SCIENCE FAIR PHILOSOPHY

Science fair is a time for students to develop and explore their own questions in science. Through the scientific method, they have the tools they need to investigate their curiosities. Please remember to foster this process of inquiry and the joy of science. It is not about the competition, but about the pleasure of discovery and doing their personal best. Sincerely, Maried C. Swapp, Science Coordinator

SCIENCE FAIR MANUAL COMMITTEE

Linda Workman, Chairperson Northeast Middle
Pam Bogosian Barretts
Joyce L. Evans Southwest Middle
Ann Hansen Barretts
Rita Hawkins Hanna Woods
Diane Rich Northeast Middle
Rosemary Tomlovic South Middle
Jeanne Ryan Wanner Central High

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*This applies only to Middle and High School Students

PARKWAY SCIENCE FAIR WEBSITE

http://www.pkwy.k12.mo.us/C_l/science/fair.html
SCIENCE PROJECT TIME LINE

Here is a time line to help you complete the steps of your project. Be sure to read and follow the instructions in this guide and to check the Science Project Scoring Guide as you work through each step of your project.

<table>
<thead>
<tr>
<th>Date Due</th>
<th>Completed</th>
<th>Steps</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Begin a log book. Write down possible topics and ideas for your project.</td>
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<td>Select a topic and choose your study design.</td>
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<td>Gather background information about the history, significance, facts, and methods of study for your topic. Prepare a bibliography of your sources.</td>
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<td>Decide on the problem and the hypothesis. Define your independent variable (IV), dependent variable (DV), and constant variables (CV's).</td>
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<td>List the materials and write the procedure.</td>
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<td>Collect the materials you will need (including display board) and do a trial run of your procedure to be sure that it is going to work as planned.</td>
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<td>Prepare a data table for recording results.</td>
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<td>Run at least THREE trials of your procedure and collect data using metric measurements. Take photographs or draw pictures being sure NOT to include peoples’ faces.</td>
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<td>Construct a graph that shows the averages of your results and write a summary of your findings.</td>
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<td>Write the conclusion and discuss the scientific worth of your project.</td>
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<td>Write the project report (secondary only).</td>
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<td>Prepare the items for the display and arrange them attractively on the board.</td>
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Your completed science fair project is due on ___________________. 
CATEGORIES OF SCIENCE FAIR STUDIES

Behavioral/Social Science (BBS)
Any study such as is done by sociologist, anthropologists, psychologists, linguists, etc. that examines animal activities to discover recurrent patterns. For example: trigger of fear, learned behavior, actuality of prejudice, effect of color on choice, pecking order, group size. Because of protocol restrictions it is better to do observational studies in natural settings.

Biochemistry (BBC)
The chemistry of life processes such as respiration, photosynthesis, enzymes, diffusion etc. Study focuses on the chemicals and their reactions. For example reactants or products of processes, conditions which enable or regulate rate of reaction. All types of investigation design is possible in this category: collection, observation, model, experiment, and invention.

Botany (BBO)
Studies of plants, their life cycle, structure, growth, processes, and classification. Sciences of agriculture, agronomy, taxonomy, etc. For example: algae growth, leaf gas exchange, power of swelling seeds, germination, development sequence, tropism responses. All types of investigation design are possible: collection, observation, model, experiment, and invention.

Environmental Science (BEV)
Response of living organism to man-altered or to nature-altered environment. For example: pollution effects, disaster effects, profile of organism density in a specific environment. The experiment type of investigation is generally done in this category.

Medicine and Health (BMH)
Studies of diagnosing, improving, and preserving health. Includes disciplines such as medicine, dentistry, ophthalmology, nutrition, speech, hearing, etc. For example: monitoring health aspects of persons enrolled in diet or body-building programs, checking for hearing or sight loss. Because of protocol the types of investigations which are most often done are collections, observations, or models.

Microbiology (BMB)
Studies of microorganisms such as algae, fungi, protozoans, virus and bacteria and their life processes. For example: bacteria in milk, water or soil, growth rates, identity of organisms. Five types of studies can be done in this category. Be careful of pathogenic agents which require protocol.

Zoology (BZO)
Study of animals, life cycle, anatomy, classification. Includes herpetology, entomology, husbandry, etc. For example: identify, classify, earthworm growth, butterfly life cycle, unique structure. All five types of studies can be done. Beware of protocol required for vertebrates.

Chemistry (PCH)
Study of matter, its composition and its interactions. Includes inorganic and organic matter, natural and man-altered materials. For example: PH of household substances, controlling rate of reaction, producing a desired substance. All five types of studies are possible: collection, observation, model, experiment, and invention. Be careful of dangerous chemicals.

Mathematics (PMC)
Math projects deals with numbers; types, relationships, and manipulation. Includes algebra, geometry, calculus. For example: abacus design, pattern of repeating decimals, families of numbers. Collection, models, and inventions are used frequently.

Computer Projects
Studies which modify or use the hardware or software in a new way. For example: using an application in a new way. Collections, models, and inventions are used.

Physics (PPH)
Deals with the energy of matter interactions. Includes motion, mechanics, electricity, sound, light, etc. For example: forces on a falling object, trajectory of an object, electrical circuits, etc. All five types of investigations are used.
SCIENCE FAIR PROJECT IDEAS

Physical Science

1. Which detergent breaks up oil the best?
2. Which detergent makes the most bubbles?
3. How does the wattage of a light bulb affect energy use?
4. Which brand of glue holds two boards together best?
5. Which brand of diaper holds more water?
6. Which type of battery makes toys run longest?
7. How does tire pressure affect how far a bicycle will coast?
8. How does road surface affect the stopping distance of your bicycle?
9. How is the frequency of pendulum swings affected by the length of the pendulum?
10. What material conducts sound best—metal, water, wood?
11. How does the shape of an object affect the time it takes to fall to the ground?
12. How does the shape of an ice cube affect its melting time?
13. How does the beginning temperature of water affect the time it takes to freeze?
14. How does the thickness of a liquid affect evaporation rate?
15. How does structure affect bridge strength?
16. How does wheel size affect the speed of a skateboard?
17. What form of yeast makes bread rise fastest?
18. Does change in temperature affect the bounce of a ball?
19. Which fabrics absorb dye best?
20. How is water temperature affected by water depth?
21. How does exposure to sunlight affect the size of an inflated balloon?
22. How does wetting paper affect its strength?
23. How is the amount of water a sponge absorbs affected by the temperature of the liquid to be absorbed?
24. How is the size of a baked cookie affected by substituting butter or margarine for shortening in the recipe?
25. How does surface texture affect the bounce of a ball?
26. What method of popping (microwave, oven, stove top, etc.) pops the most popcorn?
27. Does salt affect the freezing and boiling points of water?
28. Does solution concentration affect crystal formation?
29. How are various terrains affected by erosion?
30. How does acid rain affect crops?
31. What type of material would cause a parachute to fall fastest?
32. What is the best method of purification?
33. What type of battery is longest lasting?
34. Does size and shape affect how long candles burn?
35. Is there a predictable manner in which numbers come up with dice.
36. Is it possible to predict the direction of a resting pool ball hit by a moving pool ball? (Inertia)
37. Which color absorbs more heat?
38. How can levers and pulleys be used to do more work?
39. How surface area affects the rate of evaporation.
40. How does a length of wire in a circuit affect the brightness of the lights?
41. What different materials conduct electricity best?
42. How is dissolving time affected by temperature of the liquid?
43. Which materials rust the quickest?
44. What is the best angle for a solar collector?
45. What materials are the best insulators?
46. Compare various samples of soil for nitrogen, phosphorus, and pH
47. Which fabrics absorb moisture fastest?
48. Does the moon rise every night at the same time and in the same location in the sky?
49. How accurate are long-range weather forecasts?
50. From which direction does the wind blow most frequently?
51. What is the best shape for a kite?
52. Which holds two material together better, a screw or a nail?
53. Do all objects fall at the same speed?
54. How is the distance a cart rolls affected by the mass in the cart?
55. How does the length of a vibrating body affect sound?
56. How does the design of a paper airplane affect its flight?

