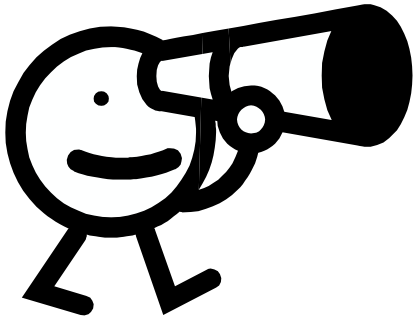
Doing Scientific Inquiry Means Students…



Ask Questions
Investigate
Use Tools
Keep Records
Develop Explanations
Share Ideas
Ask New Questions

Essential Features of Inquiry-Based Investigations

1. **Students are engaged by scientifically oriented questions.** Scientifically oriented questions center on objects, organisms, and events in the natural world; they connect to the science concepts described in the content standards. They are questions that lend themselves to empirical investigation and lead to gathering and using data to develop explanations for scientific phenomena.

2. **Students give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.** Science distinguishes itself from other ways of knowing through use of empirical evidence as the basis for explanations about how the natural world works.

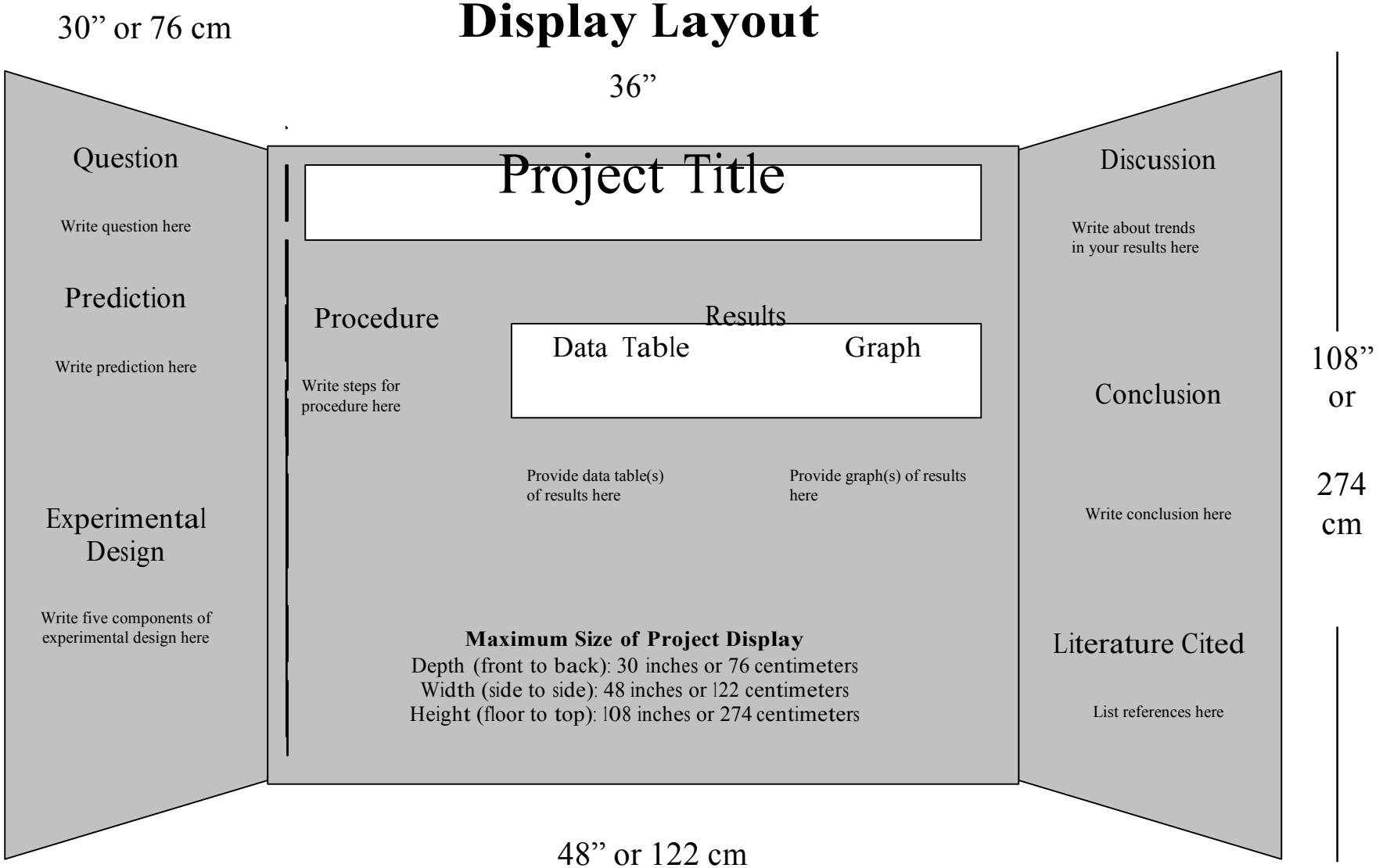
3. **Students formulate explanations from evidence to address scientifically oriented questions.** Scientific explanations are based on reason. They provide causes for effects and establish relationships based on evidence and logical argument.

