one focus.	17. draw an ellipse and demonstrate how to change its shape.	17. **Activity:** What is an ellipse? Students draw ellipses with string, cardboard, two thumb tacks and a pencil. Have students vary the spacing between the thumb tacks. What is the relationship between this spacing and the shape of the ellipse? (Science Grade 9: See References)
18. Kepler discovered that a planet moves more slowly when it is farther from the sun and more rapidly when it is closer to the sun.	18. state the relationship between the speed of a planet and its orbital position.	18. a. Have students plot the earth's distance to the sun using the changes in the apparent size of the sun. (Project Star) b. Use models to demonstrate Kepler's Equal Areas Law. (Science Grade 9: See References)
19. The earth spins on its axis. This motion is called **rotation.**	19. a. define rotation. b. demonstrate the effects of a rotating earth.	19-20 Have students model the earth's rotation and revolution.
20. The earth moves around the sun in an elliptical orbit. This motion is called **revolution.**	20. a. define revolution. b. demonstrate the effects of a revolving earth. c. model the rotation and revolution of the earth around the sun.	

UNIFYING THEME: **New Truths Become Evident When New Tools Become Available**
TOPIC A: **The Naked Eye View**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
10. Two thousand years ago, the Greeks proposed an earth-centered or geocentric universe. This model stated that the sun, stars and planets revolved in circular orbits around a motionless earth.	Students will be able to: 10. describe the geocentric model of the universe.	10. **Background information:** Discuss with the students how the geocentric model was endorsed by the Church because it fit in so nicely with the teaching that the earth and its inhabitants were the center of God's creation. The geocentric model became an article of faith and influenced thinking for 2000 years. The circle was considered the perfect shape and all heavenly bodies were viewed as perfectly smooth spheres
11. This model did not explain why some planets appear to reverse direction. This backward motion is called **retrograde motion**.	11. describe the motion of Mars as seen from the earth.	11. Planetary motion activity: Have students plot position of Mars for one year and describe its apparent motion. (Resource appendix)
12. In 150 A.D. Ptolemy, a Greek Astronomer, proposed a more complex geocentric model to account for planetary motion. In Ptolemy's model, the planets move in a very complicated way involving epicycles.	12. explain how Ptolemy's model accounts for planetary motion.	12. a. Have students rate Ptolemy's model using the characteristics of a good scientific model. b. Show students diagrams of Ptolemy's model and have them demonstrate how it accounts for retrograde motion. c. Ptolemic System http:es.rice,edu/es/humsoc/Galieo//things /ptolemaic-system.html (part of Rice Univ. Galileo Project)

PLANET EARTH - BEYOND EARTH, THE SEARCH FOR LIFE

UNIFYING THEME: **New Truths Become Evident When New Tools Become Available**
TOPIC A: **The Naked Eye View**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
1. Cosmology is the study of the structure and evolution of the universe. - Our knowledge of the universe is based on observation. - People have been observing stars and other celestial objects for thousands of years.	Students will be able to: 1. define cosmology. State that our quest to understand the universe is based on the contributions of men and women through the ages.	1. An excellent resource is Stephen Hawkings's *The Universe*. Available through PBS. - Have students do research on ancient or traditional cultures (such as Chinese, Persian, Babylonian, Greek, Roman, Mayan, Sioux, Tahitian) to find out how they observed the sky and kept records. How did their observations affect their lives? Allow students to do presentations to the class on their research in groups.
2. Their understanding of the nature of the universe was based on what they observed with their <u>naked eyes</u>.	2. explain how ancient peoples learned about the universe.	2. Ask students to estimate the number of stars they see with their naked eyes. What factors in their urban environment affect their viewing of the night sky? Have students use a grid held up against the night sky to estimate the number of stars in the sky.
3. The sun and the stars appear to move across the sky each day.	3. describe the daily apparent motion of the sun and the stars.	3. Keep a journal of the sun's apparent motion. Draw the western horizon and plot the position of the setting sun. Observe sunset from the same location once a week for a period of several weeks. (Project Star)
4. The sun's apparent motion changes during the year.	4. a. explain how the sun's apparent motion changes during the year. b. predict the point of sunset or sunrise in New York City when given the month of year.	4. Keep a journal of the sun's apparent motion. Draw the western horizon and plot the position of the setting sun. Observe sunset from the same location once a week for a period of several weeks. (Project Star)

Magnitude and Scale

3. The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Students:

- describe the effects of changes in scale on the functioning of physical, biological, or designed systems.

Patterns of Change

5. Identifying patterns of change is necessary for making predictions about future behavior and conditions.

Students:

- use sophisticated mathematical models, such as graphs and equations of various algebraic or trigonometric functions.

Optimization

6. In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Students:

- analyze subjective decision making problems to explain the trade-offs that can be made to arrive at the best solution.

Standard 7: Interdisciplinary Problem Solving

Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Connections

1. The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.

Engineering Design

1. Engineering design is an interactive process involving modeling and optimization finding the best solution within given constraints which is used to develop technological solutions to problems within given constraints.

Students:

- initiate and carry out a thorough investigation of an unfamiliar situation and identify needs and opportunities for technological invention or innovation.
- identify, locate, and use a wide range of information resources, and document through notes and sketches how findings relate to the problem.

Standard 2: Information Systems

Students will access, generate, process, and transfer information using appropriate technologies.

Information Systems

1. Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

Students:

- access, select, collate, and analyze information obtained from a wide range of sources such as research data bases, foundations, organizations, national libraries, and electronic communication networks, including the Internet.
- model solutions to a range of problems in mathematics, science, and technology using computer simulation software.

Standard 4: Science

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Physical Setting

1. The earth and celestial phenomena can be described by principles of relative motion and perspective.

PLANET EARTH CURRICULUM OUTLINE

UNIT VI: BEYOND EARTH, THE SEARCH FOR LIFE

TOPIC C: LIFE BEYOND THE SOLAR SYSTEM

1. Planets around stars

2. SETI Project (Search for Extraterrestrial Life)
    a. History
    b. Methodical scanning of the skies.

PLANET EARTH CURRICULUM OUTLINE

UNIT VI: BEYOND EARTH, THE SEARCH FOR LIFE

THEME II: "IS ANYONE OUT THERE?'

TOPIC A: THE RACE TO THE MOON-OUR NEAREST NEIGHBOR

1. The Apollo Space Program (1961)
   a. Goals - scientific and political
   b. Technical obstacles

2. Apollo 11-Landing a person on the moon
   a. Main stages
   b. Launch vehicle - escape speed
   c. Lunar module
   d. Lunar surface and rocks
   e. Lunar buggy and instruments on the moon

3. Lunar Prospector Program (1998)

PLANET EARTH CURRICULUM OUTLINE

UNIT VI: BEYOND EARTH, THE SEARCH FOR LIFE

3. Newton's Laws
   a. inertia
   b. relationship between force and motion
   c. universal gravitation

4. Stars and galaxies

TOPIC C: THE SPECTROSCOPIC VIEW

1. Chemical composition of the stars
   a. Spectral lines as fingerprints
   b. Elements and the periodic table
   c. Structure of the atom
   d. Sun is a star; stars are suns
   e. Chemistry of the universe is same as earth/sun chemistry

2. Motion of the stars
   a. Doppler effect
   b. Hubble's discovery of expanding universe
   c. Clouds of dust-galaxies beyond the Milky Way
   d. Distances in light years

3 "Big Bang" Theory-origin, fate, age and structure of universe.

PLANET EARTH CURRICULUM OUTLINE

UNIT VI: BEYOND EARTH, THE SEARCH FOR LIFE

THEME I: "NEW TRUTHS BECOME EVIDENT WHEN NEW TOOLS BECOME AVAILABLE"

TOPIC A: THE NAKED EYE VIEW

1. Heavens
   a. Daily motion of the sun and stars across the sky
   b. Motions of the moon
   c. Fixed positions of the stars/constellations
   d. Wandering "stars" - planets
   e. Heavens revolve-celestial sphere model
   f. Contributions of early civilizations

2. Models to explain observations
   a. Ptolemy's geocentric model
   b. Copernicus's heliocentric model
   c. Kepler's elliptical orbits
      - laws of planetary motion
      - Brahe's contribution of 20 years of observations and measurements

RESOURCES PROVIDED BY THE AMERICAN MUSEUM OF NATURAL HISTORY

ACTIVITIES

Earth Event Wall

The Earth Event Wall will display a giant world map at its center indicating the location of recent Earth events. The map will have four monitors, one on each corner, one for volcanic events, another for earthquakes, another for weather and climate (such as hurricanes), and the fourth will be a live feed from NASA. As events occur around the world the videos will be updated, like news stories but with comments from scientists at the American Museum of Natural History. The world map in the center will reflect the geographic location of the stories on the monitors including specific cities, plate boundaries involved, etc.

As an activity, the classrooms can create their own Earth Event Wall, like the one found in the Hall of Planet Earth at the American Museum of Natural History, to reflect current Earth events. Students will write reports and clip articles on weather and climate, earthquakes, volcanoes, etc. Place a world map in the center--use color-coded push pins to represent types of events on the map and support it with up-close images from newspapers, magazines, and the Internet.

Climate and Climate Change

The section of the hall dedicated to climate and climate change will have a video on global atmospheric circulation featuring a mid-latitude winter storm. This video will feature scientific climate modelers from Los Alamos National Laboratory and how they build and run their model.

THE TECHNOLOGY RESOURCES

Curriculum Resource Suggestions
Please note that these descriptions come directly off the Web.

Blue skies from the University of Michigan

http://www.sover.net/~redcamp/blueskies.html
A weather display system dubbed Blue-Skies has been created by University of Michigan students Alan Steremberg under grants from the National Science Foundation and The Division of Education and Human Resources. Blue-skies is designed to provide an extremely user-friendly interface so that anyone with a minimal computer background can easily learn about the weather right from their own computers hard drive. Best of all, it's free!

BLUE-SKIES offers:

- Interactive Weather Maps - A unique feature of the Blue-Skies program is the availability of Interactive Weather Maps, which contain a weather image (e.g., radar map with fronts, satellite image, etc.) in which all textual information on current conditions and forecasts is embedded.

- International Weather Maps - Color maps of temperature and precipitation are generated every 6 hours for most of the world. These maps are interactive, and display the monthly climatological data for several thousand cities across the world when you click on the city.

- Weather Animations - The Blue-Skies program allows access to Quicktime movies of the latest several hours of satellite imagery, as well as precipitation and frontal movements, temperature changes, and wind field changes.

- Ozone Hole - Recent images of the percent of normal ozone column, as reported by the TOMS satellite is made available as it is released by NASA.

- Air Pollution - All the daily Acid Rain precipitation chemistry data from the Utility Acid Precipitation.

- Assessment Program will be made available. This allows you to track a single day across sites, or a single site across days.

- Famous Weather Events - A special folder containing archives of selected weather phenomena has been created. This folder contains images and data corresponding to hurricanes, tornado outbreaks, snow storms, and other materials useful to your learning process.

The Weather Classroom (from the Weather Channel)

A comprehensive exploration of the hows, whys and wonders of weather, this new series of 33, 8 minute commercial-free television episodes and over 200 pages of designed with educators in mind.

TECHNOLOGY RESOURCES
PLANET EARTH: HURRICANES

National Weather Service - Interactive Weather Information Network
http://iwin.nws.noaa.gov/iwin/graphicsversion/main.html.
Includes: local weather; world weather; satellite radar, and hot links; and weather videos (hurricane lesson is one of the videos, PC computers only).

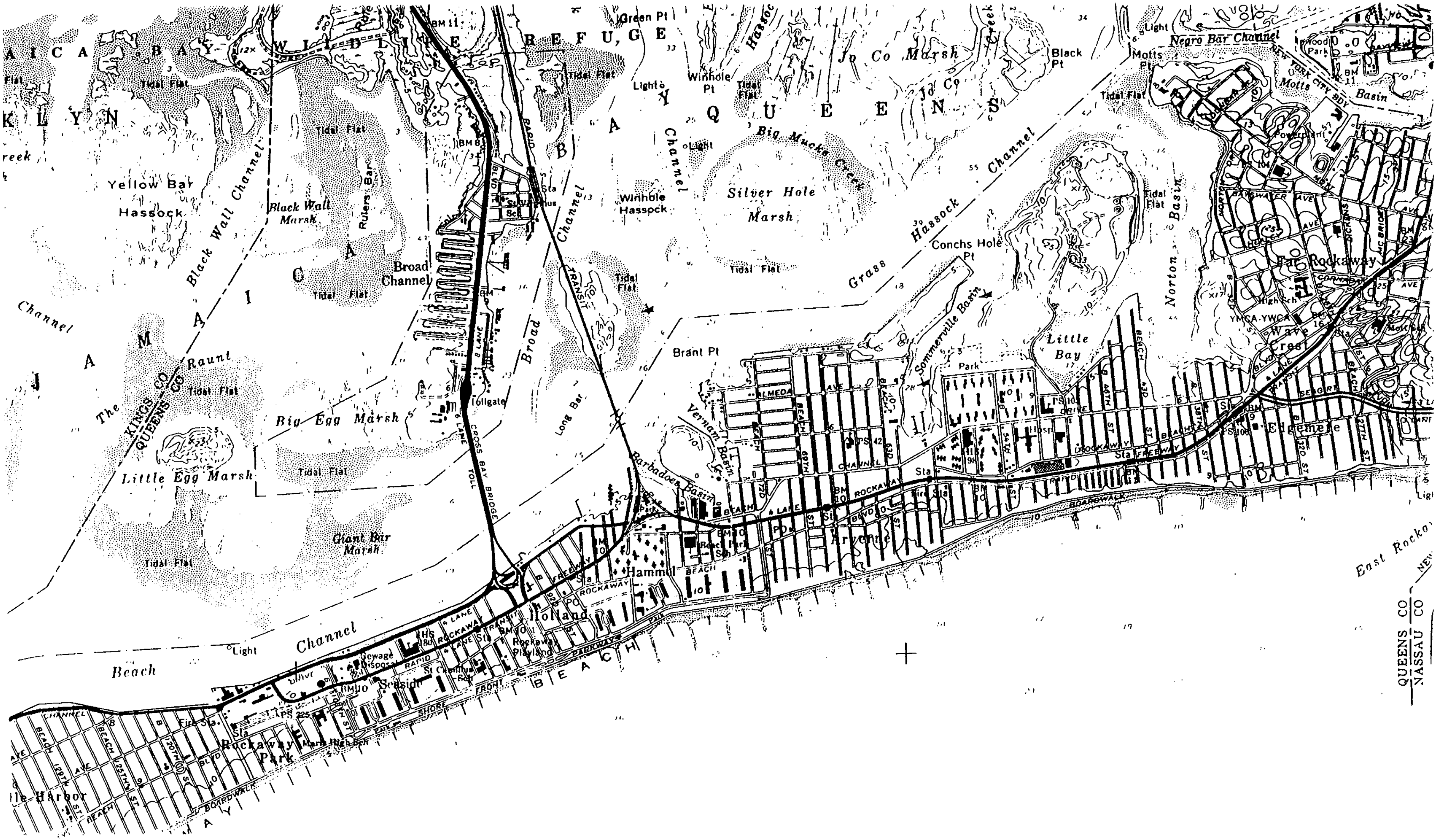
New York State Information, Subcategory of above
http://iwin.nws.noaa.gov/iwin/ny/ny/.html

Thunderstorm Formation
http://windows.ivv.nasa.gov/earth/Atmosphere/tstorm/tstorm_formation.html
Illustrations and explanations of the three stages of a thunderstorm cycle: The Curnulus Stage, Mature Thunderstorm Stage, and Dissipating Stage.

Weather Channel
Severe Thunderstorms
http://208.134.241.150/breaking_weather/encyclopedia/thunder/form.html.
Contains explanation of thunderstorm formation.

Hurricanes/Tropical
http://208.134.241.150/breaking_weather/encyclopedia/tropical/

AccuWeather's Hurricane and Tropical Storm
http://www.accuweather.com/hcnt/hcnt_index
From here you can get forecasts and updates on the latest storms, as well as storm histories, and information and trivia about these deadly storms. Satellite shots of the Atlantic and East Pacific, so that you can see what's developing, and tracking maps that can be downloaded and printed. Describe anatomy and development of a hurricane and a year end retrospective.


JAMAICA BAY WILDLIFE REFUGE
QUEENS
Jo Co Marsh
Black Pt
Motts Pt
Negro Bar Channel
Motts Basin
Green Pt
Winhole Pt
Winhole Hassock
Big Mucke Creek
Silver Hole Marsh
Grass Hassock Channel
Conchs Hole Pt
Norton Basin
Little Bay
Sommerville Basin
Far Rockaway
Wave Crest
Edgemere
Arverne
Hammel
Holland
Seaside
Rockaway Park
Brant Pt
Vernam Basin
Barbadoes Basin
Long Bar
Broad Channel
Cross Bay Bridge
Tollgate
Yellow Bar Hassock
Black Wall Channel
Black Wall Marsh
Rulers Bar
Big Egg Marsh
Little Egg Marsh
Giant Bar Marsh
The Raunt
KINGS CO
QUEENS CO
NASSAU CO
Tidal Flat
Channel
Beach Channel
Light
Rockaway Playland
Rockaway Beach
Boardwalk
East Rockaway

ROCKAWAY HURRICANE

In this laboratory, you will investigate the effects of a hurricane in Rockaway, Queens. You will use USC&GS topographical maps to help you. Topographical maps show elevations as well as buildings, sewage plant and other important buildings, they do not generally show private houses or apartment buildings. This map has an elevation interval of 5 feet. When you see numbers that are not part of street names, they are elevation markers.

A. **Housing**

Determine the Category hurricane (Saffir-Simpson Scale) that would start to submerge structures at the following locations.

	Location	Altitude	Category
1.	B124 and Rockaway Blvd. In Belle Harbor		
2.	B67 and Beach Channel Drive in Averne		
3.	B25 and Rockaway Parkway in Wave Crest		
4.	Where the subway tracks diverge from the Freeway in Far Rockaway on the east side of the map.		
5.	In the community of Board Channel Drive in Jamaica Bay.		

B. **Utilities and Services**

Describe the hurricane effects on the following essential services and utilities. For example, how will they be affected, in what category hurricane, what will result from their failure. How can surge damage be minimized?

1. Sewage treatment plant in Rockaway Park-Seaside area.

____

____

Hurricane Storm Surge

Storm surge is the elevation in the water surface that occurs in the passage of a storm. This is largely the result of wind pushing continental shelf water into shallower depths, raising it into a broad dome, many miles across. Wind then creates waves on top of the surge dome. The highest surge levels occur at the radium of maximum winds within the eyewall on the right side of the eye. Thus, surge levels rise with storm wind speed as measured on the **Saffir Simpson Scale** (below). Other factors increasing storm surge levels are lower central pressures, more gentle offshore slopes, higher tidal levels and shoreline configuration. While surge levels increase where shelf slopes are gentler, wave height increases in areas where the shelf slope is steeper. Most of the deaths in hurricanes are attributed to storm surge.

As the surge dome crosses the shoreline, it results in major destruction. The water depth at any point can be determined by subtracting the expected storm surge from the land elevation. Thus at a point 10 feet above sea level, with a surge level of 15 feet, the water will rise 5 feet above the land surface. Waves raise the actual water level higher, but we will ignore the wave effect in this exercise.

Saffir-Simpson Scale

CATEGORY	WIND SPEED(MPH)	SURGE LEVELS(FT)
1	74-95	4 - 5
2	96-110	6 - 8
3	111-130	9 - 12
4	131-155	13 - 18
5	<155	<18

1. From your reading, write the definitions for each word or phase below.

   A. Gale Force Winds ______________________________

   ____

   B. Storm Surge ______________________________

   ____

PLANET EARTH - THE INEVITABLE STORM

UNIFYING THEME: **Hurricanes**
TOPIC E: **Interaction With Land**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
18. Hurricanes can last for days, even after they move inland.	18. describe the full life cycle of a hurricane.	18. Use the Internet to access movies of past hurricanes.
19. Since they are away from the warm ocean water, they slowly lose strength as they move inland.	19. predict and explain the change in hurricane strength over land.	19. Relate hurricane strength to a tea kettle. Once the flame has been turned off, the kettle stops boiling.
20. If a hurricane slows down, it can produce heavy rains and flooding inland.	20. explain the threat of flooding inland.	20. Get newspaper articles of past hurricanes that lingered for days over inland areas.
21. The thunderstorms in a hurricane can also produce violent tornados after the hurricane moves over land.	21. explain the relationship between hurricanes and tornados.	21. Show students a video of a tornado in action.

PLANET EARTH - THE INEVITABLE STORM

UNIFYING THEME: **Hurricanes**
TOPIC E: **Interaction With Land**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
8. As hurricanes move, their forward speed is added onto the speed of the wind.	Students will be able to: 8. relate the forward movement of the hurricane to wind speeds in the hurricane.	8. Challenge students to use historical hurricane data and explain the wind speeds that were observed.
9. The winds in a low pressure system blow in a counter-clockwise fashion. Due to this motion, the strongest winds will be found on the right hand side of the hurricane.	9. determine which areas are likely to experience the highest wind speeds in a hurricane.	9. Use mathematical formulas to reinforce the idea that you must add the forward motion speed to the wind speed on the right and subtract it on the left side of the hurricane.
10. These strong winds also push the ocean water towards the north.	10. analyze maps of coastal areas and determine areas of possible flooding based on the position of the hurricane.	10. Use the Internet to collect movies of historical hurricanes. Have students record their observations and then explain them.
11. The winds on the left hand side of the hurricane are usually not as strong and push the water towards the south. The location of an area compared to the hurricane is critical in determining the amount of damage that occurs.	11. predict the "worst" case scenario for the coastal areas of New York City.	11. Take students on a field trip of areas that are at risk for severe flooding in hurricanes. Examples are the Rockaways, Jamaica Bay and Coney Island.
12. Areas that are exposed to the ocean, are at extreme risk in a hurricane.	12. predict areas that would be in extreme risk in a hurricane.	12. Allow students to examine the effects of hurricanes in the New York Area (ex. Bob '90) and challenge them to determine the worst possible scenario for different parts of the metropolitan area.
13. The number of people living within 50 miles of the east coast has increased over the past 50 years.	13. describe the population shift towards coastal areas.	13. Contact the Census Bureau and get data to show the change in population of coastal communities over the past 50 years. Create charts and compare the changes during that period of time.

PLANET EARTH - THE INEVITABLE STORM

UNIFYING THEME: **Hurricanes**
TOPIC D: **Formation and Movement**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
13. The Gulf Stream is a warm water current (80 F+) located off the East Coast of the United States.	13. describe the importance of the warm water in the Gulf Stream.	13. Connect to the Internet to access images of the sea surface temperatures off the East Coast of the United States.
14. Hurricanes pass near or over the Gulf Stream as they approach the East Coast.	14. show the path of hurricanes on the East Coast compared to the Gulf Stream.	14. Have students predict the change in hurricane strength based on the movement of the hurricane and the location of the Gulf Stream.
15. Large waves that are produced by hurricane winds can travel hundreds of miles away from the storm.	15. explain why large waves are found around hurricanes.	15. Construct a wave tank to show the effects of ocean waves. *Project Earth Science; Meteorology,* NSTA Laboratory Activity
16. These waves can create dangerous currents on the shorelines that can cause life threatening swimming hazards.	16. show the danger hurricanes can do even when they are located offshore.	16. Construct a wave tank to show the effects of ocean waves. *Project Earth Science; Meteorology,* NSTA Laboratory Activity

PLANT EARTH - THE INEVITABLE STORM

UNIFYING THEME: Hurricanes
TOPIC D: Formation and Movement

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. Hurricanes form where there are large areas of warm tropical oceans.	1. examine possible areas of hurricane development.	1. Distribute world maps to the students and challenge them to find areas of possible hurricane development.
2. Hurricanes are known by different names in different parts of the world.	2. define typhoons, cyclones and willy-willies.	2. Students should find evidence of hurricanes in other parts of the world using newspapers, magazines, and the World Wide Web.
3. The Atlantic hurricane season is from early June to late November, although hurricanes have formed in every month.	3. explain why the hurricane season occurs in North America during the summer.	3-4 Encourage students to hypothesize on the pattern of ocean temperatures found in the Atlantic Ocean. They can then access the data over the Internet and examine the results and compare them to their predictions.
4. Areas of hurricane development move eastward during the summer, due to warming of deep ocean water later in the season.	4. relate areas of hurricane development to the movement of warm water.	
5. Hurricanes usually go through several stages of development: - tropical depression - tropical storm - hurricane	5. explain the different stages of hurricane development.	5. Connect to the National Hurricane Center on the Internet to learn about hurricane development stages.
6. Tropical disturbances are defined by their wind speeds.	6. identify the critical wind speeds needed to reach each stage.	6. Use an activity on wind speed.

PLANET EARTH - THE INEVITABLE STORM

UNIFYING THEME: **Hurricanes**
TOPIC C: **Transformation of Energy**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. When water changes phase, it either absorbs or releases heat energy. This is known as **latent heat.**	1. define latent heat.	1. Experiment with the heating curve of water.
2. Energy is the ability to do work.	2. define energy.	2. Familiarize students with different forms of energy.
3. Heat energy is conserved, energy is never "lost."	3. explain how energy is conserved.	3. Experiment with a hot cup of water connected to a cold cup of water by a metal rod.
4. As water evaporates, it absorbs heat. As it condenses it releases the SAME amount of heat energy that it absorbed.	4. show that ALL the energy going into a system must equal the amount coming out.	4. Challenge students to create a device that would allow more heat energy to flow from one cup to another.
5. As rising air condenses in the formation of clouds and precipitation, large amounts of latent heat energy are released.	5. describe the massive amounts of latent heat released in a hurricane.	5. Use the idea of windchill to demonstrate how much latent heat is absorbed during evaporation. The same amount will be released in condensation.
6. This latent heat energy can be transferred into the following: - wind energy - lightening and thunder - ocean waves	6. determine how the release of latent heat increases the energy level in a hurricane.	6. Do a specific heat laboratory in which a hot metal rod is used to heat water.
7. Wind is air moving from high to low pressure. The greater the pressure difference, the greater the wind speed. As the amount of air rising in the storm increases, the air pressure falls and the wind increases.	7. relate the decrease in air pressure to an increase in wind speed.	7. Show how an anemometer works to measure wind speeds.

PLANET EARTH - THE INEVITABLE STORM

UNIFYING THEME: **Hurricanes**
TOPIC B: **Thunderstorm Formation**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
7. a. As air rises, it cools and forms clouds and precipitation. b. Due to the large amount of warm air over the tropical oceans, thunderstorms are formed by the rising air currents.	Students will be able to: 7. a. describe the formation of clouds and precipitation. b. explain the formation of thunderstorms.	7. Use the Internet to find satellite images that show how thunderstorms form. Encourage students to e-mail meteorologists at the National Hurricane Center for further information.
8. Air pressure is a measure of the weight of air pressing down on a surface.	8. define pressure.	8. Use an empty soda bottle to show the inter-relationships between volume, temperature and air pressure.
9. Pressure, volume and temperature are inter-related.	9. explain the relationship between pressure, volume and temperature.	9. Challenge students to create an experiment to determine if an empty soda can or bottle has air inside. Have students design the procedure and report it to the class.
10. As warm air over the ocean rises, it forms an area of low pressure.	10. describe the formation of a low pressure area.	10. Remove the air from an empty soda bottle to create an area of low pressure.
11. This rising air forms bands of thunderstorms.	11. explain the formation of thunderstorm bands.	11. Print out current weather maps from the Internet showing wind directions. Have students draw arrows to show the direction of the wind around areas of high and low pressure.
12. The Coriolis Effect causes thunderstorms to begin rotating.	12. explain the Coriolis Effect.	12. Demonstrate the Coriolis Effect using a spinning disk and a marble.

PLANET EARTH - THE INEVITABLE STORM

UNIFYING THEME: **Hurricanes**
TOPIC A: **New York City History**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. Major hurricanes have struck the New York City area several times in the past.	1. give examples of historic hurricanes in the New York City area.	1. Find newspaper accounts of major hurricanes that have impacted New York City.
2. The general public is not aware of this history due to the fact that a major hurricane has not impacted the New York City area in fifty years.	2. explain the reason for the general public's lack of hurricane preparedness.	2. Show students the seven minute video of "What If a Hurricane Strikes New York City?" (American Journal).
3. The New York City coastline has experienced massive development in the last fifty years.	3. describe changes in the coastal population over the past fifty years.	3. Compare photos and maps of the New York City area in the 1950's with those of current day New York City area to show the increase in development along the coastline.
4. Only through understanding hurricanes and their impact, can we develop a plan to limit hurricane damage in the future.	4. explain the importance of studying hurricanes to create a plan for the next time one strikes the city.	4. Use the *New York Times* article on the destruction of Hogg Island to show the impact of past hurricanes on New York City. **Students Writing:** Have students develop an evacuation plan for where they live.

Standard 2: Information Systems

Students will access, generate, process, and transfer information using appropriate technologies.

Standard 4: Science

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Physical Setting

2. Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

Students

- use the concepts of density and heat energy to explain observations of weather patterns.
- explain how incoming solar radiation, ocean currents, and land masses affect weather and climate.

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:

- use kinetic molecular theory to explain relationships among temperature, pressure and volume of a substance.

4. Energy exists in many forms, and when these forms change energy is conserved.

Students:

- observe and describe the transmission of various forms of energy.
- explain heat in terms of kinetic molecular theory.

Standard 6: Interconnectedness: Common Themes

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

PLANET EARTH CURRICULUM OUTLINE

UNIT V: THE INEVITABLE STORM

THEME I: "HURRICANES"

TOPIC A: NEW YORK CITY HISTORY

1. Hurricanes have occurred in the past
2. Coastline has experienced development
3. Learning about hurricanes will help us develop a plan

TOPIC B: THUNDERSTORM FORMATION

1. Role of warm water
2. Heat vs. Temperature
3. Phases of water
4. Density of air
5. Air pressure
6. Relationship between pressure, temperature and volume
7. Coriolis Effect

TOPIC C: TRANSFORMATION OF ENERGY

1. Latent Heat
2. Transfer of heat energy (Wind)
3. Eye wall and wind speeds

Name ______________________ Class __________ Date __________

14.2 Acidic Precipitation: Instructions and Data Table

When a chemical is applied to a sample of another chemical and bubbles are given off, there is a chemical reaction occurring. Acids react chemically with some kinds of rocks. In this activity, you will find out whether an acid (vinegar) reacts with various kinds of rock.

When you apply the vinegar:

1. **Be sure to avoid getting any in your eyes!**
2. Look closely for any bubbles that might form. Listen for any fizzing noises that you might hear.
3. Record your observations on the data below.

DATA TABLE FOR ACIDIC PRECIPITATION

OBSERVATIONS

rock type	visual observations	sounds	other
1. __________			
2. __________			
3. __________			
4. __________			
5. __________			

Name ______________________ Class ____________ Date ____________

13.2 Detecting Air Pollution: Data

collector #______

SITE OF PLACEMENT: address or location: ______________________

description of site/area: ______________________

____

prevailing winds from: ____________ wind condition today: ____________

sticky side facing (direction): ____________ height above ground: ____________

possible pollution sources in the area (what and where?): ______________________

____

COLLECTOR SET OUT: date: ________ day of week: ________ time: ________

position (horizontal, vertical, or ?): ______________________

notes:

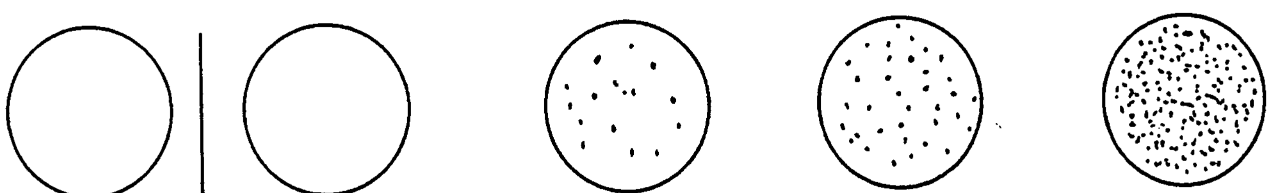
____

COLLECTOR PICKED UP: date: ________ day of week: ________ time: ________

notes:

____

The particulates on my collector look most like:



mine | **none** **light** **moderate** **heavy**

Can you identify any of the particles?

Other notes:

PLANET EARTH - THE AIR WE BREATH

UNIFYING THEME: **Air Pollution**
TOPIC C: **The Future - Current Problems**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. On many days in the summer, New York City air exceeds the federal regulations for air pollutants.	1. identify the conditions (hot, humid, possible inversions, etc.) that cause the levels of air pollutants in New York City to exceed federal regulations.	1. Contact the NYCDEP for more information.
2. Los Angeles and Denver regularly reach near-lethal levels of smog due to their locations in the mountains.	2. describe the air pollution problems in other parts of the country by relating mountains to inversions and the trapping of pollutants.	2. Have students e-mail people in other parts of the country to determine air quality.
3. The fuel efficiency of motor vehicles is not keeping up with the increasing levels of air pollutants.	3. analyze data of fuel efficiency over the past 25 years.	3. Have students research the "best buy" in a new car based on fuel efficiency. Consumer reports is a good resource for this. Research electric cars in terms of technology and politics.
4. The EPA relies mainly on pollution clean-up instead of pollution prevention.	4. compare pollution clean-up to pollution prevention in terms of efficiency and cost.	4. Conduct an activity contrasting clean up with prevention.
5. As the United States moves away from fossil fuel burning facilities, developing countries are just starting to use them.	5. predict the effects that developing countries could have on world air quality.	5. Use the book *Material World* published by the Sierra Club to identify the air pollution in the developing countries.

PLANET EARTH - THE AIR WE BREATH

UNIFYING THEME: Air Pollution
TOPIC B: Air Chemistry - Acid Rain

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
14. The northeastern United States receives some of the most acidic rain in the country. These acids can be traced back to fossil fuel burning power plants in the midwest.	14. determine the sources for acidic precipitation in the northeastern United States based on prevailing wind direction patterns.	14. Collect rain samples from around the New York City area and measure the pH levels.
15. The natural acidity of the soils and lakes will determine how they are affected by the acid rain.	15. discuss the effect of acid rain on soils and lakes.	15. Collect water and soil samples to determine the acidity of a location.
16. Trees and other plants can be devastated by prolonged periods of acid rain.	16. describe the effects of acid rain on plants.	16. Have students conduct an experiment to determine the effect of acid rain on various plants.
17. Acid rain also damages statues, buildings and car finishes. Human respiratory disease has also been attributed to inhaling high levels of chemicals produced by acid rain.	17. explain the effects of acid rain on property and people.	17. Have students conduct experiments to measure the effects of different acid levels on limestone and metals. Visit local monuments, statues in parks or graveyards to examine effects of acid rain on these stone structures. (Columbus Circle, Grand Army Plaza, and Washington Square Park) Discuss air quality policies of the Federal Government. Contrast them to the air quality policies of New York State.

PLANET EARTH - THE AIR WE BREATH

UNIFYING THEME: Air Pollution
TOPIC B: Air Chemistry - Acid Rain

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. When some substances interact with water, they may release hydrogen ions (H^+), other substances may release hydroxide ions (OH^-).	1. identify hydrogen and hydroxide ions.	1. Add an indicator to a mixture of different substances and water to show the production of hydrogen and hydroxide ions.
2. Substances that produce hydroxide ions are called **basic** or **alkaline,** while those that produce hydrogen ions are called **acidic.**	2. predict the pH of a solution based on the type of ions produced. Name common substances that are acids or bases.	2. Have students blow into a solution containing the indicator Brom Thymol blue to produce carbonic acid. Do this either through a laboratory or demonstration to measure pH of various substances.
3. The acidity of substances in water is commonly expressed in terms of pH. pH is a numerical measure of the amount of hydrogen ions in a substance.	3. define pH. Experiment with the pH scale to measure the acidity of different solutions.	3. Students should complete a lab on the pH of household materials using pH papers or other indicators.
4. On the pH scale, solutions with values below seven are acidic, while those with values above seven are basic. Seven is considered neutral.	4. relate the numbers on the pH scale to increasing or decreasing acidity.	4. Have students create an experiment to determine the levels of acidity on the pH scale. Have the students draw and label a pH scale and have them include the pH of various substances from the experiment in their scale.
5. The burning of fossil fuels releases sulfur (S) and nitrogen (N_2) into the atmosphere.	5. relate the burning of fossil fuels to the production of sulfur and nitrogen.	5. Have students perform an experiment to determine the materials produced in combustion.
6. Nitrogen reacts with oxygen to form nitric oxide and nitrogen dioxide. $N_2+O_2 \rightarrow 2NO$ $2NO+O_2 \rightarrow 2NO_2$	6. describe the combination of nitrogen and oxygen to nitrogen dioxide.	6-7 Use chemistry software to allow students to visually experience both of these complex transformations. Show how caustic corrosive (concentrated) NHO_3 can be by reacting a small amount with a copper penny. **CAUTION!!**

PLANET EARTH - THE AIR WE BREATH

UNIFYING THEME: Air Pollution
TOPIC B: Air Chemistry - Creation of Smog

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. Primary pollutants are those that can be traced to a natural event or human activities. Secondary pollutants are the result of chemical reactions in the atmosphere.	1. differentiate between primary and secondary pollutants.	1. Challenge students to create a flow chart of primary and secondary pollutants.
2. Some primary pollutants, when exposed to sunlight, are transformed into secondary pollutants.	2. describe the role of sunlight in the creation of secondary pollutants.	2. Use a radiometer to show that sunlight has energy.
3. Smog is a combination of gaseous pollutants, ozone, and solid material (particulates).	3. identify the components of smog.	3. Have students smear Vaseline on a petri dish and keep it in an open location for a few days. Examine the collection of particulate matter that accumulates. Have them propose an explanation. It would be good to do this activity at several different locations, e.g., near a street, in a park, etc.
4. Motor vehicles and fossil fuel burning power plants produce colorless Nitric Oxide. $N_2 + O_2 \rightarrow 2NO$	4. predict the result of the interaction between nitrogen and oxygen at high temperatures.	4. Connect to the Environment Protection Agency via the Internet for more information.
5. In the troposphere, nitric oxide reacts with oxygen to produce nitrogen dioxide. This gas is yellowish in color with an odor that causes choking. $2NO + O_2 \rightarrow 2NO_2$	5. describe the transformation of nitric oxide and oxygen to nitrogen dioxide.	5. Use computer models to simulate this process.

PLANET EARTH - THE AIR WE BREATH

UNIFYING THEME: **Air Pollution**
TOPIC A: **The Atmosphere - Temperature Inversions**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
7. During the winter, inversions are common and cause smoke and other pollutants to build up.	7. predict the likelihood of a temperature inversion based on the season.	7. Experiment with the heating of a rock and the air in a fish tank.
8. Mountains can also allow temperature inversions to last for several days by trapping air.	8. determine the effect of mountains on temperature inversions.	8. Have students build a model of a mountain inversion in a fish tank.
9. Temperature inversions can be identified by using balloons to measure the changes in temperature in the atmosphere as the balloon ascends.	9. explain the role of weather balloons in identifying temperature inversions.	9. E-mail a meteorologist at the National Weather Service about planning a trip to see a balloon launch or NOAA at Brookhaven.

PLANET EARTH - THE AIR WE BREATH

UNIFYING THEME: Air Pollution
TOPIC A: The Atmosphere - Structure

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. The atmosphere is composed of layers of gas (troposphere, stratosphere, and ionosphere) surrounding the Earth.	1. describe the layering and composition of the atmosphere.	1. Have students graph the layers of the atmosphere in relation to increasing altitude.
2. As altitude increases in the troposphere, pressure and temperature decrease.	2. relate changes in pressure and temperature as altitude increases.	2. Use the Internet to collect weather data from the top of a mountain and have students compare it to the surface readings. Elicit the relationship between the temperature and pressure.
3. In the stratosphere, temperature increases due to the presence of ozone.	3. explain the source of heat energy that causes the temperature to rise in the stratosphere.	3. Have students investigate the ozone "hole" over Antarctica.
4. The ozone layer blocks ultraviolet light from reaching the surface of the Earth. $Sunlight + O_3 \rightarrow O_2 + O$	4. explain the role of the ozone layer as a protective shield against UV light. Discuss why loss of the ozone layer could be catastrophic to living things including humans.	4. Have students research the effect of ultraviolet light on living things. Have them speculate on the effects of increased UV penetration into the atmosphere on life forms, including humans. For example, increased skin cancer, and the decline in the reproductive rate of frogs and salamanders.

5. Energy and matter interact through forces that result in changes in motion.

Students:

- explain chemical bonding in terms of motion of electrons.

The Living Environment

7. Human decisions and activities have had a profound impact on the physical and living environment.

Students:

- explain the impact of technological development and growth in the human population on the living and non-living environment.
- explain how individual choices and societal actions can contribute to improving the environment.

Standard 6: Interconnectedness: Common Themes

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Models

2. Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design.

Students:

- collect information about the behavior of a system and use modeling tools to represent the operation of the system.
- compare predictions to actual observations using test models.

Standard 7: Interdisciplinary Problem Solving

Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Standard 1: Analysis, Inquiry, and Design
Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Scientific Inquiry

1. The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

Students:

- elaborate on basic scientific and personal explanation of natural phenomena, and develop extended visual models and mathematical formulations to represent their thinking.
- hone ideas through reasoning, library research, and discussion with others, including experts.

2. Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Students:

- devise ways of making observations to test proposed explanations.
- refine their research ideas through library investigations, including electronic information retrieval and reviews of the literature, and through peer feedback obtained from review and discussion.
- develop and present proposals including formal hypotheses to test their explanations, i.e., they predict what should be observed under specified conditions if the explanation is true.

3. The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into phenomena.

Students:

- use various means of representing and organizing observations (e.g., diagrams, charts, graphs, equations, matrices) and insightfully interpret the organized data.

UNIFYING THEME: **Our Drinking Water**
TOPIC C: **Our City's Drinking Water: Where Does It Come From? Quality Control, Where Does It Go?**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
8. Water is checked for bacterial (coliform) contamination.	Students will be able to: 8. explain the need to monitor bacterial contamination.	8. Preform microbiology lab involving culturing E. coli if you are so equipped.
9. a. E. coli contamination of the water supply is due to untreated sewage. b. Testing for coliform is one method of monitoring water quality.		9. a. Provide case studies of E. coli contamination for discussion. b. Perform coliform tests on school fountain water.
10. Lead and copper enter the water supply from pipes in use prior to 1950's.	10. discuss why people buy home water filters and how they work.	10. Demonstrate the effectiveness of water filters.
11. Turbidity is a measure of the clearness of water.	11. define turbidity and its relation to water quality.	11. Perform turbidity test. Use the Internet to discover incidences of water pollution in New York City and report them to class.
12. Know where New York City water comes from. 1.4 billion gallons of water for 8 million residents. Water comes from 18 upstate reservoirs, 2000 miles of watershed, 6000 miles of water mains, 99,000 fire hydrants.	12. using New York City water supply system maps to identify key features of the water system infrastructure. Explain the path of water from the reservoir to an apartment faucet.	12. Demonstrate the science behind basic plumbing. Build a simple plumbing system using glass and rubber tubing, etc.
13. Used water goes into 6000 miles of sewer pipes, 99,000 storm drains, 89 pumps stations, 14 treatment plants, and five labs. Treatment plants handle a daily average of 1.5 billion gallons of waste water.	13. explain the path waste water follows when water is flushed down the toilet.	13. Demonstrate how different toilets function. Example, water saver models.

PLANET EARTH - NEW YORK, A CITY SURROUNDED BY WATER

UNIFYING THEME: **Our Drinking Water**
TOPIC B: **Water Politics and History**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. In the 1500's, the Dutch founded New York City and settled in the southern tip of Manhattan. During 1626-1671, the Dutch depended on surface water; streams, springs and ponds for their water.	1. identify the sources of drinking water.	1. Provide visuals of New York City and upstate areas that supply water for the City. Discuss the topography of these regions.
2. Public wells were constructed but soon were contaminated.	2. a. explain how sea water infiltrated fresh water wells. b. discuss the fresh water challenges of that period. c. explain how fresh water supplies may become contaminated. Example, with fecal bacteria.	2. a. Demonstrate how well water gets contaminated. b. Create a concept map for water issues.
3. As the population grew, the water supply and quality concerns increased.	3. a. discuss the need to develop a water distribution system. b. discuss how New York City's 1774 water issue is similar or different to today's issues. Example, water main breaks.	3. Use SIM EARTH to create a water system. Review historical data dealing with water issues. Gather information on water problems of today and yesterday and have the students do research and discuss their findings.
4. New York City gets most of its water from upstate reservoirs.	4. a. explain how the Croton Dam was constructed. Discuss how the Croton Dam is maintained. Draw a map that illustrates its water system. b. explain how fecal-origin disease organisms enter the water supply.	4. a. Construct makeshift dam. Test students dam designs and research activity.
5. Chlorination was established as a means to disinfect waters from fecal-origin disease organisms.	5. discuss how chlorine works as a water disinfectant.	5. Do a laboratory activity demonstrating chlorine's disinfecting ability.

PLANET EARTH - NEW YORK, A CITY SURROUNDED BY WATER

UNIFYING THEME: **Our Drinking Water**
TOPIC A: **From "Salt to Fresh"**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
1. The Hudson River and its tributaries are freshwater environments that feed into the saltwater Atlantic Ocean.	Students will be able to: 1. identify the sources of the freshwater that the Hudson River feeds into the saltwater Atlantic Ocean.	1. Interpret an area map depicting the Hudson River and its flow toward the Atlantic Ocean. The Clearwater Hudson River Sloop conducts environmental education, advocacy programs, and celebrations to protect the Hudson River, its tributaries and related water bodies. To create an awareness of the estuary's complex relationship with the coastal zone, visit the Clearwater's website http://clearwater.org
2. Salinity is the amount of dissolved salts in a sample of water. a. Freshwater is defined as water containing 0.5 parts per thousand or less. b. Saltwater is defined as water containing 30 parts per thousand or more.	2. explain that salinity is determined by the salt concentration levels in the body of water. Compare and contrast fresh, brackish, and salt water.	2. Perform a laboratory analysis on water with varying salinity concentrations. Density activity - float objects (corks) in water of different salt concentrations.
3. The Hudson River valley was carved out during four major ice age periods by the advance and retreat of glaciers.	3. describe the glaciation process by which the Hudson River valley was formed.	3. Read an article about the most recent ice age and how it helped to form the Hudson River Valley. Visit the website http://www.glacier. rice.edu. which provides global background information on glaciers and ice ages.
4. An underground spring in the lower Adirondack region in New York State is the source for the Hudson River.	4. explain that an underground spring serves as a water source for the Hudson River.	4. Read an article on the Adirondacks and locate the source of water flow for the Hudson River.
5. The region where fresh water meets the ocean is called "brackish" water.	5. relate that a transition zone exists where the freshwater source meets the saltwater region.	5. Construct a model of the transition zone between the river water and the seawater region.

PLANET EARTH - NEW YORK, A CITY SURROUNDED BY WATER

UNIFYING THEME: **The Oceans and Rivers that Surround Our City**
TOPIC E: **"Biological" Pollution and Ocean Dumping**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. Marine animals ingest poisons in pollutants which are passed along the food chain, reaching several ecological niches. Oil spills are particularly hazardous as marine life (plant and animal) is destroyed, and ecosystems are affected for decades.	1. describe how ocean dumping has damaged living ocean resources and ecosystems.	1. Model a variety of ocean food webs, analyzing the impact of damage to the organisms when contaminants are introduced into the ecosystem. Visit the website of Clean Ocean Action at http://www.cleanocean.org.
2. Fertilizers containing nitrates and phosphates, which are known pollutants, that when dumped into the water systems lead to the process of eutrophication.	2. describe the effect excess plant nutrients have upon local water environments.	2. Experiment by introducing additional fertilizer components into an aquarium system. Perform this as a on-going laboratory investigation.
3. "Red Tide," which is an example of increased algae growth, lowers the amount of available oxygen, and ultimately causes the death of animal communities.	3. explain the concept of "biological" pollution and its effect on the ecosystem.	3. Read newspaper accounts of "Red Tide" or "Brown Tide" algae blooms in local waters and the devastation it caused in the water ecosystem.
4. The United States government has been enacting laws to regulate water quality for almost 100 years. Clean Water Act bills are proposed on a continuing basis requiring all states to conform to uniform standards.	4. identify legislative measures to regulate water quality.	4. Research water pollution legislation in New York State. Write a letter to your State Legislator asking about the progress made to have the oceans free from the dumping of waste materials.
5. Laws must be strengthened and progress must be made to enable citizens and wildlife to have clean and safe water for drinking and recreation.	5. describe the problems associated with enforcing these laws.	5. Write a persuasive essay describing measures that need to be taken to ensure the enforcement of the Clean Water Act.

PLANET EARTH - NEW YORK, A CITY SURROUNDED BY WATER

UNIFYING THEME: The Oceans and Rivers that Surround Our City
TOPIC D: New York's Shifting Coastline

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
1. Shorelines are dynamic regions of the coastal ocean. Tides, winds, waves and changing sea levels (by glacial advance and retreat) help shape the coastline area.	Students will be able to: 1. identify factors that form and shape a coastal region.	1. Display a video of breakers hitting a coastline region. Examine a shoreline at an area beach at different tide cycles.
2. Breakers form when part of a circular wave is slowed down as it makes contact with the ocean bottom.	2. describe personal experiences they have had with breaking waves on the beach.	2. Demonstrate wave motions with a slinky.
3. Ocean waves continually move sand along the shore within the area of these breaking waves.	3. describe how this process affects the piers and jetties on nearby beaches and shorelines.	3. Observe nearby shores. Experiment with stream tables to demonstrate shifting sand patterns.
4. As tidal patterns and forces change, the face of the shoreline is altered, and the coastline region begins to "shift."	4. explain that the shoreline region "evolves" over time as the coastal area "shifts" in response to moving currents.	4. Construct a model tidal pool/coastal region to demonstrate "shifting" patterns and changing faces of a shoreline. Visit the Life in a Massachusetts Tide Pool website http://www.umass.edu/Public/People/Kamaral/thesis/tidepools.htm/
5. The types of beach sediments found depend upon the source material and weathering processes.	5. explain that beaches are made of materials of varying origin, composition and sizes.	5. Examine various beach sediments, sand, etc. Determine mineral composition and relate size and shape of particles to weathering processes.
6. Many coastlines are formed by marine organism activity and by the processes of erosion and deposition. These form the characteristic features associated with shorelines.	6. relate that shore features are usually temporary and are dependent upon continual changes in weather and water movement.	6. Show videos: (1) Detailing the biochemical actions of marine organisms. (2) The erosion/deposition process to illustrate characteristic features of certain coastal regions.

PLANET EARTH - NEW YORK, A CITY SURROUNDED BY WATER

UNIFYING THEME: **The Oceans and Rivers that Surround Our City**
TOPIC C: **Ocean Currents - Beaches and Tides**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
6. Since tides change by several feet every six hours, they have an important effect on water damage done by storms.	6. explain the reason for identifying water evacuation routes.	6. Study maps of local areas most susceptible to storm damage due to abnormally high tides.
7. Various animal species are dependent upon tides for feeding and mating purposes.	7. relate the importance of changing tides to animal mating habits.	7. Show a video of mating habits of horseshoe crabs and sea turtles.
8. Ocean waves are generated by energy from winds blowing across the ocean surface. The longer the wind blows over the open ocean, the higher the wave height will be.	8. describe the effect of wind energy upon the generation of water waves.	8. Demonstrate a wave generator or use a ripple tank to examine wave patterns.
9. Waves are altered when they enter shallow water. Surf is a region of breaking waves along the shore. Surf height is dependent upon wave height and the bottom topography.	9. explain that water waves form from the energy carried with them. Identify surf and its relationship to breaking waves and shoreline features.	9. Prepare a model of a shoreline system. Show video segments of surf action and its impact at area beaches.
10. Currents and wave turbulence stir up sediment which is moved along the coastline. Waves are the key factor in beach construction and erosion.	10. describe the movement of materials (sediments) as waves impact upon the beach.	10. Demonstrate the movement of sediments in a water tank and the impact of "crashing" waves upon a model "beachfront."
11. Beaches change seasonally: a. The beach landscape is cut back sharply by high, choppy waves. This occurs mainly, in winter. b. Sand is moved onto the beach, building it up in height and width. This occurs mainly, in the spring and summer.	11. explain the effect of wave impact upon the beach areas during different seasons.	11. Photograph local beaches during the different seasons and discuss differences in the "beach-scape."

PLANET EARTH - NEW YORK, A CITY SURROUNDED BY WATER

UNIFYING THEME: **The Oceans and Rivers that Surround Our City**
TOPIC B: **The Ocean as a Resource**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
7. Pearls produced by oysters are considered gems.	7. explain the process of pearl production in oysters and why they are considered valuable gems.	7. Display a variety of jewelry and ornaments made from pearls. Have students develop an explanation of **how** and **why** oysters produce pearls. Let them devise an experiment to test their explanation and debate their experiments with classmates.
8. Environmentalists are concerned that the removal of certain minerals and microorganisms from the sea floor (dredging) may have serious effects upon the existing complex food webs, tidal currents, beaches, and coral reefs.	8. identify the concerns of scientific and environmental groups relating to sea floor dredging. Describe its impact on various aspects of the ocean environment.	8. Read a passage on the process of sea floor dredging. Invite a member of a local environmental organization to discuss the impact of ocean floor dredging on the ocean environment.
9. Oceans serve the: - transportation industry - recreation industry - fishing and shellfish industry	9. describe the various ways in which the ocean is used as a means of transportation, recreation and in food industries.	9. Students should research the variety of recreational uses of the ocean.
10. Exploitation of ocean resources may have serious environmental implications.	10. relate how over-fishing, off-shore dumping and pollution can affect the marine environment.	10. Mock Trial - Put a large corporation on trial for ocean dumping. Students role play - companies, executives, judge, jury, and lawyers.

UNIFYING THEME: **The Oceans and Rivers that Surround Our City**
TOPIC A: **The Gulf Stream**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. The Gulf Stream is a narrow band of flowing water originating in the Caribbean Sea, and it separates open-ocean waters from coastal water regions.	1. identify the Gulf Stream and its point of origin.	1. Analyze the movement of Gulf Stream waters from the Caribbean Sea. American Museum of Natural History visit to the Hall of Planet Earth to view the video on Global Ocean Circulation which features the Gulf Stream.
2. The Gulf Stream currents follow a path along the East Coast of the United States, flowing northward to a latitude of approximately 35 degrees North (35°N).	2. describe the path of Gulf Stream water flow along the eastern seaboard.	2. Have students trace the path and track the movement of the Gulf Stream (from Florida) to Cape Hatteras, North Carolina. Use the Internet to view sea surface temperature maps of the East Coast. Use a map of the Atlantic Ocean to trace the path of the Gulf Stream.
3. The Gulf Stream waters then move northeastward across the Atlantic Ocean, carrying warmer waters (approximately 20° F warmer) of a relatively higher salinity.	3. characterize the changes in water temperature and salinity of the Atlantic Ocean water as the Gulf Stream moves northward.	3. Compare water temperature charts of ocean water affected by the Gulf Stream movement at a specified time of year with the temperature of ocean water in the region unaffected by the Gulf Stream water.
4. The effect of the Gulf Stream is that many locations have warmer climates than they would normally have at a particular time of year.	4. describe the effect of Gulf Stream water on the climate of various areas.	4. Interpret climate changes in New York influenced by Gulf Stream currents. American Museum of Natural History visit to the Hall of Planet Earth. Look at displays related to Climate and Climate Change. Look for the role played by ocean circulation in climate.
5. Various species of fish and marine mammals are found in these warmer waters far away from their typical migratory patterns and mating regions.	5. relate the effect of the warm Gulf Stream waters on the migratory and mating habits of marine organisms.	5. Activity - compare the density of warm vs. cold water. Show convection currents in water. Field Trip: Jamaica Bay Wildlife Refuge.

Physical Setting

2. Many of the phenomena we observe on Earth involve interactions among components of air, water, and land.

Students:

- use the concepts of density and heat energy to explain observations of weather patterns, seasonal changes, and the movements of the Earth's plates.

Standard 6: Interconnectedness - Common Themes

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Patterns of Change

5. Identifying patterns of change necessary for making predictions about future behavior and conditions.

Students:

- search for multiple trends when analyzing data for patterns, and identify data that do not fit the trends.

Standard 7: Interdisciplinary Problem Solving

Students will apply the knowledge and thinking skills of mathematics, science and technology to address real-life problems and make informed decisions

Connections

1. The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/ society, consumer decision making, design, and inquiry into phenomena.

Students:

- analyze science/ technology /society problems and issues on a community, national or global scale and plan and carry out a remedial course of action.
- design solutions to real-world problems on a community, national, or global scale using a technological design process that integrates scientific investigation and rigorous mathematical analyses of the problem and of the solution.

Going Further

1. Here are some questions for further investigation that have particular relevance to global warming issues. Any or all of these questions could be investigated by students, by collecting a sample of gas in a balloon from each source, adjusting the balloon to a standard size, and testing it with BTB, as described in this session.

   - Do older cars produce a higher concentration of carbon dioxide in their exhaust than newer cars?

   - Do cars with pollution control equipment produce less carbon dioxide than cars that do not have such equipment?

   - Do diesel engines produce more or less carbon dioxide than gasoline engines?

   - How do various types of internal combustion engines differ in their carbon dioxide output:

     two-stroke vs. four stroke
     rotary vs. piston
     four cylinder vs. six cylinder
     car vs. motorcycle

2. Have students use a plastic garbage bag to collect a volume of gas exhausted by a car in a certain time period. Have them record the time it takes to fill the bag with that volume, estimate the volume of gas collected, and the amount of time an average car would run each day. From that data, the total estimated amount of exhaust gas that a car generates in a year can be calculated.

   Students could go on to estimate the volume of human exhaust (breath!) exhaled by one person in a year. Ask them to figure out how they might go about estimating this.

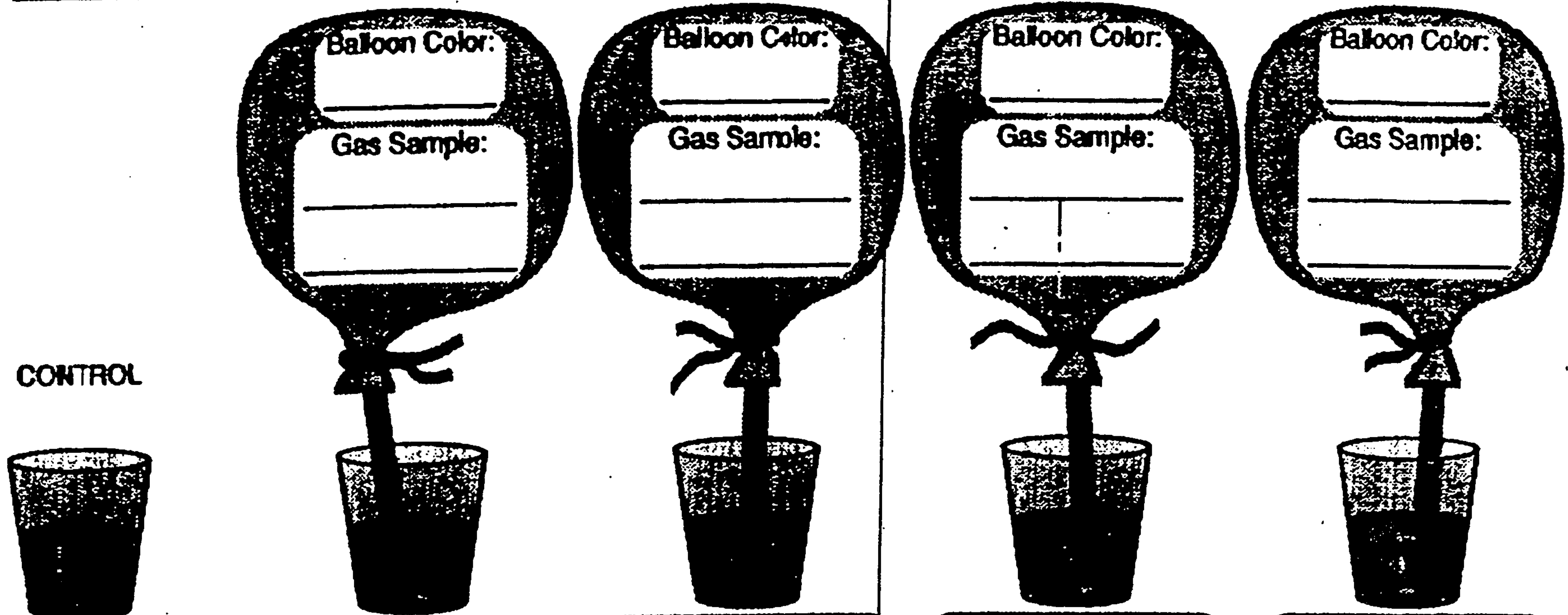
   Finally, students could compare their estimates of the volume of exhaust contributed by a car in one year to that contributed by one person in one year.

   The reasoning used and conclusions reached could provide the basis for an excellent discussion of the significance of these estimates when considering possible solutions.

Name:______________________

Four Gas Samples: Data Sheet

Date:______________________



Color of BTB solution: ______

Color of BTB solution: ______

Color of BTB solution: ______

Color of BTB solution: ______

Color of BTB solution: ______

Write the name of the gas sample where the colo: of the BTB solution fits on the color scale below.

control

Least CO_2 — blue — greenish blue — bluish green — green — yellowish green — greenish yellow — yellow — Most CO_2

What can you conclude about the carbon dioxide in automobile exhaust and the carbon dioxide in human exhalation?

____

____

____

Collecting Samples of Car Exhaust

1. Explain to the class that among the sources of carbon dioxide in the atmosphere are car exhaust and the breath of humans and animals. The students will compare the concentration of carbon dioxide from a car's exhaust with other samples.

2. Tell the students they will take a brief field trip to a car to collect samples of exhaust, which they will analyze using the BTB method they practiced in the previous session.

3. Organize the class into groups, and issue each group one twist-tie, and one balloon. (Bring along several extra balloons and twist ties, in case you have some breakage. Also bring the funnel, as well as an extra funnel, folder, scissors, and tape).

4. Tell the students to stay in groups to follow you outside. When you get to the car, they will line up, and one group at a time will hand you their balloon for filling.

5. When you reach the car, tell the students that as soon as you fill their balloons, they are to work together to tie off the neck of the balloon tightly with the twist-tie. One student should hold the balloon closed, while the other student twists the neck of the balloon to prevent gas escaping and puts on the twist-tie.

6. Collect each of the samples in turn. Ask two volunteers to help you collect two extra samples in case a group loses its sample. Return to the classroom.

Conducting the Experiment

1. When the students are settled in their groups, tell them they will be testing four gas samples. List them on the board.

    1) Car exhaust
    2) Air from this room
    3) Carbon dioxide from vinegar and baking soda
    4) Human breath

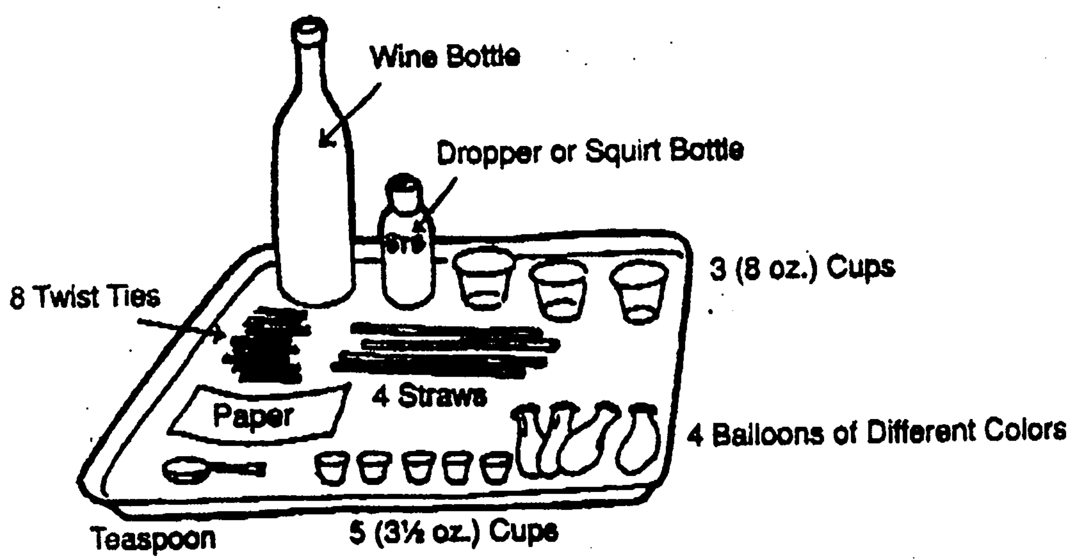
2. Point out that the groups already have their car exhaust samples, and they learned how to collect the air sample in the last session by blowing up a balloon with an air pump.

For each group of 4 students

- *☐ 1 empty glass wine bottle, 750 ml
- *☐ 1 dropper or squirt bottle containing BTB
- *☐ 1 teaspoon
- *☐ 3 plastic cups, 8 oz. size
- *☐ 5 small 3½ oz. clear plastic cups
- *☐ 4 balloons, 8–10" in diameter, three different colors
- *☐ 1 roll of masking tape or other object with a hole about 3½" in diameter; same size for all groups
- *☐ 1 tray
- ☐ 1 sheet of white paper
- ☐ 4 plastic straws
- ☐ 8 twist-ties
- ☐ 1 handout: "Four Gas Samples: Observation Sheet" (see page 88)

For each student

- ☐ 1 handout: "Four Gas Samples: Data Sheet" (see page 89)
- ☐ 1 two-sheet homework assignment: "Carbon Dioxide In the Atmosphere: Who Contributes and How Much?" (see pages 90–91)



Session 5: Sources of Carbon Dioxide in the Atmosphere

Overview

The common sources of carbon dioxide that contribute to the greenhouse effect are brought home to your students through this popular activity in which they compare the carbon dioxide content in their breath and in car exhaust.

In Session 4, your students practiced a technique for testing gas samples for carbon dioxide, using bromothymol blue (BTB). In this session they apply this technique in an experiment to investigate sources of carbon dioxide in their immediate environment. From these tests the students learn that the concentration of carbon dioxide exhaled by humans is less than in car exhaust. They discuss the implications of their results for controlling the amounts of carbon dioxide released into the atmosphere. Then, through a homework assignment, they learn about how much the various nations of the world contribute to the increase of carbon dioxide in the atmosphere.

The purposes of Session 5 are for the students to:

(1) improve their abilities to apply a chemical testing technique in conducting an experiment;

(2) practice sampling and testing procedures like those used in scientific studies of the atmosphere;

(3) draw out the distinction between "natural" and "industrial" sources of carbon dioxide in the atmosphere;

(4) communicate the relative contributions of the industrialized and developing nations to the global warming problem.

Do not be concerned about obtaining samples of gas from auto exhausts—it is really much easier than it might seem, and it's exciting for students to see the samples collected in front of their eyes! Observing how rapidly the balloons inflate is also a graphic demonstration of how much gas cars release into the atmosphere every second.

PLANET EARTH - CLIMATES THROUGH THE AGES

UNIFYING THEME: **Global Warming**
TOPIC E: **Think Globally, Act Locally**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
1. The United States accounts for nearly 25% of the world output of greenhouse gases.	Students will be able to: 1. compare, analyze and interpret the graph, "Carbon Dioxide in the Atmosphere; Who Contributes and How Much? and World Population 1992." (GEMS)	1. Calculate the average amount of CO_2 produced per person in the United States and compare it to that generated by individuals in other countries; explain any differences.
2. Power plants are responsible for over one-third of global carbon dioxide emissions.	2. explain the relative contributions of energy use, agriculture, deforestation and industrial production to global warming.	2. Construct a graph of CO_2 emissions caused by different human activities.
3. Energy conservation can decrease the rate of carbon dioxide emission.	3. detail the roles of energy-efficient appliances, lighting fixtures and vehicles in the reduction of national energy consumption.	3. a. Make an energy survey of your personnel energy consumption, daily, monthly, and annually. b. Keep your data in a journal or log. c. Bring in electric/gas bills and compare them to those of other class members. d. Show videos available from Con Edison and Keyspan Energy Company on conservation.
4. Alternate energy sources exist that do not involve the combustion of fossil fuels.	4. investigate wind power, geothermal energy, solar thermal power, solar cells, and hydroelectric power as alternatives to fossil fuels.	4. Construct a solar oven and use it to cook simple foods.
5. Forests are effective means of removing excess carbon dioxide from the atmosphere.	5. explain the mechanisms by which rain forests and other old growth forests act as reservoirs for carbon dioxide.	5. a. Use maps to locate the earth's remaining old growth forests. b. Debate: human land use vs. keeping the forests intact. c. Visit the American Museum of Natural History - Hall of North American Forests. Look at the exhibit on effective land management.

PLANET EARTH - CLIMATES THROUGH THE AGES

UNIFYING THEME: **Global Warming**
TOPIC C: **Greenhouse Gases and The Carbon Cycle**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
5. Nitrous oxides absorb heat two hundred times more effectively than carbon dioxide.	Students will be able to: 5. relate nitrous oxide emissions to vehicle exhausts, use of nitrogen-based fertilizers and sewage treatment plants.	5. Determine the effect of sports utility vehicles on United States's annual nitrous oxide emissions as compared to other vehicles.
6. Chlorofluorocarbons (CFCs) are the only greenhouse gases created solely by the chemical industry.	6. relate CFC emissions to their use in air conditioners, refrigerators, electronics and foams.	6. Make an inventory of possible CFC sources at home and in school.

PLANET EARTH - CLIMATES THROUGH THE AGES

UNIFYING THEME: **Global Warming**
TOPIC B: **The Greenhouse Effect**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
5. "Greenhouse gases" can linger in the atmosphere for many decades.	Students will be able to: 5. Explain how atomic configuration, quantity and residence time contribute to the effectiveness of "greenhouse gases" to trap heat.	5. Make molecular models of the "greenhouse gases "and compare their configurations; research the ability of tri-atomic molecules to trap heat.

PLANET EARTH - CLIMATES THROUGH THE AGES

UNIFYING THEME: **Global Warming**
TOPIC A: **What is Global Warming?**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
1. Evidence indicates that the earth's climate is warming.	Students will be able to: 1. read and interpret a graph of average global temperature change in the recent past, showing a steady rise since the 1880s. *GEMS - Great Explorations in Mathematics* and *Science* "Global Warming and the Greenhouse Effect" Lawrence Hall of Science, Berkeley, CA, 1997.	1. a. Graph and analyze your local annual mean temperature data over as many years as possible. b. Interview older people about their recollections of climate changes (*GEMS*). Global Climate Issues http://www.api.org/globalclimate/starta.htm. Includes global temperature sea level rise, and greenhouse gas information.
2. Human activities are changing the composition of the earth's atmosphere.	2. analyze *Keelings Graph* and speculate on the causes of increasing carbon dioxide in the atmosphere.	2. Make a photo-collage showing various sources of human induced air pollution.
3. "Global Warming" is the rise in global temperature due to industrial, agricultural and other human activity.	3. compare graphs of global temperature and carbon dioxide concentration during the past 160,000 years (*GEMS*); describe the correlation.	3. Brainstorm what is known about global warming to establish a prior knowledge base.
4. Global warming could severely impact earth's ecosystems.	4. understand possible consequences of global warming: rising sea levels, shifting climate zones, major changes in weather patterns, threats to human and animal health.	4. Design and perform an experiment to determine the effects of temperature change on goldfish respiration or mealworm distribution.

PLANET EARTH - CLIMATES THROUGH THE AGES

UNIFYING THEME: Climate - Past/Present/Future
TOPIC E: Fire or Ice? Future Climate

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
8. Eventually, billions of years from now, the interior of the Earth will cool and the continents will stop moving and the oceans will disappear. The sun will expand into a Red Giant destroying Planet Earth in the process. Finally, the sun will collapse into a feebly shining white dwarf star.	Students will be able to: 8. determine what will happen to Planet Earth in the distant future.	8. Students will compare our sun with other similar stars whose histories are known to determine the future of the Earth and the solar system.

PLANET EARTH - CLIMATES THROUGH THE AGES

UNIFYING THEME: **Climate - Past/Present/Future**
TOPIC E: **Fire or Ice? Future Climate**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
1. Although we can predict with a reasonable degree of accuracy the effects of current changes such as El Niño, we cannot yet predict when they will reoccur.	Students will be able to: 1. describe the inherent instability in the system of prevailing winds and ocean currents.	1. Examine weather forecasting records to determine our ability to predict significant climatic changes in advance. American Museum of Natural History visit to the Hall of Planet Earth: Climate and Climate Change section: in the El Niño Theater the current understanding of El Niño in the context of Global Climate Variability is featured with a focus on the 1982-83 El Niño and it's global impacts.
2. A major volcanic eruption can significantly cool the entire planet for several years by throwing sulfur dioxide aerosol products high into the atmosphere where they absorb solar heat.	2. explain how volcanic eruptions can affect climate.	2. a. Students can research the effects of volcanic eruptions on the extinction of the dinosaurs. b. Using the eruption of Mt. Pinatubo as an example, students will examine the climatic effects of a volcanic eruption. American Museum of Natural History visit to the Hall of Planet Earth: Climate and Climate Change section: look specifically at the ice core record from Greenland that is displayed and volcanic eruptions. - impact of these eruptions on climate indicators such as temperature will be shown. - computer interactive that allows the user to "read portions of ice core record" and identify events like volcanic eruptions, large forest fires, etc.

PLANET EARTH - CLIMATES THROUGH THE AGES

UNIFYING THEME: **Climate - Past/Present/Future**
TOPIC C: **Earth's Deep Freezes - Ice Ages**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
3. The retreat of the glaciers brought huge grasslands, distinctive lakes and the rivers that drain them, glacially eroded valleys, and rich soils.	Students will be able to: 3. describe how climatic changes since the last glacial episode of the present ice age have affected the biosphere of North America.	3. Maps, photos, and videos can demonstrate the many features left over from the previous glaciation. Field trips to Central Park to see evidence of glaciation.
4. We are still in an ice age, however, in an interglacial period during this ice age. Ice as much as a mile thick has covered New York State more than once. The Great Lakes, the Finger Lakes, Long Island and much of the landscapes in the interior of New York State were all formed as a result of this glaciation.	4. describe the effects this ice age has had on New York State.	4. a. Using a 3-dimensional model of New York State, students will examine the different features of New York State for evidence of glaciation. Visit the New York City Geology website http://research.amnh.org/earthplan/nyc_geol.html. It includes a brief discussion of glaciers. b. The students can construct a poster map of New York State and using a key, locate and identify glacial features on the map.

PLANET EARTH - CLIMATES THROUGH THE AGES

UNIFYING THEME: **Climate - Past/Present/Future**
TOPIC B: **How Can We Determine Past Climates?**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
5. When climates change the biosphere changes in response.	Students will be able to: 5. a. determine the effect of climates on the organisms alive at the time. b. speculate on the role of climate change on mass extinctions.	5. Compare fossil evidence for the Triassic, Jurassic and Cretaceous periods of the Mesozoic Era. Have students speculate on the effect of Global Warming on New York City. Students can write their thoughts in essays or journal form.

PLANET EARTH - CLIMATES THROUGH THE AGES

UNIFYING THEME: **Climate - Past/Present/Future**
TOPIC A: **Climate vs Weather**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
9. The higher the altitude, the colder the temperature, causing prevailing winds to drop their moisture on the sea side, leaving the continental side dryer. Mountain ranges may block out cold north winds. Winds are forced **upward** therefore dropping their moisture, example, Washington State, and Oregon State.	9. analyze the effect of mountains on local and regional climates. Example, Portland, Oregon; and Seattle, Washington.	9. Compare "microclimates" on windward and leeward sides of mountain ranges.
10. Earth's climate has changed periodically due to natural causes.	10. discuss astronomical, geological, and meteorological contributions to natural climate change.	10. Students read and interpret graphs of temperature fluctuations in the ancient past (see GEMS). Students read and discuss/debate an article on asteroid impact and dinosaur extinction. Visit the NASA Goddard Institute Space Studies' website http://www.giss.nasa.gov/research/modeling/ which has information on global climate modeling research. It includes links to *Popular Science* pages on climate.
11. Earth's climate is regulated by complex feedback mechanisms.	11. describe how positive and negative feedback loops can have contradictory effects on climate.	11. Use drawings to describe how decreases in cloud cover could have two opposite effects on global temperature.
12. Computer models and remote sensing help scientists to understand and predict climate changes.	12. compare the ability of different climate models to predict future global temperatures.	12. Use the data tables and graphs in spreadsheet programs to conduct simple climate modeling exercises (use data from Internet).

PLANET EARTH - CLIMATES THROUGH THE AGES

UNIFYING THEME: **Climate - Past/Present/Future**
TOPIC A: **Climate vs Weather**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. Weather is the state of the atmosphere at a given time and place. Climate is the typical weather pattern over a period of years in a given location.	1. explain the difference between weather and climate.	1. Using regional weather maps for one day for each season, students will explain the difference between the concepts weather and climate.
2. Climate is affected by latitude, altitude, prevailing winds, topography, distance from large bodies of water (ocean, lakes), nearby ocean currents.	2. describe the causes behind climatic differences around the world.	2. Examine a *New York Times* meteorological table noting the statistics for various cities. Relate these statistics to a topographic globe and map to explain climate differences around the globe. American Museum of Natural History visit to the Hall of Planet Earth: See the video on global atmospheric circulation and the relationship between atmospheric circulation and regional climate.
3. Climate results from the interaction of solar radiation with components of air, land and water.	3. use temperature and precipitation to describe the major world climate zones.	3. Compare mean monthly temperature data for cities of similar latitude (e.g., Albany and Buffalo) and account for any differences and fluctuations. Predict the climate of an "Imaginary continent" based on air, land and water.
4. Differences in latitude result in differences in insolation with resultant effects on climate.	4. explain how differences in latitude, altitude, winds, clouds, and water/land interactions affect climate.	4. Students will use a globe to examine the effects on climate of latitudinal differences (during both equinoxes, both solstices) with amount of insolation at those regions. Students will graph latitude vs temperature. Visit the website http://nesen.unl.edu/nigec/activities/climb/latitude1.htm/ **Activity:** Analysing data for two different latitudes.

Connections

1. The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/ technology/ society, consumer decision making, design, and inquiry into phenomena.

Students:

- Analyze science/ technology /society problems and issues on a community, national or global scale and plan and carry out a remedial course of action.
- Design solutions to real-world problems on a community, national, or global scale using a technological design process that integrates scientific investigation and rigorous mathematical analyses of the problem and of the solution.

Strategies

2. Solving interdisciplinary problems involves a variety of skills and strategies, including effective work habits; gathering and processing information; generating and analyzing ideas; realizing ideas; making connections among the common themes of mathematics, science, and technology; and presenting results. Students participate in an extended, culminating mathematics, science, and technology project. The project would require students to:
   - work effectively
   - gather and process information
   - generate and analyze ideas
   - observe common themes
   - realize ideas
   - present results

STANDARDS: CLIMATES THROUGH THE AGES

Standard 1: Analysis, Inquiry, and Design

Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Scientific Inquiry

1. The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

Students:

- hone ideas through reasoning, library research, and discussion with others, including experts.
- work toward reconciling competing explanations; clarifying points of agreement and disagreement.

Standard 2: Information Systems

Students will access, generate, process, and transfer information using appropriate technologies.

Information Systems

1. Information technology is used to retrieve, process, and communicate information and as a tool to enhance learning.

Students:

- access, select, collate, and analyze information obtained from a wide range of sources such as research data bases, foundations, organizations, national libraries, and electronic communication networks, including the Internet.
- model solutions to a range of problems in mathematics, science, and technology using computer simulation software.

Standard 4: Science

Students will understand and apply scientific concepts, principles, and theories pertaining to the Physical Setting and Living Environment and recognize the historical development of ideas in science.

What is the depth of the layer that has the highest level of Iridium?

____

According to what we have seen in other rock layers in the world, what type of rocks would we expect to fine at 119 meters in Carlsbad, New Mexico?

____

Sine these results seemed so strange, the scientist felt that they should check them again. They took the samples from the 65 million years old layer and tested their densities. Iridium is a very dense material (22.42), and therefore should be easily recognizable.

Density of some heavy elements

Iron	7.86	Copper	8.92	Nickel	8.9
Mercury	13.6	Gold	19.3	Platinum	21.45
Silver	10.5	Iridium	22.42		
Tin	7.3	Lead	11.30		

Chemical character of anomaly at 65 million years old layer. Please determine the density using the formula D=M/V.

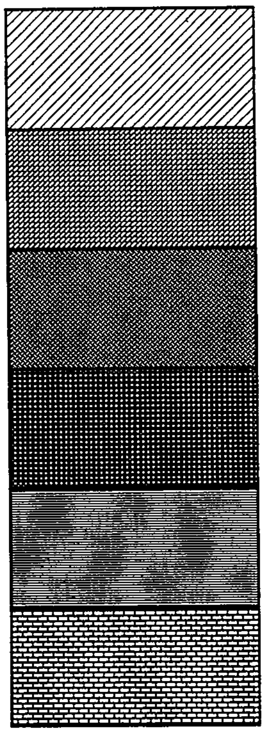
Location	**Mass (g)**	**Volume (cm^3)**	**Density (g/cm^3)**
Carmel, Co	0.500	0.0220	
Raton Basin, NM	0.750	0.0330	
Arroyo El Mimbral, Mexico	0.901	0.0397	
Beloc, Haiti	0.802	0.0360	
Caravaca, Spain	0.200	0.0089	
Gubbio, Italy	0.401	0.180	

TOTAL = ____________

AVERAGE = ____________

Create geologic profiles of each location below using the number of represent centimeters. Unknown layers should be left blank.

Carmel CO   Raton Basin, NM   Arroyo El Mimbral, Mexico   Beloc, Haiti   Carvaca, Spain   Cubbio, Italy



What layer is found in all the samples at approximately the same time?

___

Two other mysteries were unearthed. First, the type of quartz that was found is called SHOCKED QUARTZ. It is only created in nuclear explosions or asteroid/meteor impacts. Secondly, the clay/quartz layer was high in the mineral/iridium. Iridium is extremely rare on the Earth's surface and is only found in abundance in outer space and the interior of the Earth.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **Shakes, Quakes and Plates**
TOPIC D: **New York City Earthquakes**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. New York City is located near the center of the North American plate. Although earthquakes are more common near the plate boundaries, they can and do occur in the center of plates.	1. describe the position of New York City compared to the North American plate.	1. Have students investigate the New Madrid earthquake that occurred in the 1800's.
2. Earthquakes have occurred in the past near New York City and probably will occur in the future.	2. relate past occurrences of earthquakes to future possibilities; explain why New York City has few earthquakes compared to California.	2. Challenge students to predict the likelihood of an earthquake in New York City given past data. Have students examine the Richter scale values of these quakes.
3. There are no faults found on the surface around New York City, but there is evidence of buried faults around the city.	3. explain the importance of finding faults as a possible predictor of future earthquakes.	3. Use a geologic map of New York City to enhance this point.
4. Due to the fact that a large earthquake has not occurred in the last 100 years, many people are not prepared for the possibility of an earthquake.	4. describe the preparedness of the population for an earthquake in New York City. Explain the important parts of an earthquake evacuation plan.	4. Have students create a questionnaire and bring it home to question people in their family about basic earthquake safety tips. Challenge them to explain how they would convince people to evacuate the city if a large quake were predicted.
5. Newer buildings are built to withstand the stress of an earthquake. Most of the buildings in the city are older and would be unable to withstand an earthquake.	5. relate age of structure to earthquake damage.	5. Bring in a civil engineer to discuss the reason why newer buildings would stand up better in a quake. Discuss building codes. Study the new building code in New York City which takes into account the risk of earthquakes.
6. Areas built on landfill may experience liquefaction of the ground.	6. define liquefaction.	6. Identify areas of New York City that would face this problem based on the type of soil.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **Shakes, Quakes and Plates**
TOPIC C: **Earthquakes**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
1. Sometimes plates move parallel to each other. Instead of moving by each other smoothly, they move suddenly creating earthquakes. This is because potential energy is released suddenly.	Students will be able to: 1. describe how the sudden release of energy at sliding plates can cause an earthquake.	1. View the movie "Disasters" by the National Geographic. Simulate sliding plates using wood blocks.
2. A fault is a crack in the earth's surface along which motion has occurred.	2. define fault and relate it to the incidence of earthquakes	2. Have students create faults by building clay models and then creating earthquakes by bending the base of the model.
3. California lies along a plate boundary. As the plates move past each other, large earthquakes are produced.	3. explain the reason for the high number of earthquakes that occur in California.	3. Students should use the library to get information for the debate. Should Insurance Companies Be Required to Issue Policies to People Who Choose to Live in an Earthquake Zone? Use the Internet or magazines to find articles on California's earthquakes. Example, San Francisco Quake of 1905. View a cast of San Andreas fault in the Hall of the Planet Earth at the American Museum of Natural History.
4. Earthquakes can be measured and located using seismograph. The place on the earth's surface directly above an earthquake is known as an epicenter.	4. describe how a seismograph works.	4. Visit a college or institution that has a working seismograph, or buy one. If neither is feasible have students build a simple model of a seismograph. View seismic waves website http://www.geo.mtu.edu/upseis/waves.html. Basic explanation of seismic waves with diagrams.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **Shakes, Quakes and Plates**
TOPIC A: **Theory of Plate Tectonics**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. Fossil evidence indicates that the climate of New York City has been very different in the past.	1. determine the type of climate in New York City's past based on fossil evidence.	1. Give students data of paleoclimates that can be found on the Internet by using a search engine or examine the charts.
2. Mountains of similar composition and age of formation can be found in the Appalachians and in England.	2. Identify these mountains as being separated by the Atlantic Ocean.	2. Use the computer program "Plate Tectonics: *The Inside Story*" by TASA Graphics Arts to show simulations of this idea.
3. The ocean floor is generally younger than the continents.	3. relate the age of the continents to the age of the ocean floor. Identify Mid-Atlantic Ridge spreading zone as a chain of underwater volcanoes.	3. Have students complete the laboratory investigation on the mid ocean ridges. *(Earth Science Laboratory Book*, Spaulding and Namowitz).
4. All (jig saw puzzle continents, sea floor spreading, etc.) evidence supports the idea that the surface of the earth consists of plates. These plates (major and minor plates) are moving very slowly (several centimeters per year).	4. define plate tectonics. List supporting evidence and identify major and minor plates.	4. Have students compare plate boundaries to the occurrences of earthquakes and volcanos around the world (do this on a world map showing plate boundaries).
5. When these plates collide they produce earthquakes and volcanoes.	5. predict the outcome of plates interacting with each other.	5. Challenge students to create convection currents and use them to describe plate movements. Use a lava lamp to simulate convection currents in a heated fluid.
6. The plates are carried along by movement of the solid mantle as a result of convection driven by heat flow from inside of the earth. This movement is very slow (The Earth's mantle is solid. Convection occurs by solid state flow. Compare this slow movement to glaciers moving or large folds in mountain rock formations).	6. explain the source of plate movement.	6. The Hall of Planet Earth at the American Museum of Natural History will present the Los Alamos National Laboratory mantle convection model. Convection model at the center of the Plate Tectonic exhibit in the Hall of Planet Earth at the American Museum of Natural History.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **Progression of Life**
TOPIC D: **Mass Extinctions**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
1. Fossil evidence shows that many of the life forms that have lived on earth no longer exist. Extinction occurs when the last members of the species dies.	Students will be able to: 1. define extinction.	1. Connect to Greenpeace on the Internet to find discussions of this.
2. During the history of life on earth it has been common for life forms to become extinct.	2. identify organisms that have gone extinct.	2. Examine fossil specimens of species that no longer exist. Visit the Fossil Halls at the American Museum of Natural History.
3. Mass extinctions (when a substantial number of species on earth become extinct at one time) occurred a number of times in the past.	3. Define mass extinctions.	3. Use the *Craters* workbook by NSTA to examine this more fully. Have students do research on recent extinctions. For example, Dodo, and the passenger pigeon. Visit the American Museum of Natural History to see the exhibit on extinctions and endangered species.
4. Scientists have theorized that natural events, such as asteroids, volcanism, rise in sea level and climatic changes may have been responsible for most of these mass extinctions.	4. predict the effect of changes in the climate of the earth on life forms.	4. Use the computer simulation "Sim Earth" to examine the effects of climactic change on living things.
5. The latest mass extinction is currently occurring and is due to the impact of human activity on the earth's environments.	5. describe the effect of humans on other species.	5. Examine the effects of deforestation on species in the Rain Forest. Have students choose an endangered species and report on the physical changes to their environment that caused it. Visit the Hall of Biodiversity at the American Museum of Natural History to learn about the mass extinction currently taking place. Will include a full-size rainforest diorama.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **Progression of Life**
TOPIC B: **Radioactive Dating**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
5. Other radioactive elements, such as Uranium 238, left over from the formation of the earth can be found in non-living materials.	5. compare the use of Uranium 238 to the use of Carbon 14.	5. Allow students to e-mail a geologist for more information on radioactive dating. Have students create a chart comparing various types of radioactive dating.
6. Radioactive dating is used to determine the absolute age of materials.	6. compare absolute age to relative age. Explain why different methods of radioactive dating are used based on the suspected age of the materials.	6. Challenge students to find as many objects that could be dated using absolute age.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **Progression of Life**
TOPIC A: **Reading Rock Strata**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. When living things die, they can be fossilized in the rocks. Fossils are the remains, impression or trace of an organism that lived in the geologic past.	1. describe the process of fossilization and define fossils.	1. Build models of fossils using Plaster of Paris. Show and pass around examples of real or models of two types of fossils. Visit the Fossil Halls at the American Museum of Natural History to observe vertebrate fossils.
2. By determining the age of the rock strata, the age of fossils in that rock can be determined. A geologic profile is a side view of the rock layers underneath a location.	2. explain the relationship between rock layer age and fossil age.	2. Have students create geologic profiles based on the different aged fossils found there. Visit the exhibit "Reading the Rocks Section" in the Hall of Planet Earth at the American Museum of Natural History
3. If the rock layers have not been distributed, the oldest rock layers will be below the youngest ones.	3. identify the youngest and oldest rock layers in a geologic profile.	3. Relate this idea to the fact that the oldest newspapers in a pile are usually at the bottom.
4. Measuring the age of rock layers compared to other rock layers will tell us the relative age of the fossils.	4. determine the relative ages of rock strata in a geologic profile.	4. Challenge the students to determine the relative age of several materials. If you are brave include yourself as one of the materials!
5. The type of fossil found in a rock layer indicates what the environmental conditions were when the fossil was deposited.	5. compare fossils from different environments.	5. Use real fossils to have students describe the environment in which they lived.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **In the Beginning**
TOPIC J: **Aerobic and Photosynthetic Organisms**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
4. As life forms adapted to these changing conditions, they grew in complexity, in cell size and in cell number.	4. relate that organisms become more complex while adapting to the changing environment and with this complexity came an ability to process varying types of energy.	4. Have students produce a concept map or other flow diagram to display the increased complexity in organisms and their energy needs, during the changing environments.
5. Eukaryotes (true nucleated cells) evolved from simpler Prokaryotic cells. Over time, single cells aggregated into colonies which eventually developed specialization of functions. In due time, multicellular organisms evolved, inhabiting water, air and land.	5. describe how multicellular organisms developed from simpler one cell and colonial forms.	5. Explain the 5-Kingdom system of taxonomy and have students describe the respiration and nutritional requirements of representative organisms from each Kingdom.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **In the Beginning**
TOPIC I: **The Access to Sunlight**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. The early, simple chemotrophs and heterotrophs that inhabited the ocean waters were not directly dependent upon visible light from the sun. Early heterotrophs added more CO_2 to the atmosphere.	1. state how the early heterotrophs added CO_2 to the atmosphere.	1. Demonstrate the process of photosynthesis using *Elodea.* Students should determine the rate of photosynthesis and graph data obtained by varying the light intensity or temperature.
2. One theory states that as competition for depleting mineral resources increased, those organisms with adaptations to utilize sunlight, began to thrive.	2. relate the concept of adaptation to the level of increased competition for available resources.	2. Study Darwin's concept of competition for resources in his Theory of Natural Selection.
3. Photosynthetic organisms generated their own organic food supply from inorganic CO_2 and H_2O with the energy from sunlight. $6CO_2 + 12H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6H_2O + 6O_2\uparrow$	3. identify photosynthesis as a conversion of light energy into stored chemical energy.	3. Have students compare the energy input and output (reactant energy and product energy) of photosynthesis.
4. In the process of photosynthesis, carbohydrates are produced and free O_2 is released. This further changed the atmosphere by adding abundant levels of O_2.	4. describe the process of photosynthesis.	4. Trace the photosynthesis reaction and the production of molecular oxygen (O_2) as liberated gas.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **In the Beginning**
TOPIC F: **The Ocean Region**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. Complex organic compounds were synthesized from the molecules in the atmosphere and oceans with the energy supplied by internal radioactive decay and high-energy radiation from space.	1. describe how organic compounds formed in the early atmosphere and oceans.	1. Display a computer simulation of the formation of organic molecules.
2. The heterotroph hypothesis states that under conditions existing on earth about 1 billion years ago, protein complexes could form non-living aggregate clusters called **coacervates.**	2. define "aggregate" and "coacervate". Explain Oparin's idea of the "heterotroph hypothesis."	2. Read and interpret the experimentation of Oparin's heterotroph hypothesis and also Stanley Miller's experiment.
3. Coacervates have been produced under laboratory conditions from proteins and other organic molecules.	3. explain Miller's experiment on formation of organic molecules from primitive Earth atmospheric gases. Discuss why this is not likely to occur today.	3. Research the properties of life, and ask students to define a position on "coacervates as life forms."
4. The membrane-type structure surrounding the coacervates maintained an equilibrium balance between the internal environment of the aggregate cluster and the external watery environment.	4. characterize the importance of a membrane structure in maintaining a homeostatic balance with the environment.	4. Demonstrate the function of the cell membrane as a structure able to maintain a dynamic balance between the internal and external environments. Visit the American Museum of Natural History Hall of Human Biology.
5. These non-living structures may have developed biochemical reactions and released energy into the environment.	5. relate how biochemical reactions can generate energy.	5. Demonstrate exothermic reactions to illustrate the process of "biochemical" reactions liberating heat into its environment.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **In the Beginning**
TOPIC E: **The Release of Heat Energy**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. Transfer of heat within the earth is relatively slow because of the high heat capacity of rocks.	1. describe the concept of heat capacity and explain the process of heat energy transfer.	1. Demonstrate heat transfer through various types of matter, metals, rocks, water, air, etc.
2. "Hot spots" are areas of high, variable heat flow out of the Earths mantle. They occurred under oceanic and continental crust.	2. identify the concept of "hot spots" and their locations in the Earth's lithospheric. - explain why zones of active volcanism "youngs" in one direction using plate tectonics.	2. Create Jell-O molds of the Earth's lithosphere. Let them solidify and slowly pass them over a Bunsen burner.
3. Heat released from volcanic eruptions warms the atmosphere, lowering its density and increasing its capacity to hold gases, including water vapor.	3. describe the release of heat through volcanic activity and the resultant change in the properties of air.	3. Demonstrate the holding capacity of a solute, such as, salt in warm water compared to cooler water.
4. Volcanos affect the climate by changing the composition of the atmosphere, and in fact, often the result of a large eruption is cooler temperatures because volcanic dust suspended in the atmosphere blocks out the sun.	4. describe the effects of volcanic eruptions on climate.	4. Analyze climatic changes in regions of recent volcanic activity. Visit the Hall of Planet Earth at the American Museum of Natural History section on Climate and Climate Change.
5. Early in the Earth's history, the dynamic processes of heat transfer and the distribution of various chemical compounds had created an environment conducive to major changes.	5. Characterize the dynamic state of the Earth and its environment through heat transfer and the magnitude of change in the system.	5. Have student illustrate the Earth's high energy atmosphere, mineral-rich waters and active land regions in diagram, concept map, or diorama form.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **In the Beginning**
TOPIC D: **The Heat Within**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. Volcanic activity arises from high temperatures deep within the Earth. Volcanic activity originates in the upper part of Earth's mantle, not the core. Pressure alone favors the solid state, not melting.	1. describe volcanic processes.	1. Visit the Hall of Planet Earth's Volcano Exhibit. Assign a reading selection and show film or TV news segments about known volcanic eruptions, such as, Mt. Vesuvius, Mt. Saint Helens, and Montserrat, and Hawaii.
2. During a volcanic eruption (on land or under the sea), gases from within the interior and molten rock (magma) are brought to the surface.	2. explain the flow of magma and the release of volcanic gases.	2. Perform a Laboratory Activity on "Analysis of Patterns of Volcanic Activity."
3. Sea floor spreading results in the flow of magma from the mantle up into the oceanic crust. This new magma also fills in the spaces created as the sea floor spreads. Sea floor spreading is the consequence of convection in the mantle.	3. describe the concept of sea floor spreading. - explain how the mantle, which is solid, flows in response to convection.	3. Display website www.amnh.org-Black Smoker computer simulation on ocean-floor spreading processes or draw a diagram on the chalkboard. Include description of spreading, online and offline activities.
4. Magma that reaches the surface is called **lava** and forms the basis for many island formations and mountain regions.	4. describe lava flow and how different types of volcanos' result from different types of lava concept of viscosity?	4. Display laserdisc/video of Hawaiian Island formation and other lava flow formations. Compare Hawaii to Cascades.
5. Ocean crust material is thinner and more dense than continental crust material. The chemical compounds that make-up oceanic crust is predominantly composed of basaltic rock, while continental crust primarily consists of granite rock.	5. compare the differences between oceanic and continental crust composition and explain why ocean crust is more dense (contains more Fe). Make iceberg analogy between continents and ocean crust. Continents are like icebergs and ocean crust is like pack ice. Define the concept of isostasy.	5. Compare the densities and the chemical compositions of oceanic and continental crust using reference tables and texts.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **In the Beginning**
TOPIC B: **Formation of the Atmosphere**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. When the earth first formed, it had no atmosphere. The earliest atmosphere was primarily composed of hydrogen and helium, most of which were released back into space.	1. identify the light elements hydrogen and helium as the initial gases in the earliest atmosphere. Explain how scientists know this.	1. Demonstrate the low density of helium using a helium-filled balloon.
2. Chemical reactions involving simple elements lead to the formation of simple compounds.	2. describe how chemical reactions generate new compounds	2. Demonstrate simple chemical reactions to produce simple molecules (example, sulfur + iron filings → iron sulfide).
3. It is theorized that some volatile gaseous compounds such as methane (CH_4), ammonia (NH_3) and water vapor (H_2O) were first trapped within the pore spaces of rock grains, then released to form a primitive atmosphere.	3. describe the primitive atmosphere as viewed through scientific theory and experimentation.	3. Graph the composition of Earth's atmosphere over time. Analyze the chemical importance of the compounds methane and ammonia in the early atmosphere. Visit the American Museum of Natural History Hall of Planet Earth exhibit on formation and evolution of the atmosphere.
4. Volcanic activity spewed out carbon monoxide (CO), carbon dioxide (CO_2) and molecular nitrogen (N_2) into the atmosphere along with intense heat. Large amounts of water vapor and sulfur gases were also released. There was no free oxygen.	4. explain how volcanic action added vital gases into the primitive atmosphere.	4. Distribute reading passages on the effects of increasing levels of carbon monoxide (CO) and carbon dioxide (CO_2) into the atmosphere.
5. Cosmic rays, X-rays and ultraviolet (UV) radiation freely passed through this atmosphere, energizing the molecular components of this region.	5. explain how high energy radiation was a direct influence on the molecular composition in the primitive atmosphere.	5. Discuss the effects of high-level radiation on molecular motion, interaction and energy states.

PLANET EARTH - THE EARTH ALIVE

UNIFYING THEME: **In the Beginning**
TOPIC A: **Formation of the Earth**

CONCEPTS	PERFORMANCE OBJECTIVES	TEACHING STRATEGIES
	Students will be able to:	
1. It is estimated that the Earth was formed 4.6 billion years ago.	1. identify the approximate age of the Earth. Explain how scientists estimate the age of the earth.	1. Sketch a time line of Earth, citing major conceptual events in its history. Visit the Hall of Planet Earth at the American Museum of Natural History beginning 6/99. Exhibits on formation of the Earth, its early evolution, and how scientists determining the age of the Earth.
2. The most widely-believed theory (condensation theory) is that clouds of gases were pulled together under gravitational forces and were condensed into our home planet. (Protoplanet Hypothesis)	2. describe the accepted model of the formation of the Earth.	2. Display a laserdisc/video depicting the condensing cloud model of solar system formation. Visit the Hall of the Universe at the American Museum of Natural History and the Big Bang Theater.
3. The majority of the "parent" cloud most probably consisted mainly of the gases hydrogen and helium and small amounts of other elements.	3. identify the primary components of early Earth matter.	3. Show the Periodic Table of Elements and discuss the atomic arrangement of hydrogen and helium. Visit website http//periodictable. com for discussions and history of the Periodic Table.
4. An element is a pure substance consisting of only one kind of atom. A compound is a substance consisting of two or more atoms of different kinds. Elements are represented by symbols using a capital letter or a capital letter followed by a lower case letter, e.g., N=nitrogen Ni=nickel	4. define "element" and "compound" then compare and contrast element and compound.	4. Display some common elements. Have the students observe and describe the physical properties of each element shown.

Students:

- revise a model to create a more complete or improved representation of the system.
- compare predictions to actual observations using test models.

Magnitude and Scale

3. The grouping of magnitudes of size, time, frequency, and pressures or other units of measurement into a series of relative order provides a useful way to deal with the immense range and the changes in scale that affect the behavior and design of systems.

Students:

- describe the effects of changes in scale on the functioning of physical, biological, or designed systems.

Equilibrium and Stability

4. Equilibrium is a state of stability due either to a lack of changes (static equilibrium) or a balance between opposing forces (dynamic equilibrium).

Students:

- describe specific instances of how disturbances might affect a system's equilibrium, from small disturbances that do not upset the equilibrium to larger disturbances (threshold level) that cause the system to become unstable.
- cite specific examples of how dynamic equilibrium is achieved by equality of change in opposing directions.

Patterns of Change

5. Identifying patterns of change necessary for making predictions about future behavior and conditions.

Students:

- search for multiple trends when analyzing data for patterns, and identify data that do not fit the trends.

Standard 7: Interdisciplinary Problem Solving

Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

Standard 4: Science

Students will understand and apply scientific concepts, principles, and theories pertaining to the Physical Setting and Living Environment and recognize the historical development of ideas in science.

Physical Setting

1. The earth and celestial phenomena can be described by principles of relative motion and perspective.

Students:

- describe current theories about the origin of the universe and the solar system.

2. Many of the phenomena we observe on Earth involve interactions among components of air, water, and land.

Students:

- use the concepts of density and heat energy to explain observations of the movements of the Earth's plates.

3. Matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity.

Students:

- explain the properties of materials in terms of the arrangements and properties of the atoms that compose them.
- use atomic and molecular models to explain common chemical reactions.
- apply the principle of conservation of mass to chemical reactions.
- use kinetic molecular theory to explain rates of reactions and the relationships among temperature, pressure and the volume of a substance.

4. Energy exists in many forms, and when these forms change, energy is conserved.

Students:

- observe and describe transmission of various forms of energy.
- explain heat in terms of kinetic molecular theory.

5. Energy and matter interact through forces that result in changes in motion.

PLANET EARTH CURRICULUM OUTLINE

UNIT I: THE EARTH ALIVE

THEME I: "IN THE BEGINNING"

TOPIC A: Formation of the Earth

TOPIC B: Formation of the Atmosphere

TOPIC C: Formation of the Oceans

TOPIC D: The Heat Within

TOPIC E: The Release of Heat Energy

TOPIC F: The Ocean Region

TOPIC G: Chemistry of the Ocean Vents

TOPIC H: Chemosynthesis

TOPIC I: The Access to Sunlight

TOPIC J: Aerobic and Photosynthetic Organisms

PLANET EARTH VARIANCE CURRICULUM

TABLE OF CONTENTS

FOREWORD

The *Planet Earth* syllabus has been developed as a strong Regents-level foundation course, aligned to the New York State commencement level Physical Setting Standards. This course will provide students with the skills, including critical and analytical thinking; problem-solving and reasoning; and knowledge of scientific methodology, to be successful in more specialized Regents science courses, such as biology, chemistry, physics and earth science, as well as, Advanced Placement courses. New York City's diverse student population will benefit from this inquiry-based, technology-driven curriculum that focuses on topics which are based on a study of the forces that affect our planet and are also highly relevant to the lives and interests of the students.

Planet Earth is relevant to the lives of the students because it is customized for the local area. For example, some of the topics in *Planet Earth* will teach the science concepts as they relate to New York City and its Boroughs. For instance, storms indigenous to this region (nor'easters and hurricanes) will be the focus of the meteorology unit. Similarly, stress will be placed upon the geology of New York City's watershed as well as how ocean currents and tides affect our beaches, and on the widespread results of El Nino and global warming.

The program was developed by the New York City Board of Education in partnership with the American Museum of Natural History, with the support of the New York State Education Department, representatives from the City University of New York, and the New York City Urban Systemic Initiative.

The course is divided into major units and each unit is subdivided into themes. Each unit was written by a team made up of assistant principals and teachers of science in collaboration with working scientists from the American Museum of Natural History and NASA, and university professors.

The program begins with Unit I - The Earth Alive, a unit that deals with the beginning of the planet, the fossil record of the progression of life; and the forces which shape the planet's surface, such as earthquakes and plate tectonics.

Unit II - Climate Through the Ages, Unit III - New York City - A City Surrounded by Water, Unit IV - The Air We Breath, and Unit V - The Inevitable Storm, all identify conditions on earth that make it a habitable planet. They also examine natural disasters, such as hurricanes, and negative human impacts such as global warming, water, and air pollution which threaten our very existence.

The last unit, Unit VI - Beyond Earth, The Search for Life, examines earth's place in the universe, the technology we use and ha used to learn about our position, and finally the search f 'ife beyond Earth.