Biological Science

1. How is mold growth affected by the amount of moisture?
2. How does soil type affect plant growth?
3. Does the use of insecticides or herbicides affect the growth of plants?
4. Photosynthesis (can test many factors that affect photosynthesis, including the effects of light, colored cellophane, amount of starch produced, etc.)
5. What are the effects of various chemicals on the growth rate of plants?
6. Seed germination (how it is affected by temperature, depth of planting, moisture, and fertilizer).
7. What is the relationship between temperature and the rising time of yeast dough?
8. How is a plant affected by a deficiency of various nutrients?
9. Hydroponics: Can a plant be grown without soil? Will plants grow better in soil or water?
10. What foods contain the most moisture? (using dehydration)
11. What plants best prevent soil erosion?
12. How do the moon phases affect plant germination?
13. How fast do roots grow?
14. What is the effect of chlorinated water on plant growth?
15. Will frozen seeds sprout?
16. How do the number of seeds produced by different plants compare?
17. What can be done to increase the decomposing rate of plants?
18. Do living plants give off moisture?
19. Do living plants give off oxygen?
20. Effects of temperature on meal worm production.
21. What kind of animal life can be found in one square meter of backyard soil?
22. How do meal worms respond to light?
23. How does an earthworm react to light and darkness?
24. Do different kinds of caterpillars eat different amounts of food?
25. Do mint plants repel insects?
26. What color of flowers attract hummingbirds best?
27. What colors attract moths and other insects at night?
28. Does temperature affect the flash rate of fireflies?
29. Which grows faster, body hair or scalp hair?
30. How do fingerprints differ?
31. Do all people have the same normal body temperature?
32. Are certain dominant traits exhibited in the same family?
33. Who has bigger hands, boys or girls?
34. How accurately can you tell the temperature of an object by touch?
35. Who are generally taller-boys or girls?
ACKNOWLEDGEMENTS - Statements which give recognition to anyone who helped with the project. General terms such as "teacher", "parent", "specialist", "expert", should be used in place of individuals’ names.

BACKGROUND INFORMATION - Report which contains information collected from research notes.

BIBLIOGRAPHY - Alphabetical list of the resources used when completing research notes that is written in a special way listing authors, titles, publisher, pages etc.

CONCLUSIONS - Statements that summarize the experiment and relate the results to the hypothesis and the background information.

CONSTANT VARIABLES - The many parts of the experiment that are kept the same during all tests.

CONTROL - The part of the experiment with no change to the independent variable.

DATA TABLE - Metric measurement of each of the trials recorded in columns, plus two additional lines at the bottom showing the total and average of each of the trials. The data table should have a title which is labeled with the dependent variable and the independent variable.

DEPENDENT VARIABLE - The condition in the experiment that is watched and measured. The results of the tests should be recorded in metric measurement, when applicable.

DISPLAY BOARD - Three-sided, free-standing board with attached base; it displays the parts of the project.

FUTURE STUDY - A statement which tells what you might do if you decide to perform this experiment again.

GRAPH - A bar or line graph of the averages shown on the data table. The horizontal or "X" axis is labeled with the independent variable. The vertical or "Y" axis label is labeled with the dependent variable. A title should be written at the top.
HYPOTHESIS - A prediction or educated guess about the expected results of the experiment. It is written with "If " as the first word in the statement, "then" in the middle of the statement.

INDEPENDENT VARIABLE - The part of the experiment that is changed and tested as the experiment is done three different ways. Example: three different brands of popcorn that are being tested - each of them with at least three trials.

LOG BOOK - Daily diary of every step of the experiment which is generally handwritten. It includes dates, notes, data, interviews, thoughts or reflection. Pages must be numbered.

PROBLEM - A question that asks what will be tested in the experiment.

PROCEDURE - A list of the materials used in the experiment and the exact steps done to complete the experiment. This part is to be written carefully so that if another person were to perform the test, he/she could follow the procedure easily.

RESEARCH NOTES - Collections of information about the experiment that come from encyclopedias, CD-ROM encyclopedia printouts, science books, library books, magazines, interviews, etc.

SCIENTIFIC WORTH - Statements that assess the quality of a study and describes any scientific advantage to knowing the results.

SUMMARY OF RESULTS - One or two statements which explain the graph.

TITLE - Cleverly written words used as an attention-getter on the display board.

TRIAL - One entire run of the experiment with a control and each alteration of the independent variable. A minimum of three trials is needed.
Project Scoring Guide

TOTAL SCORE:  
Elementary ____/100  
Secondary ____/125

Display (15 points)  ALL EXHIBITS

Display is easily viewed, faces forward, materials easily read in a top to bottom/left to right order. ____ / 2
All sections of study design are clearly labeled with bold print. ____ / 2
Attractive. Good use of color and graphic design. Very neat. ____ / 2
Clear and concise writing. Correct grammar and spelling. ____ / 4
Creative approach - Evidence of student’s original and creative input (unique display or an unusual topic or novel approach.) ____ / 5

Written Report (25 points)  SECONDARY PROJECTS ONLY

Standard Sections
Background Information, Procedure, Results (with data tables and graphs), Conclusion/Scientific Worth, Bibliography ____ /15

Correct Format
Writing style is clear, concise, and objective; report is neatly typed on 8.5” by 11” white, unlined paper; report is in either a folder or notebook; section titles are present. ____ /10

Judge Question & Answer

Q: Refresh my memory on what an IV, DV, and CV are?
A: IV=Independent variable remember as the ‘I vary variable’ What was changed?
DV=Dependent variable remember as the ‘data variable’ What was watched and recorded?
CV=Constant variable or CC=constant conditions What needed to remain the same?

Q: By what standards should I judge projects?
A: Make sure that your expectations match the grade level. Be fair and follow the points recommend for each section. Remember to reward a student’s curiosity and creativity.

Q: Can a student’s name or picture be present on the project?
A: No. No names are allowed in the project or report and pictures may not show faces.

Q: Does the log book have to be hand-written?
A: It is preferred that it is hand-written, even messy, but this is not required.

