Chapter 2 – Scientific Method

Day	Activity	Homework
1	Notes I,II	Cost/Benefit Case*
	Article Analysis	
2	Notes III, IV	Metric System WS/
	Oil Spill Experiment*	Graphing*
3	Notes V	
	Satellite Imaging Activity*	
4	Newspaper Survey*	
	Test/Assessment	

* found in "Supplemental Activities"

Alternate Activities

1. Students gather various examples of science in the media and use them to make a product (scrapbook, analysis of current trends in the news, etc.)
2. In groups, students use the information from the overview unit to make a newscast, or write a news article. Or have the entire class create a newspaper about current issues and the scientific method.
3. Students use the internet to access current satellite images and design a questions they can use the images to answer.
4. Students develop their own reliability index for the news, a journal, or other media, and then apply during the newspaper survey.

SCOS Goals

1.02 – Design and conduct scientific investigations to answer questions related to earth and environmental science.
1.03 – Evaluate the uses of satellite images and imaging techniques in the earth and environmental sciences.
1.04 – Apply safety procedures in the laboratory and in field studies.

Chapter 2 – Scientific Method

How do you decide whether to trust the information presented by the media about Earth and the environment?

I. The Nature of Scientific Knowledge

A. Tentative

1. Scientific ideas are based on data

a. As technology improves, data may become more accurate (Example: the use of computer sensors)

b. Data is interpreted using information we currently know, and the interpretation may change if new information becomes available

2. Scientific conclusions often change to include new information, to correct errors, or to refine a theory

B. Theories versus Laws

1. Theory

a. "Explain" phenomena we observe

b. Are never proved – theories represent the most logical explanation based on currently available evidence

c. Become stronger as more supporting evidence is gathered (or existing data is interpreted in different ways)

d. Provide a basis for prediction and further research

2. Law

a. Universal generalizations (i.e. they hold true everywhere)

b. Examples – gravity, relationship of forces and motion

C. The "Rules" of Science

1. Science is objective (unbiased and based on evidence)
2. Scientific measurements are exact and usually quantitative (measured using numbers).
3. Scientific explanations must adhere to the rules of evidence, make predictions, be logical, and be consistent with observations and conclusions.

D. The Limitations of Science

1. Scientific information is only as accurate as the technology and information available at the time.
2. Science is performed by people, and therefore can be affected by bias, mistakes, and limitations of the scientists.
3. Ideas and questions that cannot be answered using data as evidence are outside the boundaries of science. Examples:
    a. Religious values
    b. Ethical solutions

Review Questions

1. Why is science described as "tentative"?

2. What is the main difference between a theory and a law?

3. What are reasons we can trust scientific conclusions? Conversely, what are reasons we need to carefully examine conclusions produced by science?

II. Science in Society

A. The progress of science is often directed by the needs and challenges of society.

1. Ex. - Scientists searched for ways to clean up oil spills after the first major oil spill occurred.
2. Ex. – The government funds many scientific research labs, and thus decides current areas of interest.

B. Bioethics

1. Ethics is a study of the standards of what is right and wrong.
2. Bioethics examines the ethical consequences of scientific discoveries, technologies, and methods.
3. An example of a process used to study a bioethical issue:
   a. Clearly define the problem and gather all relevant facts.
   b. Identify the values that apply to the ethical issue. (Ex. Moral values, political values, economic values)
   c. Develop a cost/benefit analysis of the situation for each possible solution.
   d. Analyze the impact of possible decisions in terms of values and the cost/benefit in order to form conclusions.

C. Science impacts the views of society

1. Ex: The development of the internet has changed the way we communicate and gather information.
2. Ex: New understandings about medicine and health have changed the way we preserve food, treat water, and treat illnesses.

Review Questions

1. Which do you think is greater, the impact of science on society or the influence of society on science? Defend your answer.

2. What is a cost/benefit analysis?

III. Scientific Process

A. Identify a Problem (or unanswered question)

B. Research relevant topics (Background information)

C. Hypothesize possible answers

1. A hypothesis is an educated possible explanation that must be testable. Often a hypothesis is stated as "If … , then …"
2. A hypothesis should include objective (fact-based), not subjective (feeling-based) words. (Ex. "20 meters" versus "long distance")
3. Example: If detergent is released into the water source, then the grass population will decline.

D. Design an Experiment

1. Identify an independent and dependent variable.
    a. Independent variables are deliberately changed for each group by the scientist. (Ex. Detergent)
    b. Dependent variables are measured to determine the reaction of the subject to the independent variable. (Ex. Grass Population)

2. Plan ways to keep all other variables constant. (Ex. Amount of light, temperature)
3. Divide the subjects into control and experimental groups.
    a. The control group either lacks the independent variable, or is under "normal" conditions for the subjects. (Ex. No Detergent)
    b. The experimental groups experience different amounts or types of the independent variable. (Ex. Group A may have 2 gallons of detergent added to the water source, Group B may have 10 gallons)

E. Collect and record data.

F. Analyze the data and form a conclusion based on the data.

G. Share the results and allow peers to validate the conclusions.

IV. Lab Safety

A. Read the entire procedure and carefully follow teacher directions.

B. Notice safety signs and act accordingly (Ex. A picture of a flame means flammable. Don't place that substance near heat or flame.)

C. Never smell, taste, or mix chemicals unless instructed to do so.

D. Know how to use and be able to locate all safety equipment in the lab, including the fume hood, fire extinguisher, and eye washes.

E. Handle equipment carefully to avoid accidents such as spills.

F. If a safety error occurs, immediately (and calmly) notify your teacher.

Review Questions

1. What are the seven basic steps of the scientific method?

2. How does the scientific method help define science?

V. Earth/Environmental Science

A. Some Areas of Study

1. Astronomer – study of space
2. Oceanographer – ocean environments
3. Meteorologist – weather and the atmosphere
4. Climatologist – global weather patterns
5. Geologist – structure and history of Earth
6. Seismologist – movements of Earth's surface
7. Geophysicist – study Earth using gravity, magnetic, electric, and seismic methods
8. Ecologist – interactions of organisms and their environment
9. Paleontologist – prehistoric life and fossils

B. A Few Tools of Earth/Environmental Science

1. Microscopes – used to examine microscopic cultures (Ex. A water culture) and magnify the properties of items (such as rocks)
2. Telescope Types
   a. Optical – collects and focuses visible light from distant objects such as stars and galaxies using a series of lenses or mirrors.
   b. Radio – picks up and focuses radio waves given off by stars. Computers then produce an image of the object using the waves.
   c. Infrared, Ultraviolet, and X-ray – collects infrared, ultraviolet, or X- rays released by objects in space. These telescopes must be carried out of the atmosphere to be effective.
3. Satellite Images and Imaging Techniques
   a. Weather Satellites – track weather patters all over the world. By studying and charting weather patterns, scientists can

predict the weather (such as where a hurricane will strike) with greater accuracy.

b. Military Satellites – observe the Earth with higher resolution capabilities. These are usually encrypted (coded).

c. Earth Observation Satellites - observe the planet for changes in everything from temperature to forestation to ice-sheet coverage. The most famous are the LANDSAT series.

d. Other Scientific Satellites – observe the Earth and universe for various specific scientific missions (the Hubble Space Telescope is actually a scientific satellite).

4. Additional Artificial (man-made) Satellites

a. Communication Satellites – beam television programs, radio messages, and other kinds of information all over the world. The satellite receives a signal from a transmitting station on Earth and then beams the signal to a receiving station somewhere else.

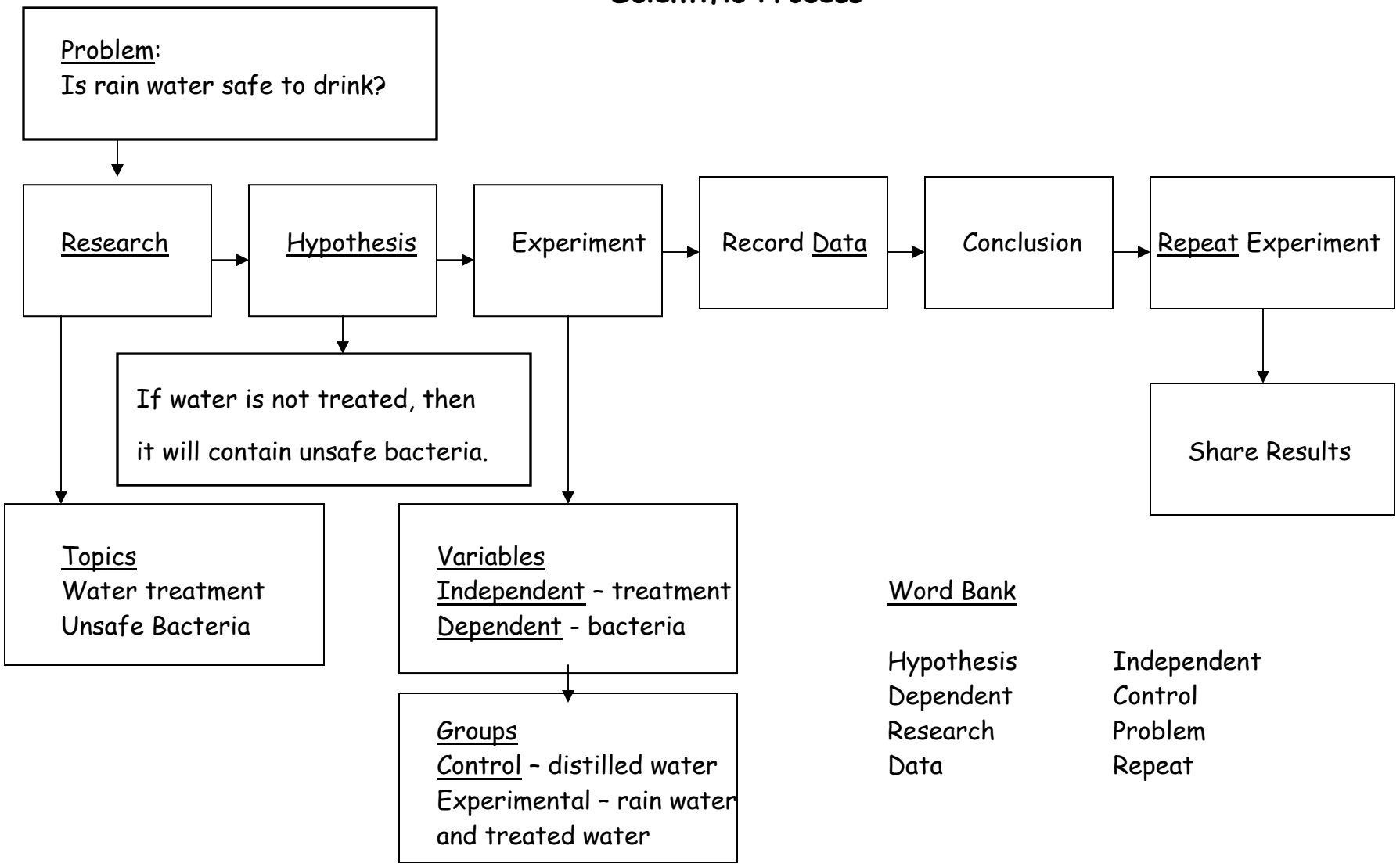
b. Navigation Satellites – send precise, continuous signals to ships, planes, and some cars and trucks. (Ex. GPS)

Review Questions

1. Which types of artificial satellites are commonly used to make images?

2. How can making images of the Earth and objects in space help earth and environmental scientists?

Scientific Process



Word Bank

Hypothesis	Independent
Dependent	Control
Research	Problem
Data	Repeat

Article Analysis

(based on an activity that appears in the EELE for New River State Park, NC, published by the NC Dept. of Environment and Natural Resources)

Purpose: To identify and analyze the facts regarding an environmental issue, and to identify and analyze values held by different key individuals or groups regarding that issue.

Procedure:

1. Read an article (or articles) about an environmental issue affecting your town or state.
2. Identify each individual or group identified in the article (this could be a person, a business, an association, etc.) In a chart (on data sheet), write down the name of each affected individual or group, their beliefs/position (using evidence from the article), and their likely values (using the values sheet at the end of this activity.)
3. List others who might have a stake in this issue who were not included in the article. If you were a newspaper reporter, what would you ask of each of these players?
4. List the <u>facts</u> given in the article.
5. What facts are not given in the article that would be helpful to have?
6. What types of scientific studies might be needed to fully evaluate this issue?

Data Sheet

Part 1: Chart

Individual/Group Name	Beliefs/Position	Values

Part 2:

Other Individuals/Groups	Questions

Part 3:

Facts

Fact Not Included

Scientific Studies

Analysis Questions:

1. Explain the difference between facts and values.

2. Why is it important to get all the pertinent facts about an environmental issue?

3. Why is it important to know the values of different players in an environmental issue?

4. How should facts and values be balanced when making decisions that affect the environment? Explain your position.

5. Did the writer of the newspaper article give a balanced treatment of the issue? Did the article contain any bias?

6. Write a letter to the editor about the article you read from the point of view of one of the individuals or groups mentioned in the article. Include your stand on the issue, and the reasons you feel this way.

Description of Environmental Values

Ethical – present and future responsibilities toward the environment and things in the environment

Moral – "should" and "should not"s regarding how humans treat fellow humans

Political – the activities, functions, and policies of governments and their agents

Economic – the use and exchange of money and materials

Religious – belief systems that are based on faith

Educational – understanding how natural systems operate

Aesthetic – appreciation of the environment through the senses

Recreational – use of the environment for leisure activities

Ecological – maintenance of the health of natural systems (includes ideas of balance, stability, integrity, and diversity)

Health – maintenance of positive human physiological conditions in relation to the environment