4. **Students evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.** Evaluation, and possible elimination or revision of explanations, is one feature that distinguishes scientific from other forms of inquiry and subsequent explanations.

5. **Students communicate and justify their proposed explanations.** Scientists communicate their explanations in such a way that their results can be reproduced. It requires clear articulation of the question, procedures, evidence, proposed explanation, and review of alternative explanations. It provides for further skeptical review and the opportunity for other scientists to use the explanation in work on new questions.

Adapted from *BSCS Science Tracks* (2006) by the Biological Sciences Curriculum Study and *Inquiry and the National Science Education Standards* (2000) by the National Research Council.

Display Layout



Creating Your Science Fair Display

- Your display should be mounted on a display board that can sit on top of a table and stand up by itself.
- Your display must fit into a space 36 inches high and 48 inches wide.
- Your display should be easy to read, neat, and organized. Please see the sample display layout for suggested organization.
- Use color, photographs, drawings, graphs, tables, and charts to emphasize your findings and draw viewers' interest.
- Your display should include all the sections listed below.

Sections to include in your Science Fair Display

1. **Title** *is a statement describing an investigation.*
   - The title of your project should be a complete sentence.
   - The title should state how the independent variable and the dependent variable in your investigation are related.
     Sample: "The Effect of the Changes in the independent variable on the dependent variable."
2. **Question** *describes the focus of the investigation.*
   - You question should be testable.
   - Write your question so someone else can easily understand what you are asking.
3. **Prediction** *is a statement of the relationship of an independent and dependent variables to be tested in an investigation; it predicts the effect that the changes purposely made in the independent variable will have on the dependent variable.*
   - Your prediction should make a statement about what you think will happen.
   - Your prediction should relate the independent variable to the dependent variable.
4. **Experimental Design**
   - Using the five components below, describe the design of your investigation.
     - **Independent variable:** *the variable that is changed on purpose by the experimenter*
     - **Dependent variable:** *the factor or variable that may change as a result of changes purposely made in the independent variable*
     - **Constant variables:** *factors in an investigation that are kept the same and not allowed to change or vary*
     - **Control group:** *the part of an experiment that serves as a standard of comparison; a control is used to detect the effects of factors that should be kept constant, but which vary; the control may be a "no treatment" group or an "experimenter selected" control*
     - **Number of repeated trials:** *the number of times that a level of the independent variable is tested in an investigation or the number of objects or organisms tested at each level of the independent variable*
5. **Procedure**
   - List the steps you followed to complete your investigation.
   - Write the list of steps in the order you completed them.
   - Check the list carefully for accuracy.
   - If you are using part of a procedure from your text book or from the teacher, you may reference that procedure instead of re-writing it.
6. **Results**
   - Include at least one data table and one graph to represent your data. In addition, other representations of data may be used to show results.

     Data Table
     - Give your data table a title.
     - Make a table containing vertical columns for the independent variable and dependent variable.
     - Subdivide the column for the dependent variable to reflect the number of trials.

- Order the values of the independent variable, preferably from smallest to largest.
- Record values of the dependent variable.
- Calculate the average results of each trial and record the values.
- Use correct units of measurement.

Graph

- Give your graph a title.
- Draw and label the *x* and *y* axes of the graph. Place the independent variable on the *x*-axis, and the dependent variable on the *y*-axis.
- Determine an appropriate scale for the *x* and *y* axes; subdivide the axes.
- Use correct units of measurement.
- Provide a legend.
- Decide the most appropriate form to plot the data (line, bar, or pie graph)
- Summarize data trends on the graph.