Q: What do I do if the report is missing on a secondary project, but all parts are on the board?
A: They still loss the 25 points for the formal writing experience is required for 6-12 grades.
**Collection Study** (the purpose is to collect and identify a set of natural objects)

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<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Score</th>
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<tbody>
<tr>
<td><strong>Log Book (15 points)</strong></td>
<td>A start-to-finish, dated record of all work done on the project. Includes personal thoughts, interviews, reading notes for background information. Recorded plans, actions, data, observations and conclusions.</td>
<td>____ / 5</td>
</tr>
<tr>
<td><strong>Background Information (10 points)</strong></td>
<td>Presented in the student’s own words. History of people and findings related to the topic (as appropriate). Significance of topic (What is important or valuable about this study? Why is it worth doing?) Facts such as major terms and definitions and procedural information about special methods, equipment, or measurement units. Minimum of three sources (Elementary) or five sources (Secondary). Works are cited in the bibliography using correct format.</td>
<td>____ / 4</td>
</tr>
<tr>
<td><strong>Problem (or Purpose) (5 points)</strong></td>
<td>Why is the collection being made? What question do you want to answer while collecting?</td>
<td>____ / 5</td>
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<tr>
<td><strong>Hypothesis (or Prediction) (5 points)</strong></td>
<td>An “I think I will find …” statement predicting specific results</td>
<td>____ / 5</td>
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<tr>
<td><strong>Procedure (10 points)</strong></td>
<td>Where, when and how of the study? List the steps to replicate the collection. Explain how recording will be done. Uses metric units if measurements are involved. (Points are not deducted if metric units are not appropriate.)</td>
<td>____ / 5</td>
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<tr>
<td><strong>Number of Items (10 points)</strong></td>
<td>Enough items are collected to demonstrate diversity and respond to the problem.</td>
<td>____ /10</td>
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<tr>
<td><strong>Identification (10 points)</strong></td>
<td>All objects are labeled correctly.</td>
<td>____ /10</td>
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<tr>
<td><strong>Results (10 points)</strong></td>
<td>Diagram or table shows the use of characteristics to classify and identify items. Diagram or table has title, labels and appropriate units.</td>
<td>____ / 5</td>
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<tr>
<td><strong>Conclusion (5 points)</strong></td>
<td>Statement describes what was learned and links to the background information.</td>
<td>____ / 5</td>
</tr>
<tr>
<td><strong>Scientific Worth (5 points)</strong></td>
<td>Student reflects on following the procedure and on improvements/extensions for future study. (These elements may be found in conclusion or log book.)</td>
<td>____ / 5</td>
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**Observation Study** (the purpose is to find a pattern of events)

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<th><strong>Log Book (15 points)</strong></th>
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<tr>
<td>A start-to-finish, dated record of all work done on the project.</td>
<td>___ / 5</td>
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<td>Includes personal thoughts, interviews, reading notes for background information.</td>
<td>___ / 5</td>
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<tr>
<td>Recorded plans, actions, data, observations and conclusions.</td>
<td>___ / 5</td>
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<thead>
<tr>
<th><strong>Background Information (10 points)</strong></th>
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<tr>
<td>Presented in the student’s own words.</td>
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<tr>
<td>History of people and findings related to the topic (as appropriate). Significance of topic (What is important or valuable about this study? Why is it worth doing?)</td>
<td>___ / 4</td>
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<tr>
<td>Facts such as major terms, definitions and the event being observed and procedural information about special methods, equipment, or measurement units</td>
<td>___ / 4</td>
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<tr>
<td>Minimum of three sources (Elementary) or five sources (Secondary) Works are cited in the bibliography using correct format.</td>
<td>___ / 2</td>
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<thead>
<tr>
<th><strong>Problem (5 points)</strong></th>
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<tr>
<td>Why are the observations being made? Clearly stated question about the IV-DV relationship.</td>
<td>___ / 5</td>
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<tr>
<th><strong>Hypothesis (5 points)</strong></th>
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<tr>
<td>An “If......, then....” statement that predicts the expected IV-DV relationship.</td>
<td>___ / 5</td>
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<tr>
<th><strong>Procedure (10 points)</strong></th>
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<tr>
<td>Includes the where, when and how of observations (CV), what IVs are selected to be observed, and DVs to be recorded.</td>
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<td>All materials are listed with quantities needed for the entire observation. Uses metric units if measurements are involved.</td>
<td>___ / 5</td>
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<tr>
<th><strong>Observations (20 points)</strong></th>
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<td>Actual observations (drawings and words) are included.</td>
<td>___ / 10</td>
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<td>There is evidence that enough observations were used to support/not support expected outcome in hypothesis.</td>
<td>___ / 10</td>
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<tr>
<th><strong>Results (10 points)</strong></th>
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<tr>
<td>Diagram or table of organized observations shows the IV-DV pattern.</td>
<td>___ / 5</td>
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<tr>
<td>Diagram or table has title, labels and appropriate units.</td>
<td>___ / 5</td>
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<tr>
<th><strong>Conclusion (5 points)</strong></th>
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<tr>
<td>Statement describes what was learned and links to background information.</td>
<td>___ / 5</td>
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<th><strong>Scientific Worth (5 points)</strong></th>
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<td>Overall plan is thorough, follows plan, comments on consistency of data, gives possible future study. (These elements may be found in conclusion or log book.)</td>
<td>___ / 5</td>
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**Model Study** (the purpose is to learn about an object by building a scale or functional model)

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<th>Section</th>
<th>Points</th>
<th>Description</th>
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<tr>
<td><strong>Log Book (15 points)</strong></td>
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<td>A start-to-finish, dated record of all work done on the project. Includes personal thoughts, interviews, reading notes for background information. Recorded plans, actions, data, observations and conclusions.</td>
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<tr>
<td><strong>Background Information (10 points)</strong></td>
<td></td>
<td>Presented in the student’s own words. History of people and findings related to the topic (as appropriate). Significance of topic (What is important or valuable about this study? Why is it worth doing?) Facts such as major terms, definitions and photo or drawing of the real object; procedural information about special methods, equipment, or measurement units. Minimum of three sources (Elementary) or five sources (Secondary). Works are cited in the bibliography using correct format.</td>
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<tr>
<td><strong>Problem (or Purpose) (5 points)</strong></td>
<td></td>
<td>Why is the model being made? What question do you want to answer by building the model?</td>
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<tr>
<td><strong>Hypothesis (or Prediction) (5 points)</strong></td>
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<td>An “I think my model will show …” statement that predicts how the model will be similar to the actual object or event</td>
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<tr>
<td><strong>Procedure (10 points)</strong></td>
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<td>Includes where, when and how the model is built and whether it is a workable or scale model. Procedure gives numbered steps that would allow exact duplication of the model. Drawings will be completed for the model. All materials are listed with quantities needed. Uses metric units if measurements are involved.</td>
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<tr>
<td><strong>Construction (20 points)</strong></td>
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<td>Photographs and log statements are made throughout the construction. The model demonstrates quality of design and construction.</td>
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<tr>
<td><strong>Results (10 points)</strong></td>
<td></td>
<td>Model parts accurately relate to real object(s). Model is tested for workability or scale (Photographs showing scale and function).</td>
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<tr>
<td><strong>Conclusion (5 points)</strong></td>
<td></td>
<td>Statement describes what was learned and links to background information.</td>
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<tr>
<td><strong>Scientific Worth (5 points)</strong></td>
<td></td>
<td>Student reflects on following the procedure and on improvements/extensions for future study. (These elements may be found in conclusion or log book.)</td>
</tr>
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</table>
**Experiment Study** (the purpose is to study a cause-effect relationship)

### Log Book (15 points)
- A start-to-finish, dated record of all work done on the project. __________ / 5
- Includes personal thoughts, interviews, reading notes for background information. __________ / 5
- Recorded plans, actions, raw data, observations and conclusions. __________ / 5

### Background Information (10 points) Presented in the student’s own words.
- History of previous findings related to the topic (as appropriate). Significance of topic (What is important or valuable about this study? Why is it worth doing?) __________ / 4
- Facts such as major terms, definitions and the process or cause-effect involved and procedural information about special methods, equipment, or measurement units. __________ / 4
- Minimum of three sources (Elementary) or five sources (Secondary). Works are cited in the bibliography using correct format. __________ / 2

### Problem (5 points)
- Why are you doing this experiment? Clearly stated question about the IV-DV relationship __________ / 5

### Hypothesis (5 points)
- An “If....., then....” statement that predicts the expected IV-DV relationship __________ / 5

### Procedure (15 points)
- Variables are clearly identified (What is the IV and how was it changed? What is the DV and how was it measured? What CV’s were held constant?) __________ / 5
- All materials are listed. Procedure gives numbered steps that would allow duplication of the experiment. May be found in report or log book. __________ / 5
- Uses metric units if numerical measurements are involved. (Points are not deducted if metric units are not appropriate.) __________ / 5

### Trials and Samples (10 points)
- There is evidence that enough trials and samples (minimum of three repetitions) were used to support/not support expected outcome in hypothesis. __________ / 5
- The control is identified, clearly described, and used as a comparison for at least three alterations of the IV. (Some experiments may not lend themselves to a control. Experimenters should not be penalized.) __________ / 5

### Results (10 points)
- Data table shows changes of the IV and data for the DV in each trial/sample.
  - Data table has title, labels and appropriate units. __________ / 3
- Graph shows IV-DV relationship.
  - Graph title identifies the IV-DV relationship, shows IV on the x-axis and DV on the y-axis, and uses averaged values. Axes are correctly labeled and include units. __________ / 5
- Written summary of results is included. __________ / 2

### Conclusion (10 points)
- Reaction to hypothesis is consistent with results. __________ / 5
- Includes link to hypothesis and background information; explains significance of results. __________ / 5

### Scientific Worth (5 points)
- Student reflects on following the procedure and on improvements/extensions for future study. (These elements may be found in conclusion or log book.) __________ / 5
**Invention Study** (the purpose is a specification set for a model or experiment) - Mostly Engineering, Math, and Computer projects.

### Log Book (15 points)
A start-to-finish, dated record of all work done on the project.  
Includes personal thoughts, interviews, reading notes for background information.  
Recorded plans, actions, data, observations and conclusions.  

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log Book</td>
<td>5</td>
</tr>
<tr>
<td>Includes personal thoughts, interviews, reading notes for background information.</td>
<td>5</td>
</tr>
<tr>
<td>Recorded plans, actions, data, observations and conclusions.</td>
<td>5</td>
</tr>
</tbody>
</table>

### Background Information (10 points)  
Presented in the student’s own words.

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of people and findings related to the topic (as appropriate).</td>
<td>4</td>
</tr>
<tr>
<td>Significance of topic (What is important or valuable about this study? Why is it worth doing?)</td>
<td>4</td>
</tr>
<tr>
<td>Facts such as major terms and definitions and procedural information about special methods, equipment, or measurement units.</td>
<td>4</td>
</tr>
<tr>
<td>Minimum of three sources (Elementary) or five sources (Secondary). Works are cited in the bibliography using correct format.</td>
<td>2</td>
</tr>
</tbody>
</table>

### Problem (or Purpose)  
Clearly stated question or statement of purpose for the invention

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem (or Purpose)</td>
<td>5</td>
</tr>
</tbody>
</table>

### Hypothesis (or Prediction)  
An “I think my invention will be able to …” statement that predicts how my invention solves the problem.

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesis (or Prediction)</td>
<td>5</td>
</tr>
</tbody>
</table>

### Procedure (20 points)
Includes how the invention is designed and whether it is workable.

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure</td>
<td>20</td>
</tr>
<tr>
<td>Includes how the invention is designed and whether it is workable.</td>
<td>10</td>
</tr>
<tr>
<td>All materials are listed with quantities needed.</td>
<td>5</td>
</tr>
<tr>
<td>List steps that indicate how controlled trials will be conducted as the invention is tested and modified.</td>
<td>5</td>
</tr>
</tbody>
</table>

### Trials and Samples (10 points)
There is evidence that enough tests and/or samples (minimum of three repetitions) are used to support/not support expected outcome in hypothesis.

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials and Samples (10 points)</td>
<td>10</td>
</tr>
<tr>
<td>Uses a control (no invention/prior invention) to compare student invention</td>
<td>5</td>
</tr>
</tbody>
</table>

### Results (10 points)
Graph shows modifications to the invention (IV) and the results (DV) in each trial. (Bar graph if IV is words; line graph if IV is numbers)

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results</td>
<td>10</td>
</tr>
<tr>
<td>Graph shows modifications to the invention (IV) and the results (DV) in each trial. (Bar graph if IV is words; line graph if IV is numbers)</td>
<td>5</td>
</tr>
<tr>
<td>Graph has title, labels and appropriate units.</td>
<td>5</td>
</tr>
<tr>
<td>Graph title identifies the IV-DV relationship, shows IV on the x-axis and DV on the y-axis, and uses averaged values. Axes are correctly labeled and include units.</td>
<td>3</td>
</tr>
<tr>
<td>Written summary of results is included.</td>
<td>2</td>
</tr>
</tbody>
</table>

### Conclusion (5 points)
Statement describes what was learned and links to background information.

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conclusion</td>
<td>5</td>
</tr>
</tbody>
</table>

### Scientific Worth (5 points)
Student reflects on following the procedure and on improvements/extensions for future study. (These elements may be found in conclusion or log book.)

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific Worth</td>
<td>5</td>
</tr>
</tbody>
</table>
HOW TO DO A SCIENCE FAIR PROJECT

Begin a Log Book

The log book is a hand-written start to finish dated record of all work done on a project. It is generally hand-written with all pages numbered in the top right corner. It is to contain detailed notes of every step of the project from beginning to end - all notes on background information, all observations, all plans and actions, all data, and all thoughts, reflections, and conclusions. You may acknowledge those who helped you but refer to them as “teacher,” “parent,” etc. Do not include names of any people in your log book, report, or on your display. The log book is the single most valued piece of work in your project. Your log book begins with a record of possible topics and ideas, areas of interest, and a brainstorming list of possible problems to study. You always keep your log book with you whenever you work on your project. It is your personal record of your science fair project.

INCLUDE:

READING NOTES, ARTICLES, AND DATA

Any information you gather for your research goes in this section. Your notes and recorded data belong here as well.

DECISIONS, ACTIONS, OBSERVATIONS

I’ve decided to experiment with plants.

ACTIONS

Today I went to the library to find books on my topic. I found a lot of books,......

I set up my planters and grow lights, and I took pictures of them to show my progress.

OBSERVATIONS

I noticed that the plants are starting to wilt, so I need to water them more.

The crystals are very fragile, so I can’t put them on my display. I will need to take lots of pictures.

THOUGHTS AND REFLECTIONS

I noticed that many of the seedlings are dying. I wish I used more seeds. I'm worried that all my plants will be dead before the experiment is finished.
**Select a Topic**

For many students, one of the most difficult parts of a science project is selecting a topic. It is a challenge to decide on a topic that is original and interesting. An experiment can be done on many things. Topics do not have to be “science stuff”! In other words, you do not have test tubes, microscopes, batteries, etc. Begin with your interests. Do you like sports? Run a test on techniques used in sports. Do you like cooking? Alter a recipe and measure the results. Do your parents work in a field in which a test could be run: building industry, art, media, photography, etc.? Experiments can be conducted in many non-science as well as science areas. **WRITE DOWN ALL YOUR IDEAS IN YOUR LOG BOOK.**

A more common way of selecting a topic is to find a topic, or an experiment, in a book from the science section of the library. If you find an interesting experiment, you can alter the experiment to make it different, or original, by changing the independent variable. Consider, for example, the experiment, “Will the number of paper clips on the nose of a paper airplane affect the distance that it can fly?” The independent variable was the number of paper clips on the nose of the paper, same size of paper, same airplane design, same kind of paper clips, same amount of thrust to fly the plane, same breeze less hallway, and same angle of release. By making one of the constant variables the independent variable, you can come up with several “new” experiments.

**Examples:**

1. Will the type of paper used to make a paper airplane affect the distance that it can fly? (construction paper, tissue paper, cardboard, typing paper)
2. Will the size of the paper used to make a paper airplane affect the distance that it can fly? (8" X 10", 4" X 5", 12" X 15")
3. Will the design of the paper airplane affect the distance that it can fly? (glider, dart)
4. Will different amounts of thrust used to fly a paper airplane affect the distance that it can fly? (fast, slow, moderate speed)
5. Will different amounts of wind currents affect the distance a paper airplane can fly? (breeze less, low fan speed, high fan speed)
6. Will different angles of release affect the distance that a paper airplane can fly? (210 degrees, 180 degrees)
7. Will the placement of the paper clips on the plane affect the distance that the paper airplane can fly? (nose, tail, wing)

**Please remember the following Science Fair rules as you consider ideas:**

1. Do not do human research (except observations).
2. Do not use vertebrate animals in your research other than observations of animals under natural circumstances.
3. No research involving pathogenic (disease-causing) agents, recombinant DNA, blood or other human tissue, or controlled substances (tobacco, alcohol, or drugs)
Choose your Study Design

Ask yourself, “What will I be doing while carrying out the experiment? Match your answer to one of the five given below and use the design suggested.

1. I’ll be collecting something in order to identify it. Use the collection design.

2. I’ll be watching a natural situation to find a pattern. Use the observation design.

3. I’ll be building something to show how it works or to show a scaled model. Use the model design.

4. I’ll be altering one condition, while keeping others constant, and watching what happens to another condition. Use the experiment design.

5. I’ll be doing a series of experiments to create a product or process. Use the invention design.

<table>
<thead>
<tr>
<th>STUDY DESIGNS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>Collection</td>
</tr>
<tr>
<td>Observation</td>
</tr>
<tr>
<td>Mode</td>
</tr>
<tr>
<td>Experiment</td>
</tr>
<tr>
<td>Invention</td>
</tr>
</tbody>
</table>
Gather Background Information

Find and observe the objects or systems that you may want to study (magnets, batteries, yeast, enzymes, pendulums or whatever you want to experiment with.) Play around with them it to get an idea for an experiment. Go to the library and read books and magazines about the topics you wish to study. Look at a variety of science books for ideas and try some of the demonstrations and experiments you find. You may notice something, and wonder why it happens. You may see something and wonder what causes it. You may want to know how or why something works. Write down observations and questions about what you have observed. Think about what you might investigate. The first step is to clearly write down exactly what you have read about, observed, and thought about.

Now get the details about what you want to investigate. Go to the library and read books and magazines about the topic you wish to study. Seek out advice from professionals in the field you wish to study. Contact government agencies or professional organizations that might provide free information. Use the internet to access reference sites, resources, or online experts. TAKE LOTS OF NOTES IN YOUR LOG BOOK!. 

Find out:

• Who is famous for studying your topic?
• What is known about it?
• How have others studied it?
• Why is studying it worth the effort?

This information will help you narrow down your topic and design your experiment. By the end of your research and experimenting, you should be able to write a “Background Information” section for your report that includes:

• Historical background - important people and their findings.
• Factual summary - major terms with their definitions and an explanation of science concepts needed to understand your experiment.
• Method summary - an explanation of the special methods, equipment, and measurement techniques used in the experiment.
• Summary of importance - What is important or significant to mankind about this topic? Why is this experiment worth doing?

PLEASE NOTE: Elementary students are expected to have at least THREE sources and secondary students are expected to have at least FIVE sources of information regarding your topic. These may be books, periodicals, encyclopedias, interviews with professionals, internet sources, etc. Carefully record in your log book where you got all your information so that you will be able to prepare a Bibliography at the end of your project. (See the page of this guide titled “How to Write a Bibliography”.)
State the Problem

The problem should be written in the form of a question. Even though the problem is just one sentence, it is very important that it is written correctly.

Identify the object, system, or process that you want to study. Based on your gathered information, list what types of things affect the object or system. Identifying variables is necessary before you can write a problem statement, make a hypothesis, or plan an experiment.

For example, lets say you are interested in paper airplanes. In your experiment, you will be altering one variable, such as the mass of your paper airplane. At the same time, you must keep other variables constant, like the shape, size, and design of the airplane. Then you will watch what happens to another variable, like the flight distance of the paper airplane. When you think you know what variables may be involved, think about ways to change one at a time. If you change more than one at a time, be aware that you will not know what variable is causing your observation.

The one condition that you choose to manipulate or purposely alter in an experiment is called an independent variable (IV). The specific condition about your object or system that you can observe and measure to see if it responds is called the dependent variable (DV). Those conditions that you try to keep the same throughout your experiment are called constant variables (CV's). Choose your variables carefully. In your log book, identify the IV and the DV, then list all the possible CV’s.

Now, write a question in the form of:

“What is the effect of _____ (the independent variable) on the _____ (dependent variable) of/in _____ (Your object or system you are studying)?”

Example:

“What is the effect of added mass on the flight distance of a paper airplane?”

Or use the form:

“What effect will the _____ (the independent variable) have on the _____ (dependent variable) of/in _____ (Your object or system you are studying)?”

Example:

“What effect will added mass have on the flight distance of a paper airplane?”
**Form a Hypothesis**

A hypothesis is an educated guess or a prediction about the relationship between the IV and the DV.

Your hypothesis must include the variables you have identified and be in the form of an “If..., then...” statement. It tells what you think the answer is what you think should happen in the experiment.

For example:

<table>
<thead>
<tr>
<th>IV</th>
<th>DV</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;If mass is added to a paper airplane, then its flight distance will decrease.&quot;</td>
<td></td>
</tr>
</tbody>
</table>

**Define the Variables**

In your log book, first write down how the independent variable (IV) is to be manipulated or changed and how you will describe how much you change it. Be sure to select only one independent variable or thing to change in an experiment. Otherwise you will not know which one causes the result you observe. Example:

**Independent Variable** - The mass of the airplane will be changed by attaching 0.5 gram paper clips to the body of the airplane.

Next, identify the dependent variable and tell out how you will measure it. You should always have a way to numerically measure the results of your test (grams, meters, milliliters, hours, days, etc.). Example:

**Dependent Variable** - The number of meters the paper airplane flies off the deck behind my house will be measured in meters using a metric measuring tape.

All the other variables must not change, they must be exactly the same for all the tests. These variables are called the **constant variables (CV’s)**. List these variables that you must keep constant so they won't affect your results. Example:

**Constant Variables**: All the airplanes are to be made out of the same size and weight paper. They will be folded exactly the same way and launched by the same rubber band launcher mounted in the same location on the railing of the deck. Experiments are to be conducted on days with no measurable wind.

*** REMINDERS:  
IV = independent variable (thing that is changed and tested)  
DV = dependent variable (the thing that you measure)  
CV’s = constant variables (things that are kept the same)
**List the Materials**

In your log book, make a list of the materials and quantities you need to do the experiment. Record in your log book where you will obtain them. Check with your science teacher if you need any special supplies or equipment.

**Write the Procedure**

A *procedure* is a step-by-step list of what you are to do in the experiment. It must tell everything that is to be done in the experiment so that another person would be able to repeat the experiment exactly the same. Be prepared to revise your procedure several times until it gives all the directions someone else would need to duplicate the experiment.

*Important Points:*

- Number the steps and give very specific instructions. All methods need to be explained in detail.

- Begin each sentence with a verb (example: fold, use, fly, aim, collect, conduct, repeat).

- Write in the third person. Do not use personal pronouns (I, me, we, etc.).

- All measurements must be in **metrics**.

- Alter your independent variable at least **three** times.

- **Be sure you have a control.** A control is a run of the experiment where the independent variable is not changed or manipulated in any way. A control is a base for comparison that allows you to see what result is produced when you change the IV. Without a control you cannot be sure that changing the independent variable causes your observations. Be sure to clearly identify the part of your procedure that represents your control. Some experiments do not lend themselves to a control. Check with your teacher if you are unsure.

- Tell how many **trials** (repetitions) are to be done. Experiments are done many times to obtain an average result. For this reason, your experiment should include **at least three “trials” or repetitions**. An average result reduces the chance that you have made an error one particular experimental run.
Collect your Materials and Do a Trial Run

Before you actually beginning your experiment, make sure you have all the materials that you will need. If you are using any technical apparatus, read the instructions carefully and plan to include a brief explanation of its use in your “Background Information”. Check your measurement tools (balance, thermometer, graduated cylinder, etc.) to make sure they are accurate and that you can correctly read them. Then, do a “dry run” or trial of your experiment to check the procedure. Be sure that it is going to work before collecting the data that you will use to form your conclusion. Record the results of your dry run in your log book. Make any necessary revisions in your procedure until you are able to get measurable results. Seek help from a parent or teacher if you can’t figure out what is wrong.

Prepare a Data Table

Before beginning the actual experiment, you will need to design a data table for recording your measurements. The title of a data table is the name of the dependent variable. Each change of the independent variable is a column heading and each row is a trial or sample. Be sure to include metric measurement units for both variables. Example:

<table>
<thead>
<tr>
<th>The Flight Distance of a Paper Airplane (in meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Added to Paper Airplane</td>
</tr>
<tr>
<td>0.0 g</td>
</tr>
<tr>
<td>Trial 1</td>
</tr>
<tr>
<td>Trial 2</td>
</tr>
<tr>
<td>Trial 3</td>
</tr>
<tr>
<td>Trial 4</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Average</td>
</tr>
</tbody>
</table>

Run the procedure

Follow your procedure exactly. Don’t take shortcuts that can produced errors in your data. Be sure to repeat your experiment or run enough samples or trials until you are sure you have enough data to allow you to form a reliable conclusion. (A minimum of three samples or trials is required. Do five or ten for more reliable results.)

Take photographs of your materials, important steps in the procedure, and the results of your experiments. Try not to get any faces in your photographs. If you do, you will need to cover any faces before using them for your project. (If you get double prints, you can put the photos in both your log book and on your display.)
Record all measurements on your data table in your log book. Then, calculate an average result for all of your trials.

Your data should also include written observations of what you noticed during an experiment. Lots of things happen during experiments that should be recorded. What did you see happening? What was unexpected? What problems did you encounter? Keep careful notes of everything you do, and everything that happens. Observations are valuable when drawing conclusions, and are useful for locating experimental errors.

**Prepare a Graph and a Summary of Results**

A graph is a visual display of your averaged data. The independent variable is labeled on the x-axis (horizontal axis) with its units of measurement. The averaged dependent variable is on the y-axis (vertical axis). Use a line graph if the changes of the independent variable can be described with numbers or was measured over time. Use a bar graph if the changes of the independent variable are described by words. The title of the graph should have the form “The Effect of the (IV) on the (DV) of (object or system).”

Example of the line graph for the airplane experiment:

The Effect of Added Mass on the Average Flight Distance of a Paper Airplane

![Graph](image-url)
Here is an example of a **bar** graph would look for a different airplane experiment. Notice that the IV on the x-axis is described by words, not a numerical scale:

**The Effect of Different Designs on the Average Flight Distance of a Paper Airplane**

![Bar graph showing the effect of different designs on the average flight distance of a paper airplane.](image)

**Summary of Results**

Write a statement that tells what generally occurred during the experiment. Describe what you see in the graph. Example:

*As the mass of paper clips added to the airplane was increased, the average flight distance of the airplane decreased.*
Write the Conclusion

A conclusion is a reaction to the hypothesis and a connection between the results of the study and the background information that was gathered. It also discusses why the results of the study are significant or important.

• Begin your conclusion by restating your hypothesis and then state whether the hypothesis was or was not supported. (Never state that your hypothesis was “proven” or “disproven.” One experiment cannot prove anything. It takes scientists many years of experimenting to “prove” something.)

• Explain how your results support or do not support your hypothesis. If your hypothesis is not supported, what could be the answer to your question?

• Tell how your results and your conclusion relate to facts in your background information?
Example:
“The results of my experiment agreed with the studies in my research that showed that the increasing the mass of wood model airplanes reduces flight distance.”

• Finally, describe how are your findings are significant or important. Discuss how you will use this knowledge in the future. Example:
If I wanted to build a wooden airplane to fly a long distance, I would use a lightweight wood.

Scientific Worth and Future Study

Now that your project is finished, assess your work and tell what your next step would be if you were to repeat the experiment or continue this study. Answer these questions:

• If you did this study again, what would you do differently next time?

• What difficulties or problems did you have while doing the experiment?

• What sources of error could have affected your results? (examples: mistakes with measurement tools, not using your equipment correctly, not keeping some variables constant, etc.)

• Why is studying this topic important?

• What new questions occurred to you while doing the experiment?

• Can you suggest new problem statements to be investigated?

What If My Science Project Didn’t Work? No matter what happens, you will learn something. Science is not only about getting “the answer.” Even if your experiments don’t answer your questions, they will provide ideas that can be used to design other experiments. Knowing that something didn’t work, is actually knowing quite a lot. Unsuccessful experiments are an important step in finding an answer. Scientists who study extremely complex problems can spend a lifetime and not find “the answer.” Even so, their results are valuable. Eventually, someone will use their work to find the answer.
HOW TO WRITE A BIBLIOGRAPHY

A bibliography is a list of the all the sources you looked at when writing a report. Sources are listed in alphabetical order by the author’s last name or by the title, if no author is given. It is to be double-spaced and the second line of each listing should be indented one-half inch (5 typed spaces). The bibliography is the last page of your written report. Below are examples showing how to write a citation for several different types of sources.

Magazine: Author’s last name, First name. "Article Title." Magazine Title. Date: Page numbers.

Newspaper: Author’s last name, First name. "Article title." Newspaper Name. Date: Page.

CD-ROM: "Article title." Title. CD-ROM. Publisher, Year.


Interview: Interviewee’s last name, First name. Personal Interview. Date.

Book: Author’s last name, First name. Title. Place of Publication: Publisher, Copyright Date.


Videotape: Title. Videotape. Production Company, Year.

Sample Bibliography:

Magazine

Newspaper

CD-ROM

Encyclopedia

Interview

Book

Internet

Videotape
HOW TO PREPARE A SCIENCE FAIR DISPLAY

It seems that many people dread making a display, but others feel that this is the fun part--the part where the hard work and research can be "shown off."

The key word is communication. The display must communicate to the judges the main points of the project. Remember that even the best product in the world won't sell unless it has good advertising or marketing, and neither will your project.

Your display must face forward and be easily viewed. You may use a standard ready-made science fair display board that can be purchased from the school store or most any office or art supply store. If you prefer, a display board may be made out of many different materials (i.e. cardboard, plywood, pegboard, etc.). It may be in any shape, within the required dimensions, but it must be able to stand alone with no supports or props and it must have an attached base. **Warning: Any display larger than 60 cm. x 60 cm. x 120 cm. will be disqualified.**

All of your information should be neatly written or typed. Your data table and graph can be neatly done by hand using a ruler and black ink. Much of the information on the display may duplicate or summarize what is in your logbook or report. All sections of the study must be clearly labeled with bold print and the materials should read in a top to bottom/left to right order. Make your writing clear and concise with correct grammar and spelling. Use photos and labeled drawings to enhance your display. Be very neat.

Remember to consider an attractive color scheme when purchasing materials. Choose two or three coordinating colors of paper to back your information. Remember to arrange all parts of your display on the board before gluing it down. Keep in mind that glue sticks or rubber cement will result in a neater project than using white school glue. Remember that the goals of your display are to catch the judge's eye, clearly communicate your experiment, and convince them you truly did work hard at your project. Have fun with this, and be creative!

**Display Rules**

- Do NOT display any animal or human food, breakable or sharp items, liquids, powders, live or preserved plant, animals or molds, microbes, body fluids, chemicals, empty chemical containers, inflammables, soil, and any mechanical or electrical hazards including batteries. Use photographs to represent the real thing.

- Do not display any valuable items. The fair assumes no responsibility for damaged or stolen items.

- The display must be self-supporting and have an attached base. The outside dimensions may not be larger than 60 cm. x 60 cm. x 120 cm.

- The name or an identifiable photo of the exhibitor is not to be displayed or recorded in any written material.
PLEASE NOTE: This arrangement is only a suggestion. These sections are to be present but may be placed differently depending on the amount of space each section requires and the recommendations of the student’s teacher.
HOW TO WRITE AN EXPERIMENTAL REPORT

1. **Definition**: A formal report which presents, in detail, the purpose, process, and findings of an experiment. **This is required for all secondary projects.**

2. **Includes**:
   - Title Page
   - Table of Contents
   - Acknowledgements (if needed)
   - Background Information
   - Method of Investigation
     - Problem Statement
     - Hypothesis
     - Variables (IV, DV, CV’s)
     - List of Materials
     - Procedure
   - Results
     - Data tables
     - Observations
     - Graph
     - Summary of Results.
   - Conclusion and Scientific Worth
   - Bibliography
   - Appendices (Only if needed for additional information)

3. **Final paper format**:
   - Report is neatly typed on 8.5” by 11” white, unlined paper (data tables and graphs may be drawn in black ink)
   - 1” margins except for a 1.5” left margin
   - Pages are numbered.
   - Section titles underlined or in boldface
   - Double space between sections
   - Writing style is clear, concise, and objective
   - Proper sentence and paragraph form with correct grammar and spelling
   - All writing is in third person. NO first person pronouns (I, me, my)
   - Underline or italicize scientific names
   - Correct bibliography form
   - Finished report in folder or report cover
Title Page

The Effect of Microwaves on the Germination of Radish Seeds

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Acknowledgments (if necessary)

Identify and thank those people who provided assistance and guidance to you. Describe specifically how each person helped you on your project but do not identify anyone by name.


**Background Information**

This section should include a detailed discussion of:

- **Historical background** - Give information about others who have studied the same or similar topic; identify important people and their findings.

- **Factual summary** - Identify major terms including their definitions and an explanation of science concepts needed to understand your experiment.

- **Method summary** - Provide an explanation of the methods, equipment, and measurement techniques used in the experiment. Are any unique methods used to observe or measure the results? If any organisms are used, give the scientific name. Tell what it is and why it was selected for this study.

- **Summary of importance** - Discuss the value of this study. What is important or significant to mankind about this topic. Why is this experiment worth doing?

As you write your report, include references to your sources -
  "According to (book title or author)"
  "The . . (book title) indicates that"

OR

Place the author’s name and date in ( ) behind the sentence or paragraph which uses/provides facts from his/her work.

All sources that are used to write the Background information are to be listen in the Bibliography. See the “How to Write a Bibliography” page in this guide.

*** A minimum of five sources is expected for this project. ***

DO NOT COPY AN AUTHOR’S WORDS AND THEN REPRESENT THEM AS YOUR OWN! THAT IS PLAGIARISM. IT IS A SERIOUS OFFENSE AND WILL RESULT IN A MAJOR REDUCTION OF CREDIT AND/OR POSSIBLY A ZERO ON THIS PROJECT.
Method Of Investigation

A. Problem Statement

This is a statement which identifies what the experiment is intended to do. (i.e., What is the experiment about?)

Example: 
What is the effect of microwaves on the germination of radish seeds? 
(include scientific name if available)

A paragraph should also be used to:
- Tell why you selected this topic.
- Discuss the value of this study.
- Explain what is significant about the topic. Tell why the study is useful or describe what is important about the topic.

B. Hypothesis

A hypothesis is an educated guess that answers the question or predicts the results. It should be an "If ,then..." statement.

Example: (IV) 
If radish seeds are exposed to increased time in microwaves, then the percentage of seeds that will germinate will decrease.

(DV)

C. Variables

Independent Variable (IV) - Identify the one factor or condition in the experiment which is to be manipulated or altered. Explain exactly how it is to be changed and how the amount of change is described or measured.

Dependent Variable (DV) - The factor or condition which you expect will respond. Explain how it is to be measured or observed.

Constant Variables (CV's) List those factors of the experiment which are to be kept the same (constant) throughout the experiment.

Example: Independenent Variable (IV) - The exposure of the radish seeds to microwaves will be manipulated by placing 20 radish seeds in a microwave oven and operating the oven on its lowest power for 1 second. Additional sets of 20 seeds will be exposed for 3,6,10,and 15 seconds.

Dependent Variable (DV) - The germination of the radish seeds will be determined by placing the seeds between wet paper towels and then counting the number of seeds that have sprouted a root after three days.
Constant Variables (CV’s) - Those factors of the experiment which are to be kept the same (constant) throughout the experiment are the use of the same microwave oven, the same kind and seed lot of radish seeds, the same plates, paper towels and amount of water used to germinate the seeds, and keeping the germinating seeds at the same temperature with the same lighting.

D. Materials

Provide a complete and detailed list of all the materials and the quantities needed to perform the entire experiment

Example:

- 600 radish seeds
- 60 Styrofoam paper plates
- 60 paper towels
- Water
- Microwave oven

E. Procedure

List in detail the exact steps you followed to complete your experiment. Each step is numbered and gives a specific. Remember not the use “I” or “we.” MEASUREMENTS SHOULD BE IN METRIC. Include a picture(s) or drawing(s), tell how many times the IV was changed, how many trials you ran, and how many subjects/specimens you “tested.”

Example:

1. Count out 120 radish seeds and divide them into six sets of twenty seeds each. Place each set on a Styrofoam plate.
2. Place one set of twenty seeds in the microwave oven. Run the microwave for one second at its lowest power.
3. Transfer the microwaved seeds onto a paper towel on another Styrofoam plate. Spread out the seeds and cover them with a second paper towel. Pour 30 mL of water onto the paper towels and seeds and then cover with the first Styrofoam plate that was used to microwave the seeds. Label the plate of seeds “1 second”.
4. Repeat steps 2 and 3, running the microwave at its lowest power for 3 seconds. Label this plate of seeds “3 seconds”.
5. Repeat steps 2 and 3, running the microwave at its lowest power for 6 seconds. Label this plate of seeds “6 seconds”.
6. Repeat steps 2 and 3, running the microwave at its lowest power for 10 seconds. Label this plate of seeds “10 seconds”.
7. Repeat steps 2 and 3, running the microwave at its lowest power for 15 seconds. Label this plate of seeds “15 seconds”.
8. Repeat steps 2 and 3, without placing the seeds in the microwave oven. Label this plate of seeds “0 seconds”. This is the control group.
9. Place all six plates of seeds in a warm location.
10. After three days, remove the top Styrofoam plate and paper towel. Count and record the number of seeds that have sprouted a root.
11. Repeat the entire experiment four more times and record the results.
Results

This section includes your data table, observations, graph, and a summary of the results from your experiment.

A. Data Table

The raw data has to be rearranged into a format which will show a relationship or trend. Then the raw data should be converted to averages, percents, or other appropriate values that may be compared. Data tables use the dependent variable as the title, each change of the independent variable is a column heading, and each row is a trial or sample. Be sure to include measurement units for both variables.

Example:

The Number of Radish Seeds Germinated
Three Days after Microwave Exposure

<table>
<thead>
<tr>
<th>TimeExposedtoMicrowaves(seconds)</th>
<th>0 sec.</th>
<th>1 sec.</th>
<th>3 sec.</th>
<th>6 sec.</th>
<th>10 sec.</th>
<th>15 sec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>20</td>
<td>15</td>
<td>14</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Trial 2</td>
<td>19</td>
<td>16</td>
<td>13</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Trial 3</td>
<td>18</td>
<td>18</td>
<td>10</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Trial 4</td>
<td>20</td>
<td>14</td>
<td>11</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trial 5</td>
<td>16</td>
<td>17</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>93</td>
<td>80</td>
<td>56</td>
<td>17</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Average</td>
<td>18.6</td>
<td>16</td>
<td>11.2</td>
<td>3.4</td>
<td>1.6</td>
<td>1</td>
</tr>
</tbody>
</table>

B. Observations

Record underneath the chart anything you see or notice during the experiment. Plan to write several sentences about how the experiment went and what you observed. Take note of anything that could be significant when you try to analyze your data. Were there any indications of possible error in the experiment? Use your log book to help you describe the changes you observed during your experiment.
C. **Graph**

An experiment uses a graph with the averaged dependent variable on the y-axis and the independent variable on the x-axis. Use a line graph if the changes of the independent variable can be described with numbers or was measured over time. Line graphs use a "best fit" curve. Use a bar graph if the changes of the independent variable are described by words. The title of the graph should have the form "The Effect of the (IV) on the (DV) of (object or system)".

Example:

*The Effect of Microwave Exposure on the Germination of Radish Seeds*

![](image)

D. **Summary of Results**

Write a general statement of what happened to the DV in this investigation. Describe what you see in the graph which has caused you to arrive at this statement.

Example:

*When the time that the radish seeds were exposed to the microwaves was increased, the number of the radish seeds that germinated decreased.*
Conclusion

Definition: A final statement of what the results show or support.

In this section of the report, relate your results to your hypothesis and your background information. Restate your hypothesis and tell whether or not the data supports or does not support your hypothesis. Use your data to explain why the hypothesis should be accepted or rejected. How do your results and your conclusion relate to facts in your background information? If your hypothesis is not supported, what could be the answer to your question? How are your findings significant or important? If your results show something totally unexpected or unusual, it is to be mentioned here.

What difficulties or problems did you have while doing the experiment? What were some possible sources of error in the experiment? Do you need to change the procedure and repeat your experiment?

Scientific Worth and Further Study

If you did this study again, what would you do differently next time? What difficulties or problems did you have while doing the experiment? What sources of error could have affected your results? (examples: mistakes with measurement tools, not using your equipment correctly, not keeping some variables constant, etc.). Why is studying this topic important? What new questions occurred to you while doing the experiment? How might these questions lead to future studies? Can you suggest new problem statements to be investigated?

What would you do different next time? What new questions occurred to you while doing the experiment? How might these questions lead to future studies? Finally, make suggestions for new problem statements for further study or experimentation.

Bibliography

This is an alphabetical list of your resources. They should be listed alphabetically by author's last name, or by the title of the publication if the author's last name is not given. In order to document your statements or to refer to sources in the text of your paper, place the author's name and date in ( ) behind the sentence or paragraph which uses that information. See the page titled “How to Write a Bibliography” for further instructions.

Appendices (If needed)

Any additional information needed to support your project is to be placed in an appendix. This could be detailed background information about equipment or procedures, additional raw data, calculations, and statistical tests.