CHAPTER 1

Getting Started

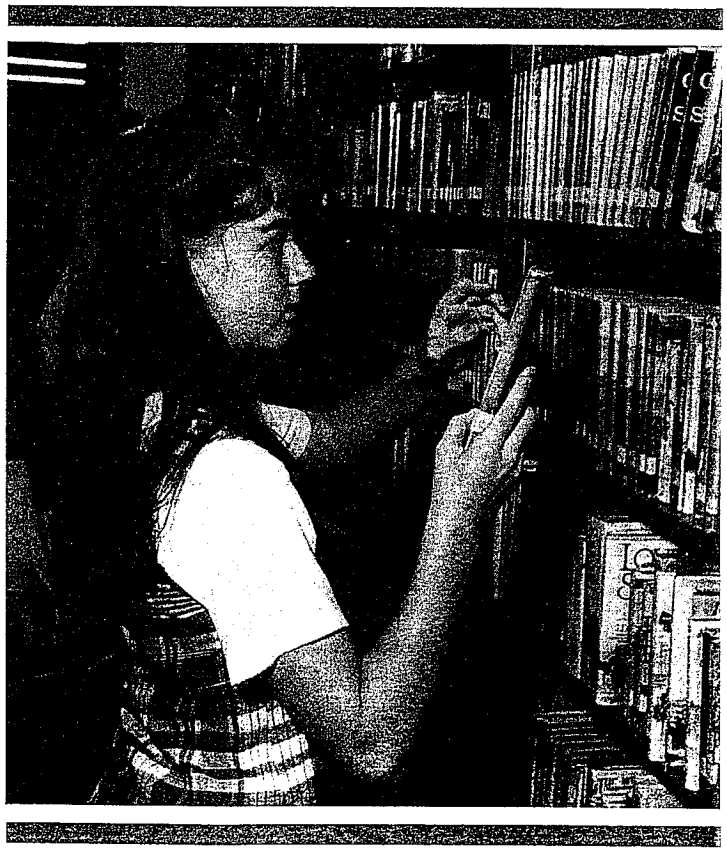
Topic Choice and Background

A science project is a largely independent activity in which you research a topic and then conduct a series of experiments to solve a scientific problem. Science projects give you the opportunity to go beyond what you learn in science class and explore other areas which interest you.

Science in Action divides the science project into **four distinct parts:**

- The Investigative Report
- The Scientific Investigation
- The Science Project Exhibit
- The Oral Presentation

This book is written to guide you in the preparation of a science project. Instructions are given for each part of the project, along with practical suggestions, examples, and ideas. You will **follow these steps** in completing the project:



Step **(Chapter 1)**

1 Choose Topic.

2 Write Background.
(Part 1 of Investigative Report)

(Chapter 2)

3 Choose Problem.

4 Write Investigation Plan.
(Part 2 of Investigative Report)

(Chapter 3)

5 Conduct Investigation.

6 Write Followup.
(Part 3 of Investigative Report)

(Chapter 4)

7 Prepare Science Project Exhibit.

(Chapter 5)

8 Give Oral Presentation.

Choosing a Science Project Topic

The first step in beginning a science project is to choose a topic, a field of science you would like to learn more about. Follow the guidelines listed below. Some of the fascinating fields of science you might explore are listed on pages 3–6.

Guidelines to Choosing a Topic

- Choose a topic in which you are interested.
- Choose a topic with which you are somewhat familiar.
  (Advanced students may wish to choose an unfamiliar topic which interests them.)
- Choose a topic that is specific.
- Choose a topic for which you can find adequate information.
  (Be sure to check your school or public library for available information before finalizing your topic.)
- Choose a topic that lends itself to experimentation.

Sources for Topic Ideas

1. Check general science books, books about student science projects, and encyclopedias. Look for specific fields you think you would like and read the entries about them.
2. Talk with students who have had successful projects.
3. Ask advice from teachers and librarians.
4. Seek suggestions from professional people such as engineers, professors, medical personnel, etc.

Starting the Science Project

1. Once you have selected a topic, complete the **Topic Selection Worksheet** on page 9 and submit it to your teacher for approval. Be ready to offer an alternate choice, if needed.
2. Purchase a 3-ring binder (approximately 1" size) to use as a **Science Project Notebook.** In this notebook, you will keep all of the written materials for your science project. Since the items in this notebook are irreplaceable, be sure it is clearly indentified with your name and keep it in a safe place. It will be part of your Science Project Exhibit.
3. Complete the **Science Project Work Schedule** on page 7 when your teacher gives the dates. Place the Work Schedule in the front of your Science Project Notebook and refer to it often to avoid missing a deadline.

Fields of Science

Science can be divided into two general areas—**biological science** (science of living things) and **physical science** (science of nonliving things). Within both of these general areas, there are many specific fields. Each specific field contains many subject areas. The following list will give you ideas of areas from which good science projects could be chosen.

Biology—study of living things

Fields of Biology that lend themselves to good investigation:

1. **Biochemistry**—study of chemical reactions in living things
   (food chemistry, vitamins, metabolism, enzyme activity, etc.)

2. **Botany**—study of plants; see also Cytology
   - Agriculture—science of farming
     (effects of fertilizer, soil type, soil pH, amount of water, amount of light, soil salinity, pruning, temperature, wind, carbon dioxide concentration, etc., on plant growth or seed germination; hydroponics; tropisms; composting techniques)
   - Forestry—science of growing trees
     (effects of factors listed under agriculture on germination of tree seeds or growth of very young trees; effects of pruning on tree growth patterns; tree ring studies)

3. **Cytology**—study of cells
   (effects of factors such as salinity [hypertonic or hypotonic solutions], temperature, nutrients, lighting, etc., on cell structure or replication; see also Microbiology)

4. **Genetics**—study of heredity
   (transmission of genetic characteristics; hybrids; mutations; Mendel's laws of genetics)

5. **Health and medicine**—study of the function and disorders of the human body (reflexes, digestion, reaction time, nutrition, etc.)

   Note: Experiments on humans require special handling. See Safety Concerns in chapter 2 (pp. 41–42) and discuss with your teacher how these safety concerns may affect your project.

   - Behavioral and social sciences
     (intelligence, learning, perception, mental testing, sleep)
   - Dentistry—study of the teeth, gums, and mouth
     (beneficial effects of fluoride on tooth enamel; prevention of tooth decay; resistance of tooth enamel to various acids and bases)
   - Dermatology—study of the skin
     (skin care products, etc.)
   - Immunology—study of the body's defense mechanisms
     (allergies)
   - Nutrition—study of food and nourishment
     (calorie content of foods; beneficial and harmful effects of caffeine; vitamins)
   - Ophthalmology—study of the eye
     (causes, effects, and treatment of nearsightedness [myopia] and farsightedness [presbyopia]; effects of lighting, aging, fatigue, color, diet, etc., on visual acuity; depth perception; persistence of vision; response to visual stimuli)
   - Physical fitness
     (effects of exercise on endurance, resting heart rate, strength, flexibility, agility, etc.; types of exercise [cardiovascular exercise, strength training, flexibility training, balance/agility training]; exercise value of various sports)

6. **Microbiology**—study of microscopic living things such as bacteria, fungi, molds, protozoa, etc.
   (effects of nutrients, salinity, temperature, moisture, lighting [color or intensity], disinfectants, etc., on growth of microorganisms)

7. **Zoology**—study of animals
   (learning response; intelligence)
   - Entomology—study of insects
     (effects of factors such as temperature, humidity, light, sound, toxins, abundance of food, etc., on behavior and/or growth of ants, crickets, roaches, or other insects; preferred foods of ants, bees, wasps, roaches, etc.; response of individual insects to various stimuli; visual acuity of insects; insect intelligence; etc.)
   - Ethology—study of instincts*
     (This field may overlap with fields such as entomology.)

- Herpetology—study of reptiles and amphibians*
- Ichthyology—study of fish*
- Mammalogy—study of mammals*
- Ornithology—study of birds*

*Note: Experiments with vertebrate animals require special approval and handling and are very limited in scope, making it more difficult to find good experiments in these fields. See Safety Concerns in chapter 2 also.

Physical Science—study of nonliving things

1. **Chemistry**—study of the composition, structure, and properties of matter

   Note: Do not be afraid to choose chemistry as your topic. Many chemistry projects can be completed outside a laboratory.

   - Analytical—study of composition of matter
     (chromatography, qualitative/quantitative analysis)
   - Inorganic—study of compounds not containing carbon
     (physical properties of common substances; pH of common substances; construction and testing of electric batteries using various materials; electrolysis/electroplating)
   - Organic—study of the composition of carbon compounds
     (production or analysis of soaps and detergents; polymer chemistry; petroleum chemistry)
   - Physical—study of the physical properties and behaviors of substances
     (diffusion; osmosis; laws of chemical change, conductivity, electrolytes, electrolysis, polymerization)
   - Thermochemistry—study of heat in relation to chemical reactions
     (heats of solution; exothermic and endothermic reactions; calorimetry; temperature and reaction rates; chemical equilibrium)

2. **Computers and Mathematics**
   - Computer Technology
     (comparison of speed of various computers in performing identical tasks; voice/image recognition; computer simulations of physical processes; robotics/artificial intelligence)

     Note: Computers may also be used in simulations or analysis of data in projects in other fields, such as Mechanics. (Computers can also be very useful in obtaining hard-to-find technical or scientific information for other project areas.)

   - Geometry—mathematical study of shapes
     (examples of geometric patterns in nature [planets = spheres; orbits = ellipses; trajectories = parabolas; fullerenes and intracellular vesicles = geodesic domes; tusks, spiral shells, and spiral galaxies = logarithmic spirals]; properties of shapes in non-Euclidean geometry)
   - Logic—study of reasoning and deduction
   - Mathematics
     (mathematical patterns in nature [such as Fibonacci numbers]; occurrence of in nature [such as in circles, spheres, electrostatic constant, magnetic constants, and certain probability distributions])
   - Probability/Statistics—This field will also be useful in analyzing data from experiments in other fields.

3. **Earth and Space**
   - Astronomy—study of the stars and other celestial bodies
     (long-term observations of planetary motion, moons of Jupiter, etc.; correlation of lunar phases and height of tides; analysis of space probe data)
   - Conservation—study of the wise use of natural resources
     (erosion prevention; methods of water desalination; water treatment; energy conservation; pollution control devices)

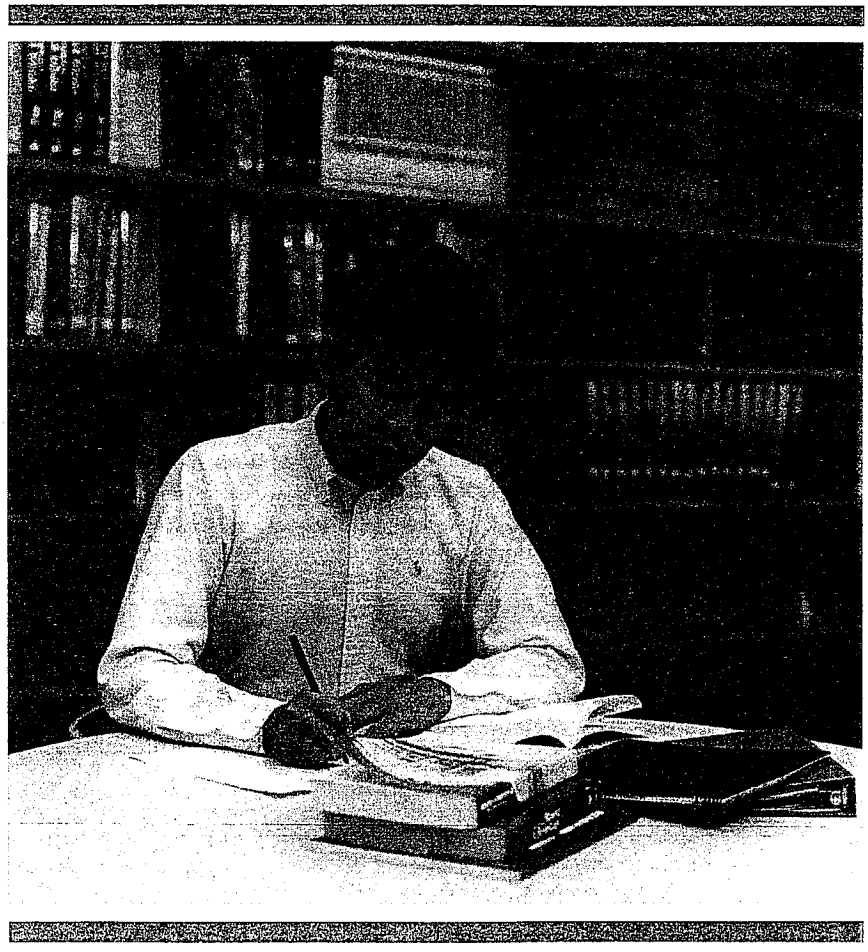
- Geology—study of the earth
  (location and identification of local fossils; seismology; methods of erosion)
- Meteorology—study of weather
  (maintain a weather station and observe how these measurements relate to changes in the weather; correlation of daily satellite weather photos [available from NASA / NOAA on Internet] with national and regional weather systems and local weather measurements; simulating weather phenomena by means of models [in water or air])
- Mineralogy—study of minerals
  (identification of local rocks and minerals; physical properties of various minerals; effects of temperature variations, water, acids and bases, etc., on mineral hardness; dripstone formation; comparison of igneous, sedimentary, and metamorphic rocks)
- Oceanography / Marine Biology—study of the seas and sea life
  (geology of the coast; beach erosion; sandbar formation; rip current simulation; ocean waves; identification and observation of local marine organisms; chemical analysis of seawater; oceanographic equipment; see also Conservation)
- Pedology—study of soil
  (composition and physical properties of different types of local soil; effects of various soil characteristics on plant growth [see Botany]; soil erosion [see Conservation]; identification and observation of soil-dwelling organisms [earthworms, mole crickets, ants, etc.; see also Entomology]; effects of earthworms on soil quality; effects of water, peat, fertilizer, ashes, lime, etc., on soil characteristics [pH, texture, etc.])

4. **Engineering**
   - Aeronautics / Aerodynamics
     (aerodynamic drag of various shapes; laminar and turbulent flow [see also Hydrodynamics]; effects of airfoil shape on aerodynamic lift; the Bernoulli principle; reducing the aerodynamic drag of an automobile or bicycle)
   - Architecture / Civil Engineering / Interior Design—study and design of buildings and other structures
     (strength of various types of trusses, arches, etc. [tested with models]; strength of various building materials [compression, shear, or tension]; buildings and earthquakes; designing buildings for energy efficiency; dam construction; cogeneration)
   - Communications—radio, telegraph, telephone, television
   - Hydrodynamics—study of liquids in motion
     (the Bernoulli principle; hydrodynamic drag of various shapes; hydrodynamic drag of various shapes of ships' hulls [tested with models]; hydrofoils; turbulence and Reynolds numbers)
   - Hydrostatics—study of liquids at rest
     (pressure and depth; pressure and fluid density; effects of various factors on buoyancy [density of fluid, depth, volume of buoyant material]; Archimedes' principle; Pascal's principle; hydraulics)

5. **Physics**—study of the interaction between matter and energy
   - Electricity
     (conductivity / resistance of common metals, nonmetals, and electrolytes; conductivity and temperature; resistance heat; electric lighting; types of electric circuits; electric generators [types of generators; factors affecting power production; "alternative" energy sources]; photovoltaic cells; superconductivity [see also Magnetism]; electromagnetic induction [see also Magnetism]; electric motors)
   - Electronics
     (electronic components; vacuum tubes and semiconductor devices; electronic circuits [audio oscillators, capacitor discharge circuits, radio receivers, etc.]; oscilloscope studies of oscillators; see also Computer Technology)
   - Magnetism
     (permanent magnets vs. temporary magnets; electromagnets)
   - Mechanics—study of motion and forces
     (first law of motion [mass and inertia]; second law of motion [force and acceleration]; third law of motion [action and reaction in static and / or dynamic systems; force pairs]; momentum [calculation of; conservation of in collisions]; kinetic energy [kinetic energy vs. momentum; kinetic energy transfer]; gravitation [acceleration of

gravity; Galileo's falling-body experiments; free fall]; trajectories of projectiles [may be anything from basketballs and baseballs to rifle bullets]; motion dynamics of a trebuchet [could construct softball-throwing model]; rotary motion [centripetal and centrifugal force; Coriolis effect; conservation of angular momentum; flywheels as a means of energy storage; gyroscopic effects])

- Optics—study of the behavior of light
  (reflection; refraction; diffraction; interference; iridescence; perception of color; lasers; holography; photography; reflector shape in directed lighting; telescopes)
- Thermodynamics—study of energy and heat transfer
  (methods of heat transfer; heat transfer in various solids; convection rate in various fluids; color and radiant heat absorption; heat engines; thermal efficiency of engines; harnessing waste heat; latent heat; refrigeration; conservation of mass-energy/first law of thermodynamics; entropy/second law of thermodynamics)
- Waves and Acoustics—study of waves and sound
  (behavior of water waves; speed of sound; behavior of sound waves; harmony and dissonance; oscilloscope studies)



Name _____

Science Project Work Schedule

Fill in the due dates as indicated by your teacher and then remove this schedule and place it in the front of your Science Project Notebook.

Date Due:

(Science Project and Notebook introduced in class)

_____ Choose Topic

Topic Selection Worksheet Due

(Background paper and Working Bibliography introduced in class)

_____ Working Bibliography Cards Due

(Outline and Note Cards introduced in class)

_____ Outline Due

_____ Note Cards Due

(First Draft of Background introduced in class)

_____ First Draft of Background due (attach Background First Draft Check)

_____ Revised Draft of Background Due

(Final Draft of Background introduced in class)

_____ Final Draft of Background Due (attach Background Grade Form)

(Investigation introduced in class)

_____ Choose Your Problem or Question

Problem Selection Worksheet Due

(Investigation Plan introduced in class)

_____ First Draft of Investigation Plan Due (attach Investigation Plan Evaluation)

_____ Revised Investigation Plan Due

_____ Final Investigation Plan Due (attach Investigation Plan Grade Form)

(Journal introduced in class)

_____ Begin Investigation

Getting Started Worksheet Due

_____ First Journal Check (attach Journal Check Report)

_____ Second Journal Check (attach Journal Check Report)

_____ Sign up for Oral Presentation

_____ Third Journal Check (attach Journal Check Report)

(Science Project Exhibit and Followup explained in class)

_____ Begin constructing Science Project Exhibit

_____ Fourth Journal Check (attach Journal Check Report)

_____ Fifth Journal Check (attach Journal Check Report)

_____ Investigation complete/Journal complete (attach Journal Grade Form)/First Draft of Followup Due

_____ Final Draft of Followup Due (attach Followup Grade Form)

(Oral Presentation explained in class)

_____ Give Oral Presentation (turn in Project Notebook; Oral Presentation Grade Form; and Exhibit Grade Form)

_____ Science Fair

Name _____

Topic Selection Worksheet

Complete the following:

The project that I have chosen is in the following general area of science:

_____ biological science _____ physical science

Within my chosen general area, the specific field I am interested in is

_____

The specific subject area of this field that I have chosen for my science project topic is

_____

After your topic has been approved, place this worksheet in your Science Project Notebook.

Teacher Response:

_____ Subject is approved.

_____ Please submit a new topic.

Writing the Background

The written portion of your Science Project is called the Investigative Report. The **Investigative Report** consists of three parts:

1. **Background** (an informative report about your subject)
2. **Investigation Plan** (details of the investigation you plan to do)
3. **Followup** (results of your investigation)

About the Investigation Background

Now that you have chosen a topic for your science project, the next step in your project work is to research your subject and write *a brief summary or overview of general information concerning your topic*. Preparing this Background paper will help you in several ways:

1. You will learn enough about your topic to better plan and conduct your scientific investigation.
2. You will gain practice in expressing yourself clearly and concisely in writing.
3. You will become more skillful at gathering information from the library and from other sources.

Writing the Investigation Background

To write a clear, informative Background report, follow the steps of the writing process: plan, write, rewrite, and edit.[1]

Step 1: PLAN

The writing process begins with *planning*. In this step, you (A) compile a working bibliography, (B) write a tentative outline, and (C) take notes from your bibliography sources. As you plan your Background paper, watch for ideas for a potential investigation you could do.

A. Compile a Working Bibliography.

A working bibliography is a collection of books, magazines, and other source materials that contain information about your topic. Note that a particular source does not have to be entirely devoted to your specific topic to qualify as a good bibliography source. Refer to your Topic Selection Worksheet and find books on your broader topic. Check those books for chapters or sections on your specific topic. Encyclopedias and textbooks are good sources for general information and common knowledge on a topic. More specific data can be obtained from the *CRC Handbook* and similar reference works as well as various science journals.

Where do I find materials for my report?

Your *library* will have several helpful resources to assist you in finding bibliography sources.

1. ***Reader's Guide to Periodical Literature.*** One fast way to locate magazine articles dealing with your topic is to use the *Reader's Guide to Periodical Literature*. This monthly publication catalogs by subject articles from a

[1]Writing process from *Handbook of Grammar and Composition* by James A. Chapman.

variety of periodicals. Your library may also have a periodical database that you could search.

2. **Catalog.** An index to the entire library is contained in an online catalog or a card catalog. The online catalog stores the index on computer; the card catalog stores it in drawers. Both catalogs provide information by author, title, and subject. By looking up your topic, you can determine what books are available in a library. After you have determined the general location of library books about your topic, it is often helpful to go to that area and search the shelves for other potential sources. Refer to the Table of Contents and/or index in the books to see if they will be helpful sources.
3. **Internet or online services.** Another source of information may be the *Internet* or *online services* available on a computer service. If you use online or Internet services, be sure to record (on your bibliography cards) the information needed to locate those services.

Should I use the first sources I find, or should I keep looking?

Search the library for the best sources, the ones that have the most information about your topic. The information should be written in a style you can easily understand. Also look for sources that will help you think of a problem or question that you can solve for your scientific investigation.

You can skim through the material to see which sources are best. Ask yourself,

- "Does this material directly relate to my topic?"
- "Do I understand what the author is saying?"

How many bibliography cards do I need?

Consult the chart below to determine the number of sources needed for your grade level. These requirements apply only to the Background report.

Suggested Bibliography Requirements

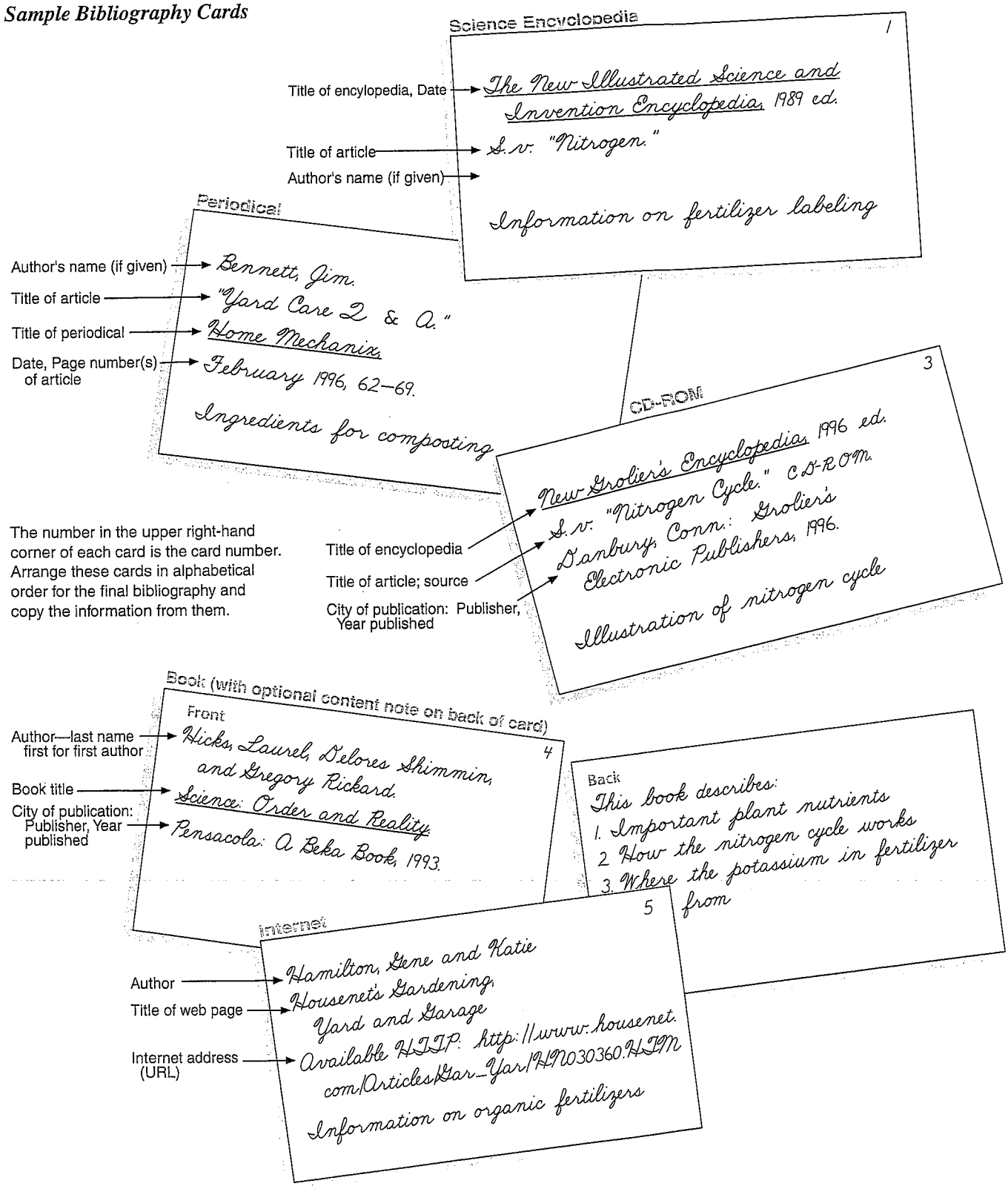
Grade	**7**	**8**	**9**	**10**	**11**	**12**
Number of Sources	5	5	6	6	6	6

How do I prepare a working bibliography?

1. Write the bibliography information on **3 x 5-inch index cards.**
2. Study the *Sample Bibliography Cards* on page 13 to determine what information you need to record. Note especially the punctuation. (If you complete your cards properly, you will be able to complete your bibliography page easily.)
3. Number your bibliography cards consecutively as you make them. Numbering your cards will save you time later when you make note cards. Using the number of a card is much faster than writing out the title of the source.
4. If you wish to remember what the source is about, write at the bottom of the card a brief description of the material in that source. If you need more room, write on the back of the card.

5. As you prepare bibliography cards, notice the points about your topic that you would like to write about in your paper. These points can be part of your tentative outline.

Sample Bibliography Cards



B. Write a tentative outline.

The next step in the planning stage of the writing process is to prepare a tentative outline.

What is a tentative outline?

1. It is an outline that *may be changed* if necessary.
2. It is a tool designed to aid you as you gather information and begin writing your paper. (It will help you avoid spending time on material which really does not apply to your paper.)
3. It is the outline (with any needed changes) that will eventually become the final outline for your Background paper.

How do I construct a tentative outline?

1. Decide what areas of your topic you will include in your Background report. Determine your main points—the two or three important ideas that you will discuss.
2. Under each main point, organize your ideas in a logical arrangement.

What does an outline do?

1. It helps determine what you write.
2. It helps determine in what order you relate information.
3. It helps organize your thoughts and direct your work.

What are the outline requirements?

1. Study the sample outline below. Note the arrangement of the ideas under each main point.
2. Each main point that has subpoints should have at least 2 subpoints. (If you have an A, you must have a B. If you have a 1, you must have a 2.)
3. Follow the spacing and indentation of the sample.
4. Points within a section should be grammatically parallel.

Sample Tentative Outline

The Role of Fertilizers in Plant Growth

I. Types of fertilizers
   A. Organic
   B. Mineral
      1. Nitrogen
      2. Phosphorus
      3. Potassium

II. Forms of fertilizers
   A. Liquid
   B. Solid

III. Production of fertilizers
   A. Countries
   B. Materials

IV. Use of fertilizers
   A. Correct amount
   B. Correct timing

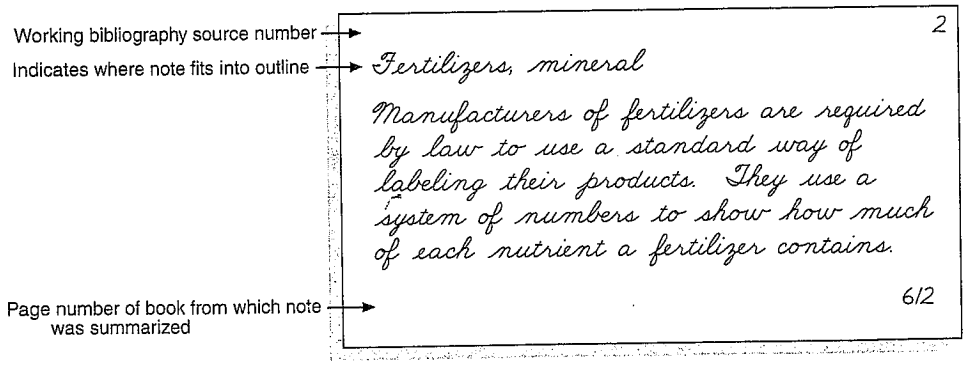
C. Take Notes.

After your outline is complete, the next step in the planning process is to carefully read your sources and to write down important information that you would like to include in your Background report.

How should I take notes?

1. Refer to Note Card Requirements below to see how many note cards you need. These requirements apply only to the Background.
2. Write the information on **4 x 6-inch index cards.**
3. Note these characteristics of a good note card:
   a. It includes the number of the bibliography source.
   b. It has a word or phrase (from the outline) at the top to indicate the subject of the information on the card.
   c. It contains only ***one idea*** or item of information. (It is acceptable to leave some blank space on the card.)
   d. It must be written ***in your own words,*** as a summary or paraphrase.
   e. It includes the page number of the source.
4. Try to find notes for each part of your outline so that you will have adequate information when you begin to write your report. You may need to adjust your tentative outline to match the information you find available.
5. As you do note cards, watch for a good idea for your scientific investigation. Think about what you are learning, and begin making a list of questions about the things you are reading. Try to think of an investigation to answer one of these questions.

Sample Note Card—Summary



How many note cards do I need?

Consult the chart below to determine the number of note cards needed for your grade level. These requirements apply only to the Background report.

Suggested Note Card Requirements

Grade	7	8	9	10	11	12
Note Cards	25	25	30	30	30	30

Will I need to document (footnote) my sources?

Most of the information in your Background report should be established

facts and common knowledge; therefore, it should not require any specific documentation in the body of the paper. Instead, the sources you consult will be listed at the end of the paper in a general bibliography. If your Background should happen to contain quotations or opinions from a particular author, however, you will need to credit the source with a footnote. See the Documentation section in Appendix C for instructions.

How can I avoid plagiarism?

Understand the meaning of *plagiarism.* Plagiarism is defined in the *American Heritage College Dictionary* as "**copying** or **imitating** the language, ideas, and thoughts of another author and passing off the same as one's original work." If you are careful to avoid plagiarism on your note cards, you will not have a problem with it in your paper.

To avoid plagiarism, reword any published information (even common knowledge, facts, etc.) in *your own words,* with *your own sentence structure.* It is not enough to just change a few words. The material must be completely reworded. The *organization* of the material must also be your own. If you use the author's exact words, they must be enclosed in quotation marks. Quotations, opinions, and little-known facts should always be documented. Well-known facts and common knowledge, however, should not require a footnote if the words and the organization are your own.

Step 2: WRITE the First Draft

After you have planned your Background paper, you are ready to write the first draft. You will use your note cards and your outline.

What is the first draft?

1. It is the first writing of the Background paper.
2. It is your working copy; that is, it is the copy you will rewrite and edit before preparing your final copy.

How do I write the first draft?

1. Arrange your note cards in order according to the tentative outline.
2. Try to write your first draft quickly, preferably in one sitting.
3. Write on every other line and on only one side of the paper to leave yourself room for editing.
4. Begin with an introductory paragraph. Open with an interesting statement to capture the reader's attention; then describe what the reader will learn from the paper.
5. Referring to your outline and note cards, write about your topic.
6. Start a new paragraph for each new point in the outline or each new subject that you discuss.
7. Use clear explanations so that those unfamiliar with the subject of your investigation will understand your report.
8. Define any unfamiliar terms that you use.
9. Do not use contractions such as *don't* or *can't.*
10. Close with a concluding paragraph summarizing the main point of the paper.

How many words should my Background contain?

1. Consult the chart below to see how many words your Background should contain. These requirements apply only to the Background part of your Investigative Report.
2. Count the words in your first draft to make sure you have the required number. Write the total on the paper after each 25 words.

Suggested Word Requirements

Grade	**7**	**8**	**9**	**10**	**11**	**12**
Number of Words	250	300	350	350	350	350

How should I submit my first draft?

Complete the **Background First Draft** Check (page 19) and give it to your teacher with your first draft. Your teacher will check your first draft in class.

Step 3: REWRITE the First Draft

After your teacher returns the first draft and Background First Draft Check sheet, you are ready to rewrite your first draft. The purpose of this rewriting is to be sure you have included everything you need in your paper and that it is in the proper order.

How should I rewrite my first draft?

1. Ask yourself the following questions:
   a. Does the paper follow the outline?
   b. Does it have *unity?* (Do all parts contribute to the single idea of the whole?)
   c. Does it have *coherence?* (Are the ideas organized so that the thought flows smoothly from beginning to end?)
   d. Does it give an overall background structure to my topic? In other words, is it clear and complete?
2. Have someone read your paper and give you his overall impression.
3. Determine what needs to be removed, added, or rearranged.
4. Now rewrite the paper until you are confident that you have included the right amount of information and have arranged it in the best order. Once again, write on every other line and on only one side of the paper.
5. Number your words again for your rewritten first draft.
6. Check your revised paper with the check sheet you received back from the teacher. Were all the suggested changes made?
7. Your teacher will check your revised first draft in class.

Step 4: EDIT for the Final Draft

After you have rewritten your first draft, you are ready to edit for the final draft. In this step, you will examine each paragraph, sentence, and word. This is your opportunity to polish your paper and give attention to the details.

How do I edit my rewritten first draft?

1. Check each *paragraph* for unity, coherence, and emphasis.
2. Check each *sentence* for correctness, clarity, and effectiveness.
3. Check your grammar (for example, subject-verb agreement), punctuation, and spelling.
4. Have an adult read your paper for a final check.

How do I prepare my final draft?

1. Type your final draft carefully from the revised draft. If you are hand writing the paper, write in blue or black ink.
2. Follow the **Background Final Check** (page 21) instructions for form. See also the **Sample** paper included at the end of this chapter.
3. Proofread the final copy and make any needed corrections.
4. Write the total number of words at the end of the report.
5. Prepare a title page and a Sources Consulted (bibliography) page for your Background paper. Do not forget to include your outline. Follow the instructions on the Background Final Check sheet.
6. Turn in the completed paper and the **Background Grade Form.**
7. After your Investigation Background paper is returned, keep it in your Project Notebook, together with the first draft, the First Draft Check, and the Grade Form.

Name _____

Background First Draft Check

Complete the following:

Date of Check _____

Number of Words Required _____

Number of Words Present _____

Answer each question by circling Y (yes) or N (no).

Y N 1. Is your first paragraph an interesting introduction?

Y N 2. Have you written only about the points listed in your outline, and have you used the sequence indicated by your outline?

Y N 3. Have you begun a new paragraph for each new point?

Y N 4. Is the topic clear in each paragraph?

Y N 5. Have you used your own words?

Y N 6. Does your paper have a concluding paragraph that summarizes the main points?

Y N 7. Are unfamiliar terms defined?

Y N 8. Have you avoided the use of contractions?

Submit this checksheet with the first draft of your Investigation Background. After your teacher returns the checksheet, keep it with your first draft in your Project Notebook.

Name _____

Background Final Check

Check (✓) each item as it is completed.

General Information

_____ 1. Use only one side of the paper.

_____ 2. Since your paper will be bound later, allow a $1\frac{1}{2}$-inch margin on the left-hand side of each page. Allow a 1-inch margin on the right-hand side of each page.

_____ 3. Your paper should be neat and clean.

_____ 4. If you are typing your paper, use a standard typeface such as 12-point Courier type (10 characters per inch). Do not use script or any other ornamental typeface.

_____ 5. Have someone proofread your completed Background paper before you hand it in.

Title Page

_____ 1. Center the main title INVESTIGATION BACKGROUND in the middle of the page (between the margins). If you have a subtitle, double-space and type it beneath your main title. See sample title page.

_____ 2. If your title is longer than 48 spaces, use two or more double-spaced lines (single-spaced if hand writing).

_____ 3. Type the following information 2 inches from the bottom right-hand corner of the page: name; date; class, grade, and section; teacher's name. (Begin on the sixth line from the bottom if hand writing.)

_____ 4. Although the title page is counted as page i (small Roman numeral I), do not place a page number on it.

Outline Page

_____ 1. Center the paper's main title (use the subtitle if you have one) 2 inches from the top. Do not use the word *Outline* as the title. (Begin on the top line if hand writing.)

_____ 2. If the title is longer than 48 spaces, type it in two or more double-spaced lines (single-spaced if hand writing).

_____ 3. Triple-space between the title and the first point of the outline. (If hand writing, begin writing the first point on the fourth line.)

_____ 4. Do not include an introduction or a conclusion in your outline.

_____ 5. Indent the first Roman numeral four spaces from the left-hand margin ($\frac{1}{2}$ inch if hand writing). Align succeeding Roman numerals by periods.

_____ 6. To start the first word of each point, strike the space bar once after the period before typing the first letter of the first word.

_____ 7. Follow this system of outlining and indenting:
I.
A.
1.
a.

_____ 8. Single-space the lines within each major division. Double-space before beginning a new major division (I, II, etc.). See sample outline.

_____ 9. Center the page number 1 inch from the bottom (bottom line if hand writing). Since the title page is page i, the outline should be page ii (small Roman numeral II).

Body of the Background Paper

(This is the corrected final copy.)

_____ 1. Center the title (use the subtitle if you have one) 2 inches from the top of the first page. (Write on the top line if hand writing.) Do not underline or put quotation marks around it.

_____ 2. If the title is longer than 48 spaces, use two or more double-spaced lines (single-spaced if hand writing).

_____ 3. Triple-space between the title and the first line of the text. (If hand writing, begin the first paragraph on the fourth line.)

_____ 4. If typing, double-space the text. If hand writing, write on every line except the last line on a page.

_____ 5. Indent the first line of each paragraph five spaces, or $\frac{1}{2}$ inch. (If hand writing, indent 1 inch.)

_____ 6. On the first page of the body, center the number 1 at the foot of the page, 1 inch above the bottom of the page. (Center the page number on the bottom line if hand writing.) Do not use a period or parentheses or hyphens with the number.

_____ 7. Double-space between the last line of text and the page number.

_____ 8. On page 2 and all succeeding pages, center the page number 1 inch from the top of the page (on the top line if hand writing). Double-space between the page number and the first line of text. (If hand writing, begin material on the third line from the top.)

_____ 9. *Do not* number every twenty-fifth word of the final copy as you did in the first draft. At the end of the paper, write the total number of words in parentheses.

Bibliography Page

_____ 1. Arrange your bibliography cards in alphabetical order according to the first word that appears on the card. This will either be the author's last name or the first word of the title (excluding *a, an,* or *the*). If you have done your bibliography cards correctly, you can simply copy the information directly from them.

_____ 2. Use the heading Sources Consulted. Center the heading 2 inches from the top of the page (top line if hand writing).

_____ 3. Triple-space between the heading and the first entry. (If hand writing, write the first entry on line three.)

_____ 4. Single-space each entry, but double-space between entries. (If hand writing, skip one line between each entry.)

_____ 5. Begin the first line of each entry flush with the left-hand margin; indent runover lines five spaces, or $\frac{1}{2}$ inch. (Indent 1 inch if hand writing.)

_____ 6. Center the page number 1 inch from the bottom of the first page of the bibliography (bottom line if hand writing). The numbering is continuous with the body. For example, if the body ends on page 3, the bibliography would begin on page 4.

_____ 7. On succeeding bibliography pages, the page number should be centered 1 inch from the top of the page (top line if hand writing).

Grading Page

_____ Tear out the Background Grade Form and submit it with your Background final draft.

Sample Title Page

Sample Background

INVESTIGATION BACKGROUND

The Role of Fertilizers in Plant Growth

John Smith
October 21, 1998
Science 7A
Miss True

Sample Outline

The Role of Fertilizers in Plant Growth

I. Types of fertilizers
   A. Organic
   B. Mineral
      1. Nitrogen
      2. Phosphorus
      3. Potassium

II. Forms of fertilizers
   A. Liquid
   B. Solid

III. Production of fertilizers
   A. Countries
   B Materials

IV. Use of fertilizers
   A. Correct amount
   B. Correct timing

The Role of Fertilizers in Plant Growth

A garden left to itself may prosper if conditions are ideal, but even under the best circumstances, production could probably be improved by fertilizers. Although man has known for centuries that certain substances improve plant development, he did not know why until recently. Today, much is known about fertilizer types, forms, production, and use.

The two main types of fertilizers are organic and mineral (commercial). Organic fertilizers include nothing synthetic and contain materials such as plant matter and animal wastes. Mineral fertilizers are the most common. The three main kinds—nitrogen, phosphorus, and potassium fertilizers—enrich the soil with nutrients needed for healthy plants. Most fertilizers are a combination of nitrogen, phosphorus, and potassium.

Fertilizer has many forms. Organic fertilizers may be in the form of manure, compost, or special soil-enriching crops. Commercial products are also diverse. Liquid fertilizer is water that contains dissolved nutrients. Solid fertilizers vary from simple compounds to pellets containing

assorted chemicals. Soil quickly absorbs most fertilizers, but some fertilizers release their nutrients slowly.

Much fertilizer is produced in the United States, Canada, France, China, and India, although other countries often supply them with materials. Some of the components used for fertilizer production are ammonia, phosphate rock, and potassium chloride. Because natural gas is used in producing ammonia, many oil companies are involved. Ammonia is used both as a straight fertilizer and as an ingredient in mixed fertilizers.

To be effective, fertilizers must be used correctly. Too little fertilizer may yield sickly plants, and too much may "burn" the plants. Because organic fertilizers have a lower nutrient concentration than commercial products have, the amount used must be adjusted accordingly. Fertilizers should be added in the right season, which depends on the climate and the fertilizer.

The importance of fertilizers cannot be overemphasized. Without fertilizers, crop production is limited. Fertilizers increase productivity, allowing farmers to grow bountiful crops. The production and availability of fertilizers will always be important. (316 words)

Sample Bibliography

Sources Consulted

Baker, Jerry. *Fast, Easy Vegetable Garden.* New York: New American Library, 1985.

Bale, Jeff. *Rodale's Garden Problem Solver.* Emmaus, Penn.: Rodale Press, 1988.

Bennett, Jim. "Yard Care Q & A." *Home Mechanix,* February 1996, 62-69.

Hamilton, Gene and Katie (1996). Housenet's Gardening,Yard and Garage [Online]. Available HTTP: http://www .housenet.com/Articles/Gar_Yar/HN030360.HTM

Hicks, Laurel, Delores Shimmin, and Gregory Rickard.*Science: Order and Reality.* 2nd ed. Pensacola: A Beka Book, 1993.

Janick, Jules. *Horticultural Science.* 3rd ed. W. H. Treeman and Co., 1979.

New Grolier's Encyclopedia, 1996 ed. S.v. "Nitrogen Cycle" [CD-ROM]. Danbury, Conn.: Grolier's Electronic Publishers, 1996.

Sinko, M. D. and L. Jarosz. "Organic Foods: Are They Better?" *Journal of the American Dietetic Association*90 (1990): 367.

Slack, A. V. *Defense Against Famine: The Role of the Fertilizer Industry.* New York: Doubleday and Co., 1970.

CHAPTER 2

Planning Your Investigation

Problem Choice and Investigation Plan

Now that you have chosen a science project topic and have written a Background paper on that topic, it is time to plan your scientific investigation. *A **scientific investigation** is an extended experiment or series of experiments designed to provide the answer to a scientific problem or question.* It is not necessary to work in a laboratory or use expensive equipment to conduct a good scientific investigation. It *is* necessary to exercise curiosity and creativity and to have some basic knowledge of your subject.

Choosing a Problem to Investigate

The first step in planning a scientific investigation is to think of a scientific problem or question you would like to solve. Your scientific investigation will probably begin with a question or problem that intrigues you.

Described below and on the following page are example investigations from several major fields of science. These examples will give you an idea of the kinds of scientific investigations that you can do.

Example Problems

Zoology Example Investigation:

Here is an interesting question you can answer about bees: "Do bees have a color preference?" Place colored paper (red, yellow, blue) with a container of sugar water on it in an area near a beehive. Use a piece of black paper with a container of sugar water on it for the control. Count the number of bees that are attracted to each color.

Chemistry Example Investigation:

If you live by the sea, you might enjoy tackling this problem: "Can drinking water be obtained from seawater?" Research biological and mechanical osmosis. Experiment with various semipermeable membranes. Try to develop a practical apparatus to convert seawater to fresh water.

Mathematics Example Investigation:

Answer this question, "Do all plants contain examples of Fibonacci numbers?" Research the Fibonacci numbers. Conduct experiments by finding natural occurrences of Fibonacci numbers in as many plants as possible. Give the percentage of the total plants that you checked that contained numbers from this sequence.

Engineering Example Investigations:

a. You could answer the question, "How do different tread designs and tread materials perform on different surfaces?" Prepare simulated road surfaces (concrete block, brick, asphalt, and others). Test various combinations to see which one results in the best grip on each surface. Then test each for coefficients of friction under various conditions and at various angles of incline.

b. If you like to build, you could answer the question, "Which truss design provides the most strength in bridge construction and home construction?" Show how different truss designs affect the strength of bridges and other structures.

Physics Example Investigation (Thermodynamics):

Here is a question you can answer with household materials: "Which household container has the best insulating ability?" Use thermos bottles, glass bottles, plastic bottles, and others to find which bottles best keep cold liquids cold and hot liquids hot.

Meteorology Example Investigation:

You can answer the question, "Is it possible for an amateur to make accurate weather forecasts?" Use weather instruments made from household materials to measure air pressure, humidity, temperature, and other factors each day. Predict the weather for the next day with these measurements and calculate your accuracy. Compare the accuracy of your forecasts to those printed in the newspaper and broadcasted on television and radio.

Sources for Problems to Investigate

1. Check science textbooks.
2. Talk with students who have had successful projects.
3. Ask advice from teachers and librarians.
4. Determine if your school library keeps science project abstracts on file. These abstracts describe projects that have been done in the past.
5. Seek suggestions from professional people such as engineers, college professors, medical personnel, etc.
6. Locate and thumb through books of science project ideas.
7. Consider doing a continuation of an investigation that you have worked on previously. With your teacher's permission, you may continue an investigation as long as you have new aspects of the problem to explore and will not be repeating work you have already done.

Guidelines to Choosing a Problem

What should I consider in choosing a problem or question to answer?

1. Choose a problem that has a practical application.
2. Choose a problem or question that is specific.
3. Choose a problem or question from an area of science for which you can find adequate information.

4. Choose a problem that you can solve by doing an extended experiment or a series of related experiments that have measurable results.
5. Choose a problem for which equipment or materials will be available and affordable.
6. Note that it is often necessary to consider more than one problem before you find one that interests you and seems workable. As you think of possible problems or questions, complete a worksheet (on pages 43–48) for each one you consider. Submit your completed Problem Selection Worksheet(s) to your teacher for approval on the date indicated on the Science Project Work Schedule.

What should I avoid in choosing a problem to investigate?

1. Avoid investigations dealing with vertebrate animals. (If you have a definite experiment in mind concerning an animal with a backbone, check with your teacher for the requirements involved. These requirements are usually very stringent and include the supervision of a professional, such as a veterinarian. See Safety Concerns for people and vertebrate animals on page 38.)
2. Avoid making a model and calling it an investigation. Model-making is valuable in developing a number of skills but is not satisfactory as a scientific investigation. It is acceptable, however, to use a model in your exhibit.
3. Avoid simply describing work which someone else has done.
4. Avoid investigations that can be completed in a couple of hours. A good investigation will involve a long-term project.

Safety Concerns

Safety is a major concern in planning an investigation. Be sure your parents know what you plan to investigate and what the investigation will involve (equipment, supplies, procedures, etc.). You will need a parent's signature on the teacher's evaluation of your Investigation Plan.

Read carefully the following special concerns.

Chemicals: Be cautious when working with any chemicals, including household ones. Read the directions for safe handling and disposal. Be careful in the handling of substances like nail polish remover (acetone), rubbing alcohol, fertilizers, plant foods, and vitamins. Adult supervision is recommended.

Equipment: Your parents need to be aware of equipment you plan to use. Use of equipment such as knives, blenders, and power tools should be supervised at home.

Bacteria: If you are planning to grow bacteria or fungi, you should order kits from science supply catalogs and use the aseptic technique to grow a known strain of bacteria. Collecting bacteria or fungi from the air, from a surface, or from a person's mouth is unacceptable.

Electricity: Projects involving electricity can be dangerous. Adult supervision is required for the use of AC or DC over 12 volts. No open top cells are allowed. As a rule, use direct current (from batteries) rather than alternating current (of course, this would not apply to commercially produced electrical appliances necessary for the investigation). Insulate all exposed wiring.

People: Projects involving humans require special handling. Survey questions of a personal nature are unacceptable. All test results should be anonymous. Avoid any project posing a risk to the subjects. Projects with acceptable risk, such as healthy people exercising, will need to be supervised by a qualified adult, such as an exercise instructor or health care professional.

ISEF (International Science and Engineering Fair) rules ban *all* experiments on minors (even surveys) unless there is prior review of procedure and written parental consent of *each* minor being tested—refer to latest ISEF rules for clarification. (ISEF bans surveys on minors because federal law bans them unless parental consent is given.) It is best to obtain written permission of the people involved for *any* investigation concerning humans, regardless of age.

Vertebrate animals: Vertebrate animals require special care and handling. Since many laws regulate experimentation with animals, vertebrate animal projects are difficult to carry out. It is wiser to use invertebrate animals, unless you plan to observe the vertebrate animals undisturbed in their habitats.

Firearms, fire, or explosives: Projects involving firearms, fire, or explosives are generally prohibited. However, with parental permission and supervision, some projects involving fire or firearms might be acceptable.

Name _____

Problem Selection Worksheet

Choosing a problem to solve (or a question to answer) is the most important step in planning your scientific investigation. Think of two or three problems you are interested in and complete a worksheet for each. (Note that there are three Problem Selection Worksheets in this book.) On the day that your problem is due, turn in the worksheet of the topic you prefer. If you are unsure, you may turn in more than one worksheet. Your teacher will help you select the best topic. Place the approved worksheet in your Science Project Notebook.

I. The general field of science that I have chosen as my science project topic is _____. The specific area of this field that I have chosen is _____.
(Refer to your Topic Selection Worksheet if necessary.)

II. Describe the problem you would like to solve or the question you would like to answer.

III. Explain three main steps you could follow in your investigation to answer the question or solve the problem. Include what your variable would be and what you would use as a control.

A.

B.

C.

IV. Supplies

A. List 5 items you might need to conduct this investigation.

1.

2.

3.

4.

5.

B. Where will you get these supplies?

C. If you have to buy supplies, about how much will they cost? Is this amount affordable?

V. Will you be able to conduct this investigation at home, or will you need to do it in a laboratory?

VI. Will environmental conditions such as weather (cloudy days, cold days, or rainy days), length of days, etc., affect your ability to conduct this investigation?

VII. Do your parents approve of this investigation idea?

Name _____

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VI. Will environmental conditions such as weather (cloudy days, cold days, or rainy days), length of days, etc., affect your ability to conduct this investigation?

VII. Do your parents approve of this investigation idea?

Name _____

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B.

C.

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1.

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B. Where will you get these supplies?

C. If you have to buy supplies, about how much will they cost? Is this amount affordable?

V. Will you be able to conduct this investigation at home, or will you need to do it in a laboratory?

VI. Will environmental conditions such as weather (cloudy days, cold days, or rainy days), length of days, etc., affect your ability to conduct this investigation?

VII. Do your parents approve of this investigation idea?

Writing the Investigation Plan

Characteristics of a Good Investigation

Now that you have decided what problem or question you intend to investigate in your science project, the next step is to actually design the investigation. Remember that a scientific investigation is *an extended experiment or series of experiments designed to provide the answer to a scientific problem or question.* The characteristics of a good scientific investigation can be summarized as follows:

1. The investigation should be as **specific** as possible.

   Example: Rather than testing the effect of nutrients on plants, test one specific nutrient (such as nitrogen or potassium) on one specific type of plant. The project traced in this book is one in which nitrogen fertilizer was added to radish plants.

2. A good investigation will have only **one variable. All other factors are held constant.**

   Example: The sample fertilizer investigation used 3 groups of plants to determine how nitrogen fertilizers affected plant growth. All factors were held constant (type of soil, type of plant used, the number of seeds per cup, amount of sunlight, amount of water, age of plants when fertilizer was first applied, and frequency of watering and fertilizing) except the nitrogen content of the fertilizer used.

3. A good investigation will also have a **control.** The control proves that the factor being tested actually caused the result being observed. It is a basis for comparison, the one logical explanation for the results that occur.

   Example: In the fertilizer investigation, the control was a group of plants to which no fertilizer was added. This group showed how plants of this type grew without nitrogen fertilizer. When the other groups of plants showed variations from the control group, the logical explanation for these variations was that they were caused by the differing amounts of nitrogen applied.

4. A good investigation will be **extensive;** it will be carried out for a period of time—days or weeks—and will test a large population.

   Example: The fertilizer investigation used 30 plants (2 groups of 10 plants each, plus a control group of 10 plants). The plants were observed for two months (9 weeks).

5. The experiments in a good investigation will be designed so that the results are **measurable or countable.**

   Example: In the fertilizer investigation, the results were determined by measuring the height of the plants and counting the number of leaves each week.

6. To get accurate results, a good investigation must have a **large sample size** or be **repeated** several times. Both criteria may apply to some projects. (The plant/fertilizer investigation traced in this book was limited to 30 radish plants for demonstration purposes. More accurate results would be obtained by using more plants in each group.)
7. If possible, the results of the investigation will be **compared to known data.**

   Examples: A student made his own hydrometer and used it to test the specific gravity of 20 substances. He compared his results to the known specific gravity of each substance. Another student made her own calorimeter. She used it to determine the calorie content per gram of several foods and compared her results to the known calorie content of each of the foods.

   Note: Science textbooks, handbooks, and reference books often contain charts and tables of known scientific data. One recommended handbook is *CRC Handbook of Chemistry and Physics*, edited by David R. Lide (Boca Raton, Florida: CRC Press).

About the Investigation Plan

Careful planning is the key to a successful scientific investigation. As you make specific plans, you will prepare a written **Investigation Plan.** This plan will be Part 2 of your Investigative Report.

How do I plan my investigation?

As you plan your investigation, you will need to answer the following questions:

1. What supplies and equipment will I need in order to complete the steps I plan to follow for solving the problem?
2. Where will I get the equipment and supplies?
3. Will I need to work in a laboratory?
4. Do the steps I need to follow comprise a single experiment or several experiments?
5. What will I measure or count to determine the result of my experiment(s)?
6. What is the experimental group for each of my experiments? How many specimens will they contain?
7. What is the control group for each of my experiments? How many specimens will they contain?
8. What are the constant factors for each experiment?
9. What is the variable for each experiment?
10. Will I need to repeat my experiments to get accurate results? If so, how many times?
11. Is known data available for comparison with my results? Where will I get this data?
12. What safety procedures will I need to follow?

How do I write the Investigation Plan?

Step 1: Write your **first draft.** Include these sections:

1. **Problem**—the question you intend to answer in your investigation
2. **Hypothesis**—the expected solution to your question/problem
3. **Procedure**—a step-by-step description of the method or procedures you will use to answer your question or solve your problem. (If you use a procedure from a published source instead of one you planned, credit the source from which the procedure was taken. See the Documentation section in Appendix C for instructions.) Include in your procedure the materials you will use to conduct your experiments.
4. **Safety**—an explanation of safety procedures you will follow in conducting the investigation. List these procedures as *safety steps* you will take.

Write your name on the Investigation Plan Evaluation and submit the evaluation with your Investigation Plan first draft. When your teacher returns this evaluation, review it with your parents and have them sign it.

Step 2: **Revise your first draft.** The purpose of this revised plan is to make any changes (restrictions, safety precautions, etc.) your teacher has suggested. After your teacher checks your revised copy, do any final editing needed.

Step 3: Prepare your **final copy.** Follow the Investigation Plan Final Check. Include a title page. You will not have an outline, and you will not need a Sources Consulted (bibliography) page unless you used a procedure from a published source. Remember to use the headings, format, and spacing illustrated in the sample Investigation Plan. Submit the Investigation Plan Grade Form with your Investigation Plan.

Note: Place your graded Investigation Plan in your Science Project Notebook. This plan will be your guide as you conduct your investigation.

Name _____

Investigation Plan Evaluation

Submit this form with the first draft of your Investigation Plan. Your teacher will evaluate your plan and make recommendations on this form.

Teacher: Complete the following evaluation and make needed recommendations.

Statement of Problem or Question

_____ Well-written

_____ Restate your problem using more specific wording.

Hypothesis

_____ Logical

_____ Needs improvement (See suggestions checked below.)

_____ Restate your hypothesis using more specific wording.

_____ Restate your hypothesis to reflect what you have learned in your research.

Procedure

A. Experimental Design and Technique

_____ Excellent

_____ Rewrite the procedure, describing each step in more detail.

_____ Write a more detailed description of how you will accomplish the following part of your procedure: _____

_____

_____ Describe your control.

_____ Rethink your control.

_____ Modify your procedure so that all factors other than the variable are kept constant in both the experimental group and the control group.

_____ Develop a specific, measurable way to determine (if possible) the results.

_____ Plan to compare your results to known data.

_____ Include safety procedures regarding _____

_____

B. Level of Complexity

_____ Just right

_____ Add additional experiments to more accurately test your hypothesis. Plan to have at least _____ experiments.

_____ Plan to repeat each experiment at least _____ times.

_____ Enlarge the experimental group and control group so that you have at least _____ members in the experimental group and at least _____ members in the control group.

I have noted these recommendations for improving my plan of investigation.

Student's Signature _____ Date _____

Parent's Signature _____ Date _____

When your teacher returns your first draft, note his recommendations and have your parents sign this form. Incorporate these recommendations into your revised and final Investigation Plan, and keep this form in your Science Project Notebook.

Name _____

Investigation Plan Final Check

Check (✓) each item as it is completed.

General Information

_____ 1. Use only one side of the paper.

_____ 2. Since your paper will be bound later, allow a 1 1/2-inch margin on the left-hand side of each page. Allow a 1-inch margin on the right-hand side of each page.

_____ 3. Your paper should be neat and clean.

_____ 4. If you are typing your paper, use a standard typeface such as 12-point Courier type (10 characters per inch). Do not use script or any other ornamental typeface.

_____ 5. Have someone proofread your completed Investigation Plan before you hand it in.

Title Page

_____ 1. Center the main title INVESTIGATION PLAN in the middle of the page (between the margins). If you have a subtitle, double-space and type it beneath your main title. See sample title page.

_____ 2. If your subtitle is longer than 48 spaces, use two or more lines.

_____ 3. Type the following information 2 inches from the bottom of the page in the right-hand corner: name; date; class, grade, and section; teacher's name. (Begin on the sixth line from the bottom if hand writing.)

_____ 4. Although the title page is counted as page i (small Roman numeral I), do not place a page number on it.

Body of the Investigation Plan

_____ 1. Center the paper's main title (use the subtitle if you have one) 2 inches from the top. (Write on the top line if hand writing.)

_____ 2. Triple-space after the title and type the first heading. (If hand writing, place the first heading on the fourth line.) Place your headings (PROBLEM, HYPOTHESIS, PROCEDURES, and SAFETY) at the left-hand margin.

_____ 3. If typing, double-space the text and triple-space before each new heading. (If hand writing, write on every line except the last line on a page. Leave a blank line before new headings.)

_____ 4. Indent the first line of each paragraph five spaces, or 1/2 inch. (If hand writing, indent 1 inch.)

_____ 5. On the first page of the body, center the number 1 at the foot of the page, 1 inch above the bottom of the page. (Center the page number on the bottom line if hand writing.) Do not use a period, parentheses, or hyphens with the number.

_____ 6. Double-space between the last line of text and the page number.

_____ 7. On page 2 and all succeeding pages, center the page number 1 inch from the top of the page (on the top line if hand writing). Double-space between the page number and the first line of text. (If hand writing, begin material on the third line from the top.)

Bibliography Page (Optional)

_____ 1. Arrange any new bibliography cards in alphabetical order according to the first word that appears on the card.

_____ 2. Center the heading Sources Consulted 2 inches from the top of the page (top line if hand writing).

_____ 3. Triple-space between the heading and the first entry. (If hand writing, write the first entry on line three.)

_____ 4. Single-space each entry, but double-space between entries. (If hand writing, skip one line between each entry.)

_____ 5. Begin the first line of each entry flush with the left-hand margin; indent runover lines five spaces, or ½ inch. (Indent 1 inch if hand writing.)

_____ 6. Center the page number 1 inch from the bottom of the first page of the bibliography (bottom line if hand writing). The numbering is continuous with the body. For example, if the body ends on page 3, the bibliography would begin on page 4.

Grading Page

_____ Tear out the Investigation Plan Grade Form and include it with the paper.

Sample Title Page

INVESTIGATION PLAN

Sample Investigation Plan

John Smith
October 21, ——
Science 9A
Miss True

Sample Body of Paper

Investigation Plan

PROBLEM

What is the effect of high-nitrogen fertilizer on the growth of radish plants?

HYPOTHESIS

My hypothesis is that the plants that receive more nitrogen will grow taller and have more leaves than the other plants.

PROCEDURES

I will place 30 small cups in 3 groups of 10 each, and label the groups A, B, and C. I will label the cups in each group with a number. Group A will be numbers 1-10; Group B will be numbers 11-20; and Group C will be numbers 21-30. Next, I will fill each cup with sandy soil. I will plant 3 radish seeds in each cup and add 60 ml (approximately 4 tablespoons) of water. I will place the cups in a sunny location and add 30 ml of water to each cup every other day.

Two weeks after the seeds sprout, I will cut off the two smallest seedlings from each cup at dirt level so that only 1 seedling remains per cup. I will then make fertilizer solutions by pouring 1000 ml of water into each of three containers labeled A, B, and C. While wearing disposable gloves, I will add 3 ml of high-nitrogen liquid fertilizer to container A and 15 ml of the same fertilizer to container B. Each day, I will water the plants in Group A with 30 ml (approximately 2 tablespoons) of fertilizer solution from container A. The plants in Group B will receive 30 ml of fertilizer solution from container B daily, and the plants in Group C will receive 30 ml of plain water daily. To determine the effect of the fertilizer on the plants, I will make weekly measurements of height and number of leaves for two months (nine weeks).

The control group in my investigation will be the group of plants that will receive plain water only and no fertilizer. The constant factors will be the type of soil, the type of plant used, the number of seeds per cup, the location of the cups, the amount of water

given, and the age of plants when fertilizer is first applied. The variable is the amount of fertilizer given to the plants not in the control group.

SAFETY

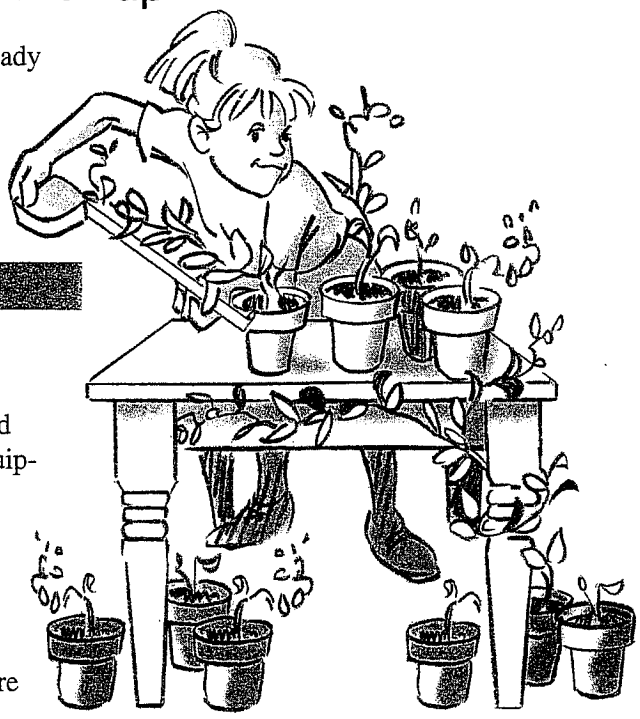
I will follow these safety procedures for this investigation: (1) understand fertilizer is a toxic substance and keep it away from small children, (2) read label instructions as to proper mixing procedures, (3) wear disposable gloves while handling the fertilizer and fertilizer solutions, (4) properly label the containers of fertilizer solution.

CHAPTER 3

Conducting Your Investigation

Experiments, Journal, Followup

Now that you have an investigation plan, you are ready to begin your investigation. In this chapter, you will learn how to conduct a scientific investigation, keep a journal of your experiments, and write a Followup paper to complete your Investigative Report.



Starting the Investigation

Gathering Supplies

1. Refer to your Problem Selection Worksheet and Investigation Plan to see what supplies and equipment you will need.
2. Determine where you will get your equipment.
   a. Many household items can be adapted for science project use.
   b. Many items can be purchased from hardware or discount stores. To save time, call the stores and ask if they sell the items you need.
   c. Certain items can be purchased or borrowed from local laboratories, community colleges, universities, high schools, industries, or hospitals.
   d. If you know a student who has done a similar investigation, ask if you can buy or borrow any supplies he still has.
   e. Certain chemicals and equipment must be purchased from scientific supply companies. It is important to note that some larger companies do not sell chemicals to individuals and do not sell small quantities. You can order from larger companies through a group or from a smaller company that sells to individuals and sells smaller quantities. Several supply companies are listed below. Note that addresses may change.
      - Carolina Biological Supply Company
        2700 York Road
        Burlington, North Carolina 27215
      - Frey Scientific
        100 Paragon Parkway
        P.O. Box 8101
        Mansfield, Ohio 44901

- Sigma Chemical Co.
  P.O. Box 14508
  St. Louis, MO 63178
- Central Scientific Co. (CENCO)
  3300 CENCO Parkway
  Franklin Park, IL 60131
- Wards Natural Science Establishment
  P.O. Box 92912
  Rochester, NY 14692

3. Record in your journal all supplies gathered and money spent. (See Journal explanation on p. 65.)

Final Preparations

Before you begin your investigation, it is important to seek advice and assistance on any part of your investigation that you do not fully understand or that requires advanced knowledge. Your science teacher may be able to answer your questions or direct you to an appropriate source.

Additional sources that may prove helpful:

- University libraries
- College and university professors
- Business, industry, and military experts
- Doctors, nurses, and other health-care professionals
- Public and private agencies and government departments (local, state, and national)
- Any organization that supports the regional science fair of your area (a list of these supporters is available from your regional fair director)

Typical regional fair supporters:

Amateur Astronomers Association
American Chemical Society
American Dental Association
American Meteorological Society
American Society of Civil Engineers
American Society for Microbiology
Eastman Kodak Company
Humane Society
Junior Engineering Technical Society
United States Space Foundation
Society of Women Engineers
U.S. Department of Energy
U.S. Marine Corps, U.S. Department of the Navy
U.S. Metric Association

Use the questions on the following **Getting Started Worksheet** as a final check on your preparations. Complete the worksheet and turn it in on the day assigned.

Name_____

Getting Started Worksheet

Answer the following questions to evaluate your planning as you begin your investigation. After your teacher returns this worksheet, place it in your Science Project Notebook. If a question does not apply to your investigation, write NA (not applicable) to the left of the question.

Answer by circling Y (yes) or N (no).

Y N 1. Have you placed all previously completed worksheets in your notebook?

Y N 2. Do you currently have all the equipment and supplies you will need to complete your investigation?

Y N 3. Have you called local stores to check on the availability of equipment and supplies you still need to purchase?

Y N 4. Have you placed an order for equipment and supplies that are not available locally?

Y N 5. Have you made arrangements to get technical help from professionals if you need it?

Y N 6. Have you made arrangements to use a laboratory if needed?

Y N 7. Have you made any entries in your journal? (The gathering and purchasing of materials should be entered into your journal.)

Y N 8. Have you arranged to handle all safety concerns mentioned in your investigation plan?

Y N 9. Is there any part of your procedure that you are still uncertain about how to accomplish? If so, please list below:

Science Project Journal

The Science Project Journal is an important part of your scientific investigation. Others can benefit from your research only if you keep a clear, complete, and accurate record of your investigative work. This journal is also vital to the Investigation Followup you will write at the conclusion of your investigation. Plan to keep the journal in your Science Project Notebook. Check and record the data of your investigation at regular intervals, and make a journal entry every time you work on your project. Think of the journal as the "diary" of your investigation.

What format should I use when writing my journal?

1. Refer to the Sample Journal (Appendix B) and study the format.
2. Begin each journal entry on a new page. The format at the top of the page includes Date, Time, Entry Number, Total Minutes This Entry, and Cumulative Total Minutes to Date. In your final journal entry, convert the cumulative minutes to hours to show how long you worked on your investigation.
3. Keep your journal entries as neat as possible. You may have to cross through data or make changes as you conduct your investigation, but it is not necessary to rewrite a page unless it is illegible.
4. It is fine to make a simple list of data, but it is usually better to organize it into a chart. Charts should also be used to organize averages and other calculations for easy reference. When making a chart, remember the following:
    a. Use a ruler and neatly draw the chart right in your journal.
    b. Draw as many columns as you need.
    c. Label each column and give a title to the chart.

Here is an example of how you could organize your first measurements of the height of radish plants into easy-to-read chart form.

Plant Height at First Measurement (cm) – October 24

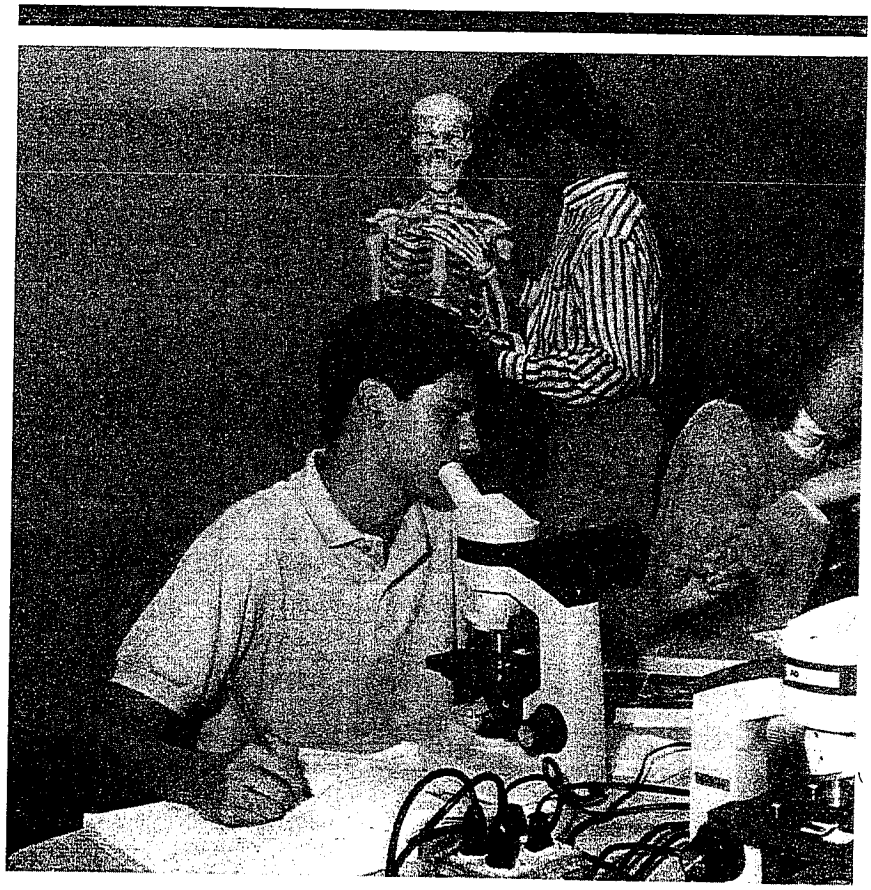
Group A		Group B		Group C	
Plant Number	Height	Plant Number	Height	Plant Number	Height
1	4.2	11	4.2	21	4.5
2	4.1	12	4.7	22	5.1
3	4.0	13	3.6	23	4.2
4	3.9	14	4.9	24	3.4
5	4.0	15	4.1	25	4.1
6	4.2	16	4.1	26	4.1
7	4.7	17	3.4	27	4.9
8	4.5	18	4.2	28	3.6
9	4.1	19	5.1	29	4.7
10	4.1	20	4.5	30	4.2
Total	41.8 cm	Total	42.8 cm	Total	42.8 cm
Avg. Height	4.2 cm	Avg. Height	4.3 cm	Avg. Height	4.3 cm

What should I include in my journal?

1. A detailed **description of the work that you do,** including the equipment and techniques you use. Sketches showing how you set up your equipment can also be helpful.
2. A **record** and **analysis** of the **data.** The data consists of the actual numbers and measurements you obtain. Use metric units for all measurements. Write down *all* data even if you think something is not significant. Your analysis includes all calculations you do with the data, such as averaging, inserting the numbers into formulas, etc. These are the calculations that enable you to arrive at a final conclusion.
3. A description of **observations** you make while doing the work. If your observations do not support your hypothesis, ask yourself why they do not support it. If you experience problems with the investigation, ask yourself why these problems occurred. Record the answers in your journal.
4. A description of **mistakes** that you make or **accidents** that occur and a note about how to prevent or correct these.
5. A record of **all the work** you do on your *investigation.* A thorough journal should have 15 to 20 entries (one per page). It is not necessary to record work that you do for your display board or oral presentation.

When will my journal be due?

Your teacher will check your journal periodically to monitor progress on your investigation. Complete a **Journal Check Report** (from pp. 67–73) each time your journal is checked in class. Place these completed reports in your Science Project Notebook. Your complete journal will be due at the end of the project as part of your Science Project Notebook.



Completing the Investigation

Data Interpretation

Concluding your experiments is the first step in completing your investigation. You will now use the information recorded in your journal to reach a conclusion. This interpretation of your data should be done directly in your journal.

Specific Ways to Interpret Your Numbers (Data)

To have a good science project, it is essential to interpret your data correctly. The following are some suggested ways to reach a conclusion:

- Average the numbers.
- Compare beginning numbers to each other.
- Compare beginning numbers to final numbers.
- Compare final numbers to each other.
- Compare averages to each other.

Refer to the Sample Journal (Appendix B) and to the explanation below to see how the data is interpreted in the sample investigation in this book. The following figures have been adjusted to contain only significant figures. (Students in grades 9–12 should see Appendix C and follow the guidelines on precision, accuracy, and significant figures given there.)

1. **Average the numbers.**

   Look at Sample Journal entry 14. The numbers have been recorded individually and then averaged at the bottom of the chart. You can do the averages as you go along or you can do them at the completion of the investigation.

2. **Compare beginning numbers to each other.**

   Refer to journal entry 14.

   Group A was originally 4.2 cm tall (average).

   Group B was originally 4.3 cm tall (average).

   Group C was originally 4.3 cm tall (average).

   Looking at these numbers, one can see that all the plants started at approximately the same height.

3. **Compare beginning numbers to final numbers.**

   Refer to the journal entries 14 and 45.

   Group A started at 4.2 cm (average) in height and ended at 11.8 cm (average). It grew an average of 7.6 cm.

   Group B started at 4.3 cm (average) and ended at 14.0 cm (average). It grew an average of 9.7 cm.

   Group C started at 4.3 cm (average) and ended at 10.5 cm (average). It grew an average of 6.2 cm.

4. **Compare final numbers to each other.**

   Refer to journal entry 45.

Group A grew to be 11.8 cm (average).

Group B grew to be 14.0 cm (average).

Group C grew to be 10.5 cm (average).

Looking at these numbers, one can see that Group B grew to be 2.2 cm taller than Group A, and 3.5 cm taller than Group C.

5. **Compare averages to each other.**

Refer to journal entry 45.

Group A grew an average of 7.6 cm.

Group B grew an average of 9.7 cm.

Group C grew an average of 6.2 cm.

Looking at these averages, one can see that Group B grew the most, 2.1 cm more than Group A and 3.5 cm more than Group C.

Graph Descriptions

The next step in interpreting your data is to convert it into graphs. A good graph will help you (and others) better understand your data and conclusions. Graphs illustrate data in an easy-to-understand format. Keep your graphs simple and accurate.

What kinds of graphs should I use?

The most useful types of graphs are **bar graphs, line graphs,** and **circle graphs.** Bar graphs are useful for comparing results of several experiments or experimental groups at a *single point in time*. Line graphs are useful for showing the *progression* of an individual experiment or experimental group over a period of time. Circle graphs are useful when expressing data as *percentages* of a whole. See Appendix C for illustrations of the types of graphs.

What are some characteristics of good graphs?

1. They are drawn neatly (using a ruler) or designed on a computer that has graphics capability.
2. They are large enough to be clearly seen.
3. They clearly show the differences (by color or other methods) among items being graphed together.
4. They are easily and quickly understood (do not have so many different items graphed together that it becomes confusing).
5. They include a key to explain colors or symbols used.
6. They have a title that tells their purpose.
7. They have labels for each axis to indicate what it represents and what measuring units it uses (meters, minutes, etc.)
8. They use equal intervals on each axis.

Your completed graphs will be included in your Investigation Followup. Remember to double check all mathematical calculations. Appendix C has an illustrated explanation of the types of graphs and how to use them.

About the Conclusion

The final step in completing your investigation is to reach a **conclusion** about the outcome of your investigation. The conclusion you reach will become part of your Followup report and will be included as a separate section of your exhibit display.

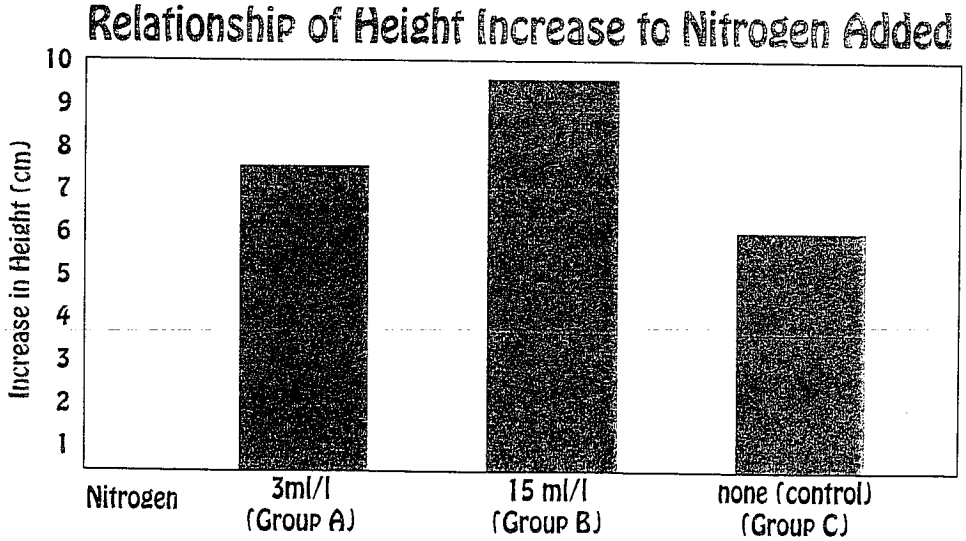
How do I form a conclusion?

To form a conclusion, look at your project from an overall viewpoint. Consider your hypothesis and study your graphs (data) to determine what your investigation has shown.

Step 1: **Consider Your Hypothesis.** As you form a conclusion, you will be answering the question, "Do these results support my hypothesis?" Do not be discouraged if your hypothesis seems to have been incorrect. Every scientist has made an incorrect hypothesis.

If your results do not support your hypothesis, look through your journal for some unplanned event that happened during your investigation. For example, in the fertilizer investigation, the plants might have tipped over, the fertilizer solution might have become contaminated, or perhaps there was a variable of which the student was originally unaware. Any of these may be the reason for faulty results. (Avoiding inaccurate or faulty results is one reason why a student needs to repeat his experiment many times and/or have a very large sample size.)

Step 2: **Study Your Graphs.** Your graphs will help you form a conclusion because they show the relationship between your variable and your results. For example, the graph below shows the relationship between the height of plants and the different amounts of nitrogen they received.

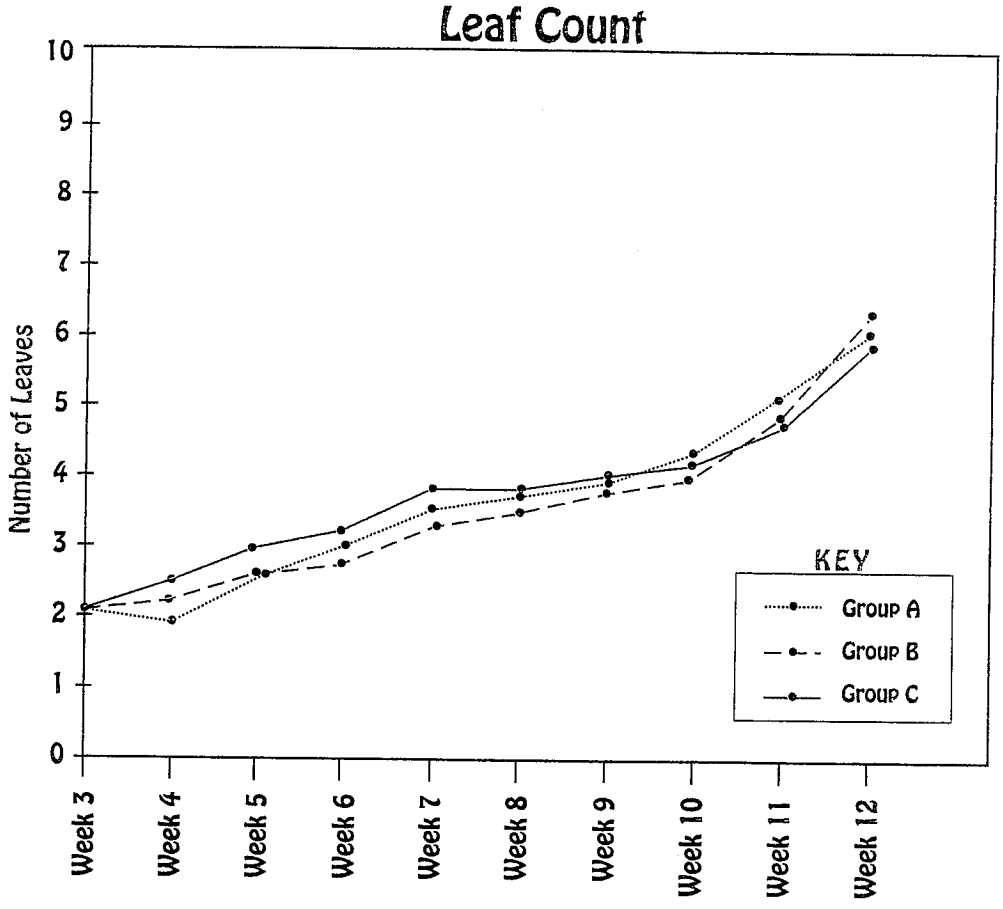


This is the conclusion that the student arrived at after studying the graphs from his investigation about nitrogen fertilizer:

(1) According to the graph, Group B grew more than Groups A and C. Group B grew 2.2 cm more than Group A grew, and 3.5 cm more than Group C grew. Also, Group A grew 1.3 cm more than Group C.

(2) The group that received the most nitrogen (Group B) grew the most; the group given a little nitrogen grew more than the control (Group C). From this he concluded that nitrogen does increase the growth of plants.

It is important that you use care when forming a conclusion. Do not base a conclusion on a graph unless the graph shows an obvious result. The student concluded after studying the graph below that the plants that received a large amount of nitrogen produced about the same number of leaves as those that received only a small amount of nitrogen or no nitrogen at all. The student therefore concluded that nitrogen, at least in this experiment, did not have a significant effect on leaf production.



Note: More extensive research indicates that nitrogen does cause plants to produce more leaves; however, the amount of nitrogen used in this investigation was apparently insufficient to produce a significant change in radish plants.

Writing the Investigation Followup

The Investigation Followup is a written report of your investigative work. It describes your experiments, your results, and your conclusions. This Followup is the final part of the Investigative Report. A sample Followup is included at the end of this chapter.

What should my Investigation Followup include?

The Investigation Followup has four sections. Write a clear description for each of the following:

1. **Procedure**—a paragraph that reviews briefly what your investigation involved. Mention your sample size and/or how many repetitions you used. Include your variable and control. State whether you were able to follow your Investigation Plan; if you made any changes, describe them.
2. **Results/Data**—a statement of the outcome of the investigation. Include mathematical statistics. Example: "The plants in Group B reached an average height of 14.0 cm." These results should be supported by charts and graphs illustrating the measurements that you recorded in the investigation. All measurements should be expressed in metric units.
3. **Conclusion**—a statement of the conclusion you reached based on the outcome of your investigation. Indicate whether it supported your hypothesis and why or why not. You may wish to use some published data (results of other studies, theoretical values, etc.) in your discussion of the investigation in the Followup section of your Investigative Report. *You do not have to use published data in your discussion,* but if you do, you must credit the source from which the material was taken. See the Documentation section in Appendix C for instructions. End the conclusion by stating practical benefits that you have learned from your investigation.
4. **Bibliography** (optional)—a list of any new references you used in doing your investigation (especially if you changed your procedure) or in preparing your Followup, such as any sources used to compare the results of your investigation with published data.

After you have written your Followup first draft and revised it, use the **Followup Final Check** to prepare the final draft. Attach the **Followup Grade Form** and turn your Followup in. Once your teacher returns your paper, place it in your Science Project Notebook.

Name _____

Investigation Followup Final Check

Check (✓) each item as it is completed.

General Information

_____ 1. Use only one side of the paper.

_____ 2. Since your paper will be bound later, allow a $1\frac{1}{2}$-inch margin on the left-hand side of each page. Allow a 1-inch margin on the right-hand side of each page.

_____ 3. Your paper should be neat and clean.

_____ 4. If you are typing your paper, use a standard typeface such as 12-point Courier type (10 characters per inch). Do not use script or any other ornamental typeface.

_____ 5. When your Investigation Followup is complete, have someone proofread it before you hand it in.

Title Page

_____ 1. Center the main title INVESTIGATION FOLLOWUP in the middle of the page (between the margins). If you have a subtitle, double-space and type it beneath your main title.

_____ 2. Type the following information 2 inches from the bottom of the page in the right-hand corner: name; date; class, grade, and section; teacher's name. (Begin on the sixth line from the bottom if hand writing.)

_____ 3. Although the title page is counted as page i (small Roman numeral I), do not place a page number on it.

Body of the Followup Paper

(This is the corrected final copy.)

_____ 1. Center the title (or subtitle, if you are using one) 2 inches from the top of the first page. (Write on the top line if hand writing.) Do not underline or put quotation marks around it. Place your headings, PROCEDURES, RESULTS/DATA, and CONCLUSION at the left-hand margin.

_____ 2. Triple-space between the title and the first heading. (If hand writing, place the first heading on the fourth line.)

_____ 3. If typing, double-space the text and triple-space before the second headings and each one after that. (If hand writing, write on every line except the last line on a page. Leave a blank line before new headings.)

_____ 4. Indent the first line of each paragraph five spaces, or $\frac{1}{2}$ inch. (If hand writing, indent 1 inch.)

_____ 5. On the first page of the body, center the number 1 at the foot of the page, 1 inch above the bottom of the page. (Center the page number on the bottom line if hand writing.) Do not use a period, parentheses, or hyphens with the number.

_____ 6. Double-space between the last line of text and the page number.

_____ 7. On page 2 and all succeeding pages, center the page number 1 inch from the top of the page (on the top line if hand writing). Double-space between the page number and the first line of text. (If hand writing, begin material on the third line from the top.)

Bibliography Page (Optional)

_____ 1. Arrange any new bibliography cards in alphabetical order according to the first word that appears on the card.

_____ 2. Center the heading Sources Consulted 2 inches from the top of the page (top line if hand writing).

_____ 3. Triple-space between the heading and the first entry. (If hand writing, write the first entry on line three.)

_____ 4. Single-space each entry, but double-space between entries. (If hand writing, skip one line between each entry.)

_____ 5. Begin the first line of each entry flush with the left-hand margin; indent runover lines five spaces, or $\frac{1}{2}$ inch. (Indent 1 inch if hand writing.)

_____ 6. Center the page number 1 inch from the bottom of the first page of the bibliography (bottom line if hand writing). The numbering is continuous with the body. For example, if the body ends on page 3, the bibliography would begin on page 4.

Grading Page

_____ Remove the Investigation Followup Grade Form and include it with the paper.

Sample Title Page

INVESTIGATION FOLLOWUP

John Smith
Date
Science 7A
Miss True

Sample Body of Paper

Investigation Followup

PROCEDURE

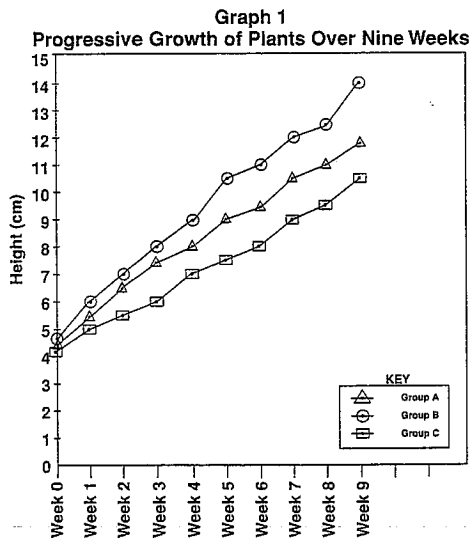
To test the effects of nitrogen fertilizer on the development of radish plants, I exposed radish plants to varying amounts of nitrogen fertilizer for nine consecutive weeks. I gave a concentration of 15 ml/l to 10 plants, 3 ml/l to 10 plants, and no fertilizer at all to 10 plants. The amount of fertilizer was the variable; the group of 10 plants which received no fertilizer was the control. I followed the procedure already outlined in my investigation plan.

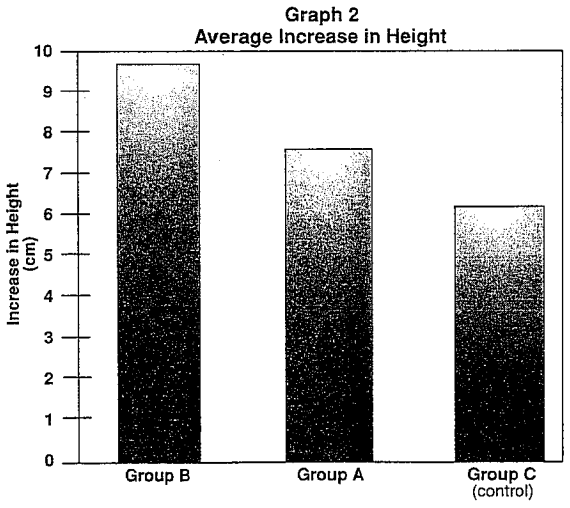
RESULTS

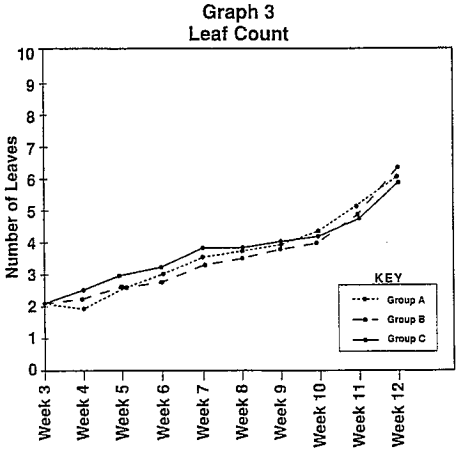
Group B (with the higher concentration of fertilizer) grew more rapidly overall than either of the other groups, growing from the average beginning height of 4.3 cm to an average total height of 14.0 cm. Group A (with the lower concentration of fertilizer) started at an average of 4.2 cm and ended at 11.8 cm, and Group C (the control group) grew from an average of 4.3 cm to 10.5 cm (refer

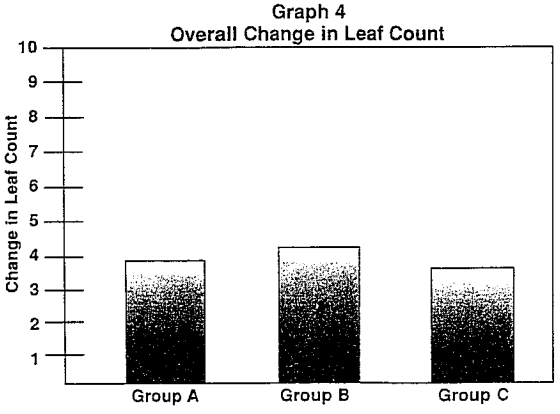
to Graph 1). Group B experienced an average growth of 9.7 cm, 2.1 cm more than Group A and 3.5 cm more than group C (refer to Graph 2).

In the beginning, Group A averaged 2.1 leaves per plant, and Groups B and C averaged 2.2. At final count, Group B averaged 6.4 leaves per plant, Group A had 6.1, and Group C had 5.9 (refer to Graph 3). Groups A, B, and C produced an average increase of 4.0, 4.2, and 3.7 leaves, respectively (refer to Graph 4).









CONCLUSION

I believe that the results of my experiment support the part of my hypothesis that nitrogen will increase the growth of radish plants. Group B, which received the most nitrogen, grew significantly more than either of the other groups. Group C, which received no nitrogen, grew less than the other two groups.

I do not believe my results support the part of my hypothesis that nitrogen will increase the number of leaves on plants because the groups showed an average leaf count variation of no more than .5. Group B received the most nitrogen and should have produced a significantly greater number of leaves in order to support my hypothesis. The results are too close, however, to claim that nitrogen improves leaf count.

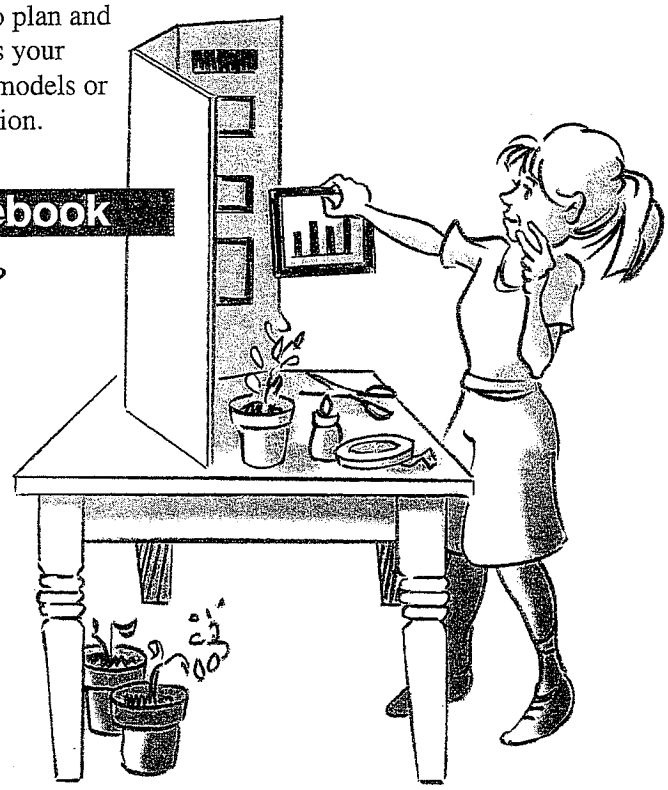
This investigation has taught me several things about the role fertilizers play in plant development. The proper fertilizer application is vital for maximum plant productivity. I believe that more research is needed, not only about nitrogen but also about other nutrients, to determine the ideal combination and amount of fertilizer for each type of plant.

CHAPTER 4

Preparing Your Exhibit

Project Notebook and Display

Now that your investigation is complete, it is time to plan and build your Science Project Exhibit. The exhibit includes your Science Project Notebook, your display board, and any models or equipment that help to explain your project or investigation.



Assembling the Project Notebook

What is included in the Science Project Notebook?

Your notebook should include the following:

1. Investigative Report, including:
   - Background
   - Investigation Plan
   - Followup
2. Journal
3. Worksheets (optional)

How do I set up my Science Project Notebook?

Step 1: Prepare the **Investigative Report.**

1. Make a title page, following these guidelines:
   a. Use a colored sheet of paper.
   b. Center the title, I. INVESTIGATIVE REPORT, in the middle of the page (between the margins), using all capitals.
   c. Type the following information 2 inches from the bottom in the right-hand corner of the page: name; date; class, grade, and section; teacher's name. (Begin on the sixth line from the bottom if hand writing).
2. Make a table of contents for the Investigative Report. Place it after the Investigative Report title page. Follow these guidelines for the contents page:
   a. Center the title, Table of Contents, 2" from the top of the page.
   b. Triple-space and type the names of the three sections (Investigation Background, Investigation Plan, and Investigation Followup), double-spacing after each name, and centering each one.
   c. Do not use any page numbers.

3. Insert the three parts of the Investigative Report immediately after the table of contents. Include the title page for each part.

Step 2: Prepare the **Journal.**

1. Use a colored sheet of paper.
2. Make a title page for your Journal, following the same guidelines you did for the Investigative Report title page. Use the title II. JOURNAL.
3. Place the Journal title page in the Science Project Notebook with your journal pages (these should already be in your notebook). Note: Names of people tested in your investigation should not appear anywhere in your Journal or notebook.

Step 3: Prepare a **Worksheet section** (optional).

1. Use a colored sheet of paper.
2. If your teacher wishes you to include your worksheets, make a title page for them, following the same guidelines you did for the Investigative Report title page. Use the title III. WORKSHEETS.
3. Place your Worksheet title page and worksheets in the Science Project Notebook after your Journal.

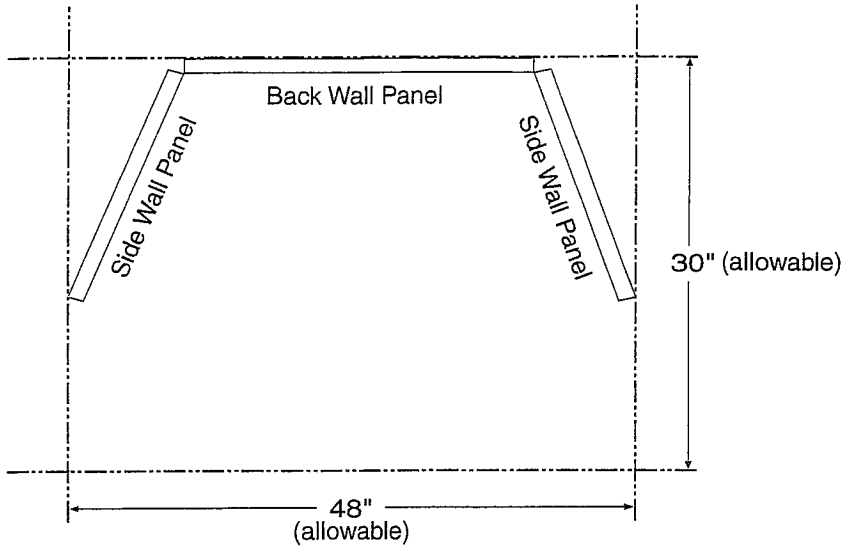
Assembling the Project Display

What are the physical requirements for the board?

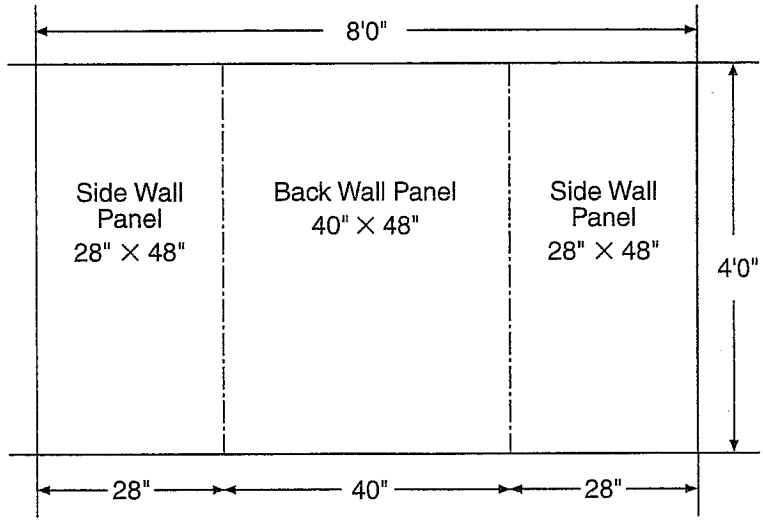
1. A variety of commercially prepared display boards are available in office or school supply stores. The board you choose should be able to be folded into panels. If you build your own display board, you will want to use durable materials such as plywood or "Masonite" hard-board.
2. Paint your display board or cover it with felt. If you use felt, the material should be pulled tightly and fastened securely.
3. When the display board is lying flat, the *maximum* size is 4' x 8'. A good guideline is to cut the back wall panel 40" x 48" and each of the side wall panels 28" x 48" (see diagram on next page).
4. When the board is standing upright for the oral presentation or science fair, the side panels should be folded forward so that the exhibit is only 48" from side to side and 30" from front to back. If possible, consider the height of the table on which the board will be displayed. The top of your board should not be higher than 108" from the floor.

   Note: If you plan on taking your exhibit to a regional fair, make sure that your board dimensions fit their guidelines.

OVERHEAD PLAN OF TYPICAL SCIENCE FAIR DISPLAY BOARD



CUTTING 4' X 8' PLYWOOD OR HARD BOARD FOR MAXIMUM ECONOMY



What information should go on the display board?

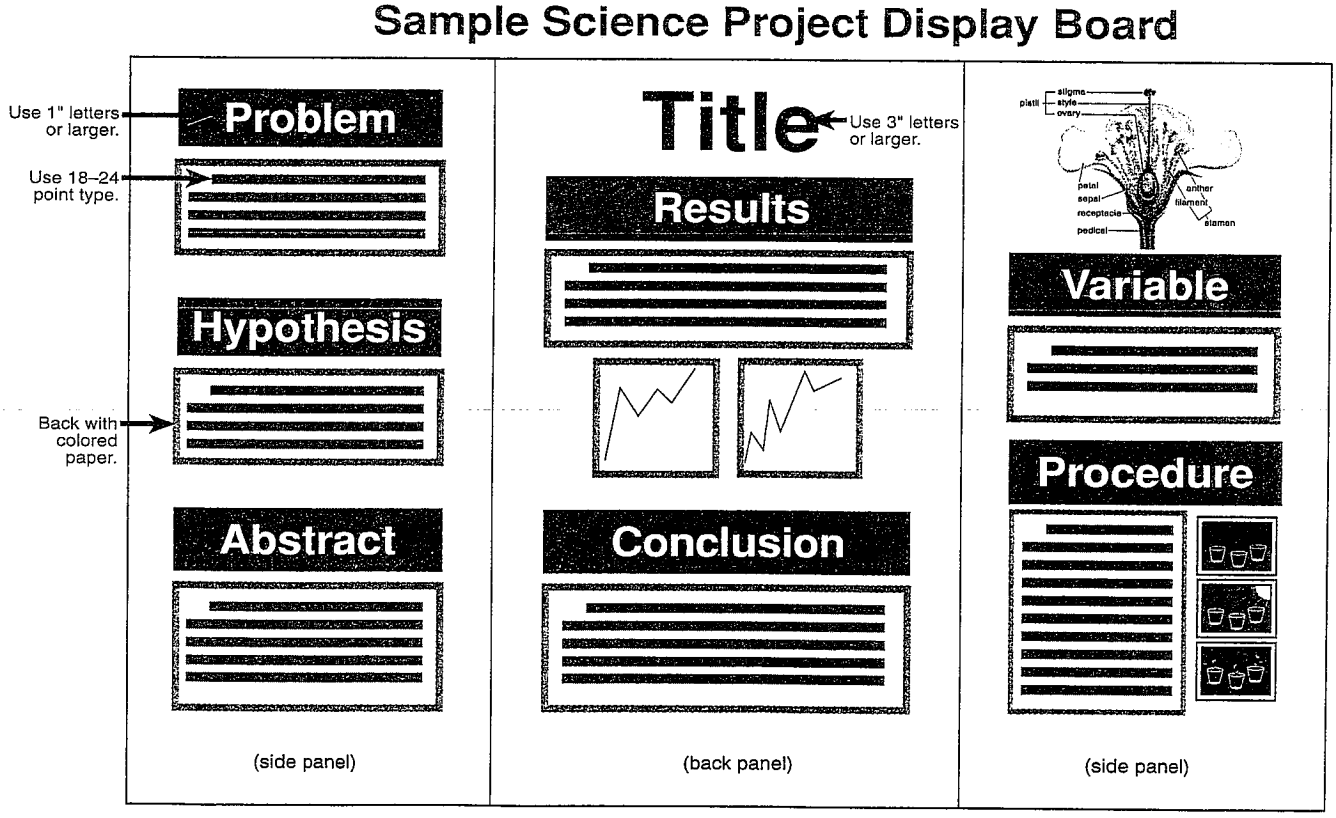
Your display board should contain a brief summary of each area of your investigation. Since your investigation is complete, you should write everything in past tense, using correct scientific terms. Do not oversimplify, but also do not be unnecessarily wordy. All measurements should be in metric units. If people were tested in the investigation, their names and/or photos should not appear anywhere on the display. Include the following information on the display board:

1. **Title**—an interesting, informative title. The following are some examples:
   Snail Trails;
   Fingerprints: The Invisible Signature;
   Get a Grip: Tire Tread;
   Does Microwave Radiation Affect Seed Germination?

2. **Problem**—a statement of the question/problem you have investigated
3. **Hypothesis**—what you believed to be the answer to your question/problem before you began the investigation
4. **Variable**—the one factor or condition that was present only in the experimental group
5. **Procedure**—a step-by-step description of how you performed your investigation. Include the materials that you used. Note that you should write this as a *list of numbered steps* rather than in paragraph form. Illustrate the steps with as many visuals (drawings or color photos) as possible to help explain what you did and what happened.
6. **Results**—a statement of the outcome supported by charts and graphs
7. **Conclusion**—a statement of your conclusion based on the outcome of your investigation; an explanation of whether your conclusion supports your hypothesis or not
8. **Abstract** (optional—see instructions at end of chapter)—a one-page summary of the investigation; may be required by your teacher and/or ISEF rules

If you did several experiments, describe the hypothesis, variable, procedure, results, and conclusion for each one. The diagram below shows one suggested organization of items on your display board. See sample of completed displays on pages 95 and 96.

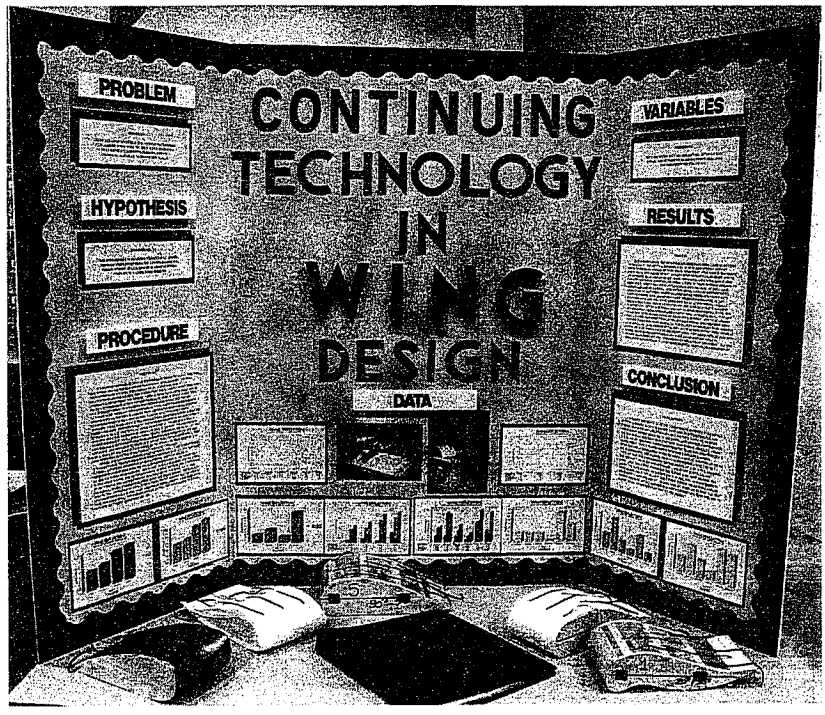
Sample Science Project Display Board



On Table: Science Project Notebook, Equipment, Display Items

How should the information be displayed?

1. Title letters should be at least 3" tall.
2. Subtitles (for Problem, Hypothesis, etc.) should be at least 1" tall.
3. All lettering should look professional. You may purchase preformed letters from hobby shops and art or school supply stores, or you may print out the proper-sized letters on a computer printer. If you cut out construction paper letters, they must be done neatly. For subheads, you can sometimes purchase sets of prepared headings from school supply stores.
4. Type all display board information. If you use a computer, use 18–24 point type (letters approximately $\frac{1}{4}$" tall) for as much of the typed information as possible. Your goal is that the typed information can be easily read 10–15 feet away from the display board; however, large type will not be practical for longer sections.
5. For longer printed sections such as Procedure, it may be necessary to mount typed sheets on top of each other. Staple them at the top so that the first sheet can be lifted to read the second sheet, etc.
6. Use a ruler to make sure that all items on your board (titles, printed sections, charts, photos, etc.) are mounted straight.
7. Use good quality glue or double-stick tape to mount items so that they will not become loose.



What are some suggestions for displaying a "top-notch" project?

1. Display color photos or diagrams that illustrate the procedure and/or results of the experiments.
2. Use pleasing color combinations. Utilize bright colors, borders, etc., to produce a vivid display. Contrast light and dark colors (i.e., a dark board with light lettering or a light board with dark lettering).
3. Position all charts and data in the center of the board high enough for judges to easily see. Leave 4" to 6" blank at the bottom of the display board.
4. You may choose to place additional information on a panel that can be attached to the display table on which your project will sit. The more information you display, the better your project will be. Include pamphlets or other factual materials that amplify the topic.

5. Do not display bacteria and fungi cultures or other potentially harmful substances. You may simulate these items or display photos of them, instead.
6. Display basic equipment and supplies used in the investigation. These items are usually displayed on the table in front of the exhibit. Make sure that they do not block the view of the display board.
7. Remember that the first impression your teacher, classmates, and judges will get of your investigation is by looking at your display. Make it look sharp to give a good first impression. Refer to your Science Project Exhibit Check to be sure you have not missed any details.

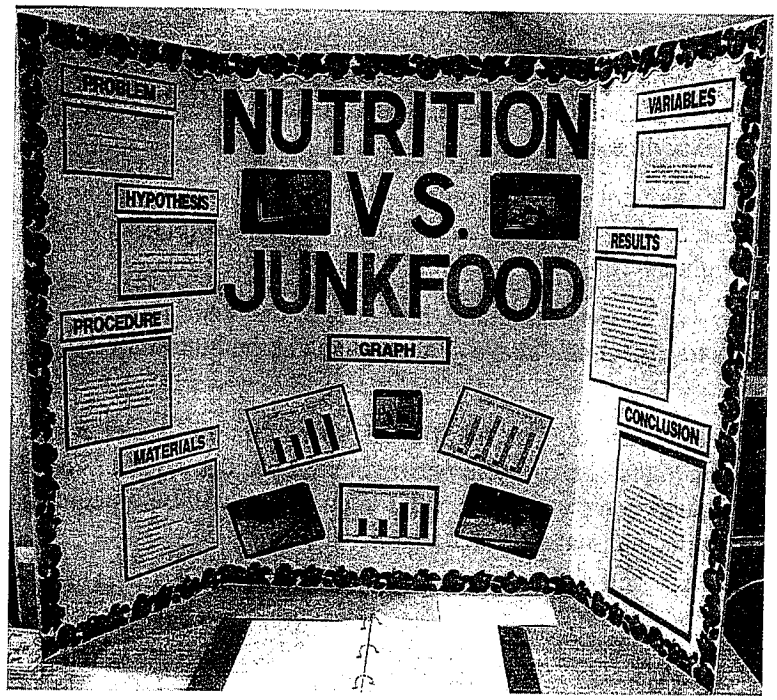
Where will I show my exhibit?

You will use the exhibit to present the project to your class during your oral presentation. Your exhibit allows you to show your work and what you have learned.

Your teacher may ask you to display your exhibit at a school science fair. An optional regional science fair may also be available in your area. Judges at both school and regional science fairs award prizes to the best projects, and these fairs are usually open to the public. Science fairs are valuable because they often give you an opportunity to discuss your project with the science teachers or professional scientists who have judged your project. If you are interested in learning more about your topic, the judges may have advice on how to further your investigation.

How do I prepare the Abstract? (optional)

The abstract is a one-page summary (200–300 words) of your investigation that others can read to get a clear understanding of your project and the results. It should include brief statements of your problem, hypothesis, materials used, and variable, as well as short descriptions of your procedure, results, and conclusion. The abstract will be similar to your Investigation Plan, but it will also include your results and conclusion. Do not be too detailed, but do include all pertinent information. A sample abstract form with instructions is provided on the following page.



ABSTRACT

TITLE (All Capitals)
Your Last Name, First Name, and Middle Initial
Sponsoring Teacher Name, School Name

(1) The entire abstract must fit within these margins which will accommodate approximately 250 words. Type abstract within limits indicated by the boundary lines.

(2) Type single-spaced. Make sure your type is sharp and dark.

(3) If the abstract is typed using a word processor or computer, set left and right margins each at 1.5" and top and bottom margins each at 1.5". Begin 1.5" from the top of the page. Begin Reference List 7.25" from the top of the page.

(4) The abstract is a summary of your project which should include:

- A statement of the purpose.
- A statement of the hypothesis.
- A brief description of methods and procedures (including control, constant factors, and variable).
- Observations, results, conclusions, and applications.

(5) Prepare and furnish copies of this Abstract.

- One copy should be placed in the Science Project Notebook.
- One copy should be placed on your display board.

REFERENCE LIST

List major sources of information in this space, including major interviews. There should be at least three or four entries.

Adapted from Florida state science fair guidelines.

Sample

ABSTRACT

THE EFFECT OF NITROGEN ON THE GROWTH OF RADISH PLANTS
Smith, John
Pensacola Christian Academy
Miss Catherine True

The purpose for this project was to determine the effect of nitrogen fertilizer on the growth of radish plants. My hypothesis was that nitrogen would help the plants to grow taller stems and produce more leaves.

Thirty small cups were filled with sandy soil and divided into 3 groups of 10 each. Three radish seeds were planted in each cup, and each cup was given 60 ml of water. The cups were placed in a sunny location and watered with 30 ml of water every other day.

When the plants were 2 weeks old, the two smallest seedlings in each cup were cut off at dirt level. Then two groups (Groups A and B) began receiving 30 ml of a nitrogen fertilizer solution every other day. Group A received a weaker concentration of fertilizer (3 ml/l), and Group B received a stronger concentration of fertilizer (15 ml/l). The third group of plants (control) received no fertilizer. The constant factors were the type of soil, type of plant used, the number of seeds per cup, the location of the cups, the amount of water given, and the age of plants when fertilizer was first applied. The variable factor was the concentration of the fertilizer.

To determine the effect of the fertilizer on the plants, height measurements and leaf counts were made weekly. At the end of 12 weeks, the group of plants that received the highest concentration of nitrogen, Group B, had grown 2.2 cm more than Group A had grown and 3.5 cm more than Group C had grown. These results seem to indicate that nitrogen does stimulate growth. My results did not show a significant effect on the number of leaves.

REFERENCE LIST

Bale, Jeff. *Rodale's Garden Problem Solver.* Emmaus, Penn: Rodale Press, 1988.

Janick, Jules. *Horticultural Science.* 3rd ed. W. H. Treeman and Co., 1979.

Slack, A. V. *Defense Against Famine: The Role of the Fertilizer Industry.* New York: Doubleday and Co., 1970.

Name _____

Science Project Exhibit Check

The following checksheet will aid you in the final stages of preparing your Science Project Exhibit.

Check off each item as completed.

Exhibit

_____ 1. Display board cut to proper size

_____ 2. Board one-eighth inch thick or thicker

_____ 3. Board painted, stained, prefinished, or covered in felt

_____ 4. Board hinged for folding

_____ 5. Arrangements made for electrical outlet (if needed)

_____ 6. All electrical circuits correctly wired

_____ 7. Machines and other operating devices properly shielded for safety

_____ 8. Pictures or other objects used instead of restricted items in exhibit

_____ 9. Bright colors and/or borders used

Lettering

_____ 1. Title in large letters

_____ 2. Subtitles in smaller letters

_____ 3. All lettering neat and professional looking

_____ 4. All information typed (using large type where possible)

Arrangement of materials

_____ 1. Appearance uncluttered

_____ 2. 4 to 6 inches of space blank at the bottom of the display board

_____ 3. Charts and results centered near top of board

_____ 4. Items mounted straight

_____ 5. Items attached tightly and neatly to board

(continued on next page)

Content

_____ 1. Interesting title

_____ 2. Clear statement of problem, hypothesis, variable, and procedure

_____ 3. No names or photos of people tested

_____ 4. Charts, diagrams, and other visuals and/or illustrations included

_____ 5. Color photos or drawings of procedures and results

_____ 6. Equipment shown

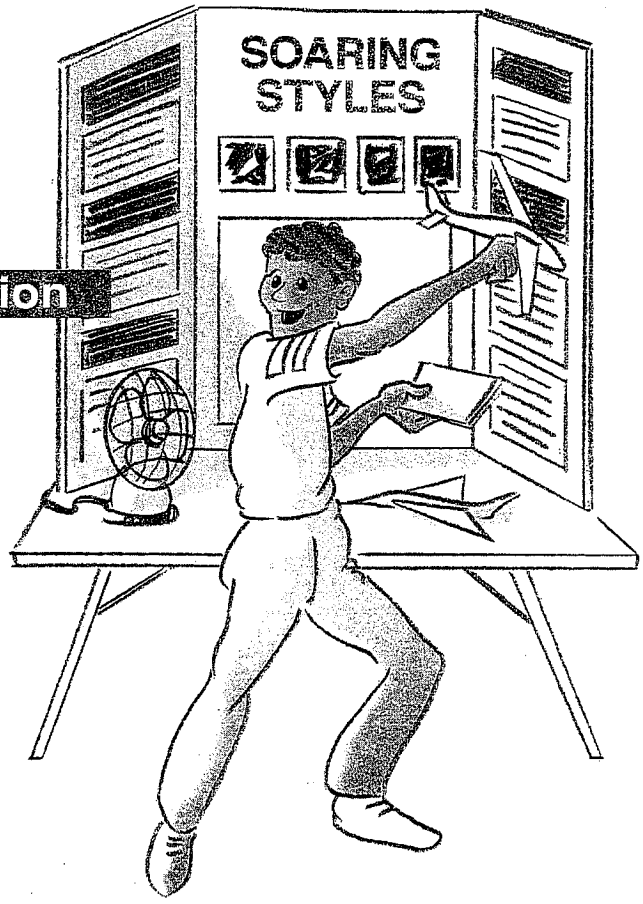
_____ 7. A clear statement of conclusion that shows you understood and interpreted the results/data correctly

CHAPTER 5

Presenting Your Science Project

Oral Presentation

The oral presentation is the last part of your science project. The purpose of this presentation is to tell your class the story of your investigation in a clear, interesting way. Your exhibit is an important visual aid in your presentation. You will refer to it often as you explain your project.



Organizing the Presentation

Your presentation should include the following sections:

1. **Introduction**—an interesting *opening statement* to catch everyone's attention, followed by an *explanation of the topic* of the investigation. Your explanation should introduce your topic and give basic information about it. This part of the presentation is actually a miniature lesson in which you teach the class about your topic. Include enough general information from your Background paper to set the stage for the explanation of your investigation.
2. **Problem / Hypothesis**—an explanation of the *problem* you investigated and your *hypothesis*
3. **Procedure**—an explanation of the *steps followed* to complete the investigation. If possible, demonstrate the steps and show the equipment that you used. Include any interesting things that occurred during your investigation. Tell how you overcame problems which arose.
4. **Results**—an explanation of the *outcome* of the investigation and how you graphed or charted the results on the board
5. **Conclusion**—an explanation of the *conclusion* you reached based on the results shown in your charts and graphs. Include whether your results support your hypothesis. Mention *practical applications* that you can see for this investigation.

Preparing for the Oral Presentation

How long should my presentation be?

The oral presentation has a minimum and maximum time requirement. The time allowed for questioning by your audience is not counted as a part of your time requirement.

Suggested Time Guidelines (in Minutes)

Grade	Minimum	Maximum
7	3	5
8	4	6
9	5	7
10	6	8
11	7	9
12	8	10

How do I prepare the presentation?

Step 1: **Organize** your thoughts, deciding what facts and information you should give for each section of your presentation.

Step 2: Since you will not be reading your presentation, **prepare note cards** to refer to as you speak. Include main points, facts, and figures.

Step 3: **Practice** your presentation at least 3 times so that you will stay within the time guidelines. Have someone watch your presentation and give suggestions. You might even want to videotape a practice session so that you can see where you need to improve. Be positive about your investigation, even if you did not enjoy it.

How can I make my presentation effective?

1. Speak freely without being tied to notes. This is accomplished by practicing the presentation several times at home to master explanations and timing.
2. Speak clearly and make eye contact with your audience.
3. Show equipment items by holding them up and by carefully pointing to key parts.
4. Stand at the side of the display while referring to graphs, charts, and other exhibit items. Do not turn your back to the class or stand in front of the part of the exhibit to which you are referring.
5. Be ready to answer questions about your work from your classmates and teacher.

What do I need on the day of my presentation?

1. Your **note cards** for what you are going to say
2. Your **exhibit**
   a. Display board
   b. Science Project Notebook
   c. Models and/or equipment that are part of your exhibit
   d. Double-stick tape or glue to reattach anything that may come loose
3. **Worksheets and Grade Forms**
   a. Exhibit Grade Form
   b. Oral Presentation Grade Form

Name _____ _____

Oral Presentation Check

Check off each item as you complete it.

Content—My presentation has the following elements and I know what I plan to say for each of them.

_____ Interesting introduction

_____ Section in which I teach the class about my topic

_____ An explanation of my investigation

_____ Problem/Hypothesis

_____ Procedure

_____ Results

_____ Conclusion

Practice

_____ I have practiced my presentation at least 3 times.

_____ I have practiced my presentation for a parent or friend who has given me suggestions for improvement.

_____ I have practiced the appropriate way to show my equipment and point to graphs, charts, and illustrations on my display board.

_____ I have timed my presentation and am able to fit it into the appropriate time.