7. **Discussion**
   - Write a paragraph summarizing the results in words.
   - Write a second paragraph including the trends or patterns in your results.
   - Write a third paragraph that describes the science knowledge that supports your results.
8. **Conclusion**
   - Restate your question.
   - State whether the prediction is supported by evidence.
   - State your most important result.
   - Give an explanation that relates your evidence to something you have learned about science.
   - Provide suggestions for further investigations based on your results.
9. **Literature Cited:** *If you referenced any sources, such as books, articles, or websites, list them in this section with the title, author, year, and URL (if website).*
10. **Oral Presentation**

    Effective communication of project including:
    - Relating scientific concepts to project
    - Describing design principle
    - Explaining data analysis
    - Discussing future studies

Scoring Rubric

Title	
3	The title clearly states both the independent and dependent variables and is written as a clear declarative statement.
2	The title is clearly connected to the investigation, but does not mention the dependent or independent variables.
1	The title is present but not does relate directly to the investigation.
0	Not attempted
Question	
3	The question that the investigation was designed to answer is well articulated and testable.
2	The question that the investigation was designed to answer is testable.
1	The question is present, but is not testable.
0	Not attempted
Prediction	
3	The prediction is clearly stated and shows a reasonable relationship between the independent variable on the dependent variable.
2	The prediction is stated but is not reasonable or only mentions one variable.
1	The prediction is present but does not show a relationship between the variables.
0	Not attempted
Experimental Design	
3	At least four of the five components of experimental design are clearly stated.
2	At least three of the five components of experimental design are clearly stated.
1	At least two of the five components of experimental design are clearly stated.
0	Not attempted or only one of the five components of experimental design is clearly stated.
Procedure	
3	A detailed, logical step-by-step procedure is listed.
2	A logical step-by-step procedure is listed, but some steps are missing or incomplete.
1	A logical step-by-step procedure is listed, but many steps are missing or incomplete.
0	Not attempted
Results	
3	Data table(s), graph(s), and other representations of data are accurate, easily understood, and complete including title, appropriate labels, appropriate placement of variables, and use of correct units of measurement.
2	Data table(s), graph(s), and other representations of data include most of the above components.
1	Data table(s), graph(s), and other representations of data include some of the above components.
0	Not attempted
Discussion	
3	Discussion includes at least three paragraphs that summarize the results in words, describe trends or patterns in the results, and relate the science knowledge that supports the results.
2	Most parts of discussion are complete and accurate.
1	Some parts of discussion are complete and accurate.
0	Not attempted
Conclusion	
3	Conclusion clearly restates the question and whether the prediction was supported with evidence; includes an explanation that effectively connects results to scientific knowledge; and also provides suggestions for further investigations.
2	Most parts of conclusion are complete and accurate.
1	Some parts of conclusion are complete and accurate.
0	Not attempted

Creativity	
3	Project is clearly the original creative work of the student researcher. Input into the project by adults is limited.
2	Project is mostly the original creative work of the student researcher.
1	There is evidence of some input from adults beyond encouragement and assistance in obtaining materials.
0	There is evidence of significant input from adults beyond encouragement and assistance in obtaining materials.
Display	
3	Display is easy to read and well-organized. Color, graphics, and other visual components add to the display.
2	Two out the three qualities listed above are present.
1	One out the three qualities listed above is present.
0	Display is difficult to read, poorly organized, and visual components, such as graphics or color, are missing or distracting.
Oral Presentation	
3	Effective communication of scientific concepts, design principles, data analysis, and further studies.
2	Two out of the four qualities listed above are present.
1	One out of the four qualities listed above is present.
0	Communication was not effective.
Project Notebook Completion (see Cover Sheet)	
3	All paperwork listed on Cover Sheet is submitted in project notebook.
2	Most paperwork listed on Cover Sheet is submitted in project notebook.
1	One to two forms listed on Cover Sheet are submitted in project notebook.
0	No paperwork listed on Cover Sheet is submitted in project notebook.

Score Sheet
Kindergarten–Grade 5

Judge's Name: _____

Student(s) Name(s): _____ **Grade:** _____

School: _____ **Teacher:** _____

Title of Project: _____

Score (circle one):

Scientific Investigation				
Title	**0**	**1**	**2**	**3**
Question	**0**	**1**	**2**	**3**
Prediction	**0**	**1**	**2**	**3**
Experimental Design	**0**	**1**	**2**	**3**
Procedure	**0**	**1**	**2**	**3**
Results	**0**	**1**	**2**	**3**
Discussion	**0**	**1**	**2**	**3**
Conclusion	**0**	**1**	**2**	**3**
Creativity	**0**	**1**	**2**	**3**
Display	**0**	**1**	**2**	**3**
Oral Presentation	**0**	**1**	**2**	**3**
Project Notebook Completion (see Cover Sheet)	**0**	**1**	**2**	**3**
Total Score (out of 36 points) _____				

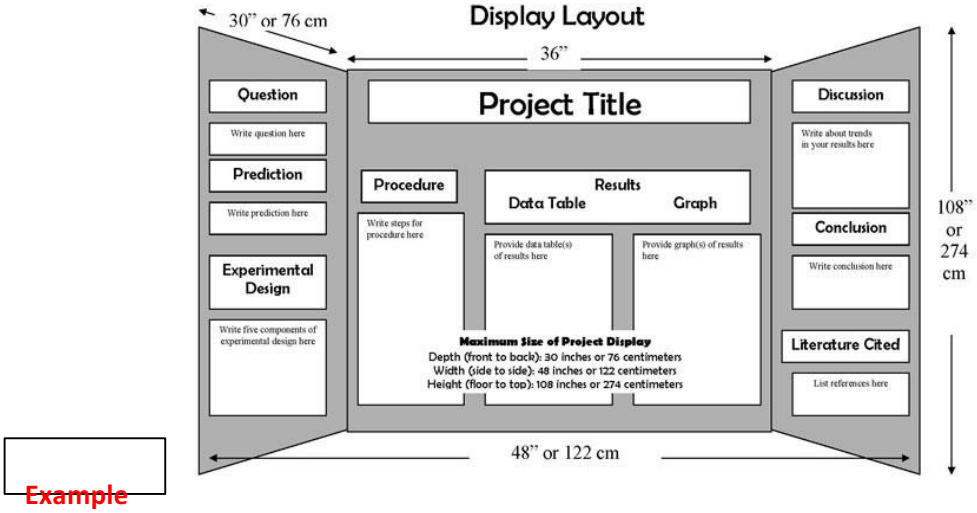
Student(s) Name(s): _____

One great aspect of your project:

One suggestion for the future:

Condensed Guidelines for Science and Engineering Fairs
Kindergarten–Grade 5

(Full version at https://student.societyforscience.org/forms)



Example

Maximum Size of Project Display
Depth (front to back): 30 inches or 76 centimeters
Width (side to side): 48 inches or 122 centimeters
Height (floor to top): 108 inches or 274 centimeters

Inquiry Projects: All projects must be inquiry-based and have testable questions. No research style or demonstration projects will be admitted. Research papers may accompany the project, however.

Required Forms: (1) Cover Page, (2) Display Board Label, (3) Registration, (4) Media Release (copy of form on file at students' schools), and (5) Student Checklist. These forms are the only ones allowed to be displayed on the display table.

Not Allowed on Display: Living or dead plant or animal materials, food, chemicals, other hazardous substances (including water, unless provided by display and Safety Committee or in enclosed apparatus), sharp items, flames, batteries with open-top cells, previous awards, photos of dissections or other lab procedures on animals, active Internet connections, glass (unless approved by Safety Committee), or other apparatus deemed unsafe by review committee.

Allowed with Restrictions: Acrylic encased samples of rock, soil, etc.; photos if not "offensive" and if, of humans, must include Human Subject Form; mechanical apparatuses if not operated; and lasers.

Other Requirements: Participant must be present for safety inspection; no changes may be made after inspection; project data books and/or research papers are recommended; lights and/or sounds must not be distracting; no food or drink (except small bottle of water for participants); Safety Committee must approve all technical, audio, or visual equipment.

Team Projects: Maximum of three members; teams compete in separate category; team members may not change from fair to fair; one member should be appointed team spokesperson; all team members' names must appear on Abstract Form.

Roles and Responsibilities

Student is responsible for all parts of experiment and may not be older than 21. **Adult Sponsor** is teacher, parent, professor, or scientist who reviews Student Checklist and Research Plan to ensure rules and procedures are properly followed. Each project must have **Designated Supervisor** (usually teacher) who is well versed in the project and its area of science.

Human Subjects: If human subjects are used, refer to complete guidelines and review informed consent requirements.

Risk Activities: Cannot be more than minimal. Even surveys asking about past abuse, sexual conduct, or emotional stress is more than minimal.

Vertebrate Animals: If used, read guidelines for required documentation and proper “humane” care of vertebrates.

Potentially Hazardous Biological Agents: Includes microorganisms, rDNA, and vertebrate tissues
(e.g., blood, frozen tissue, bodily fluids). Read complete guidelines, as many agents are prohibited.

Important! If human, vertebrate, or potentially hazardous biological agents are used, approval committees
must approve projects **before** experimentation begins.

Cover Sheet
Kindergarten –Grade 5

O **Student Project Contract**

O **Display Board Label**

O **Registration Form**

O **DPS Media Release Form** *(copy from form on file at students' schools)*

O **Abstract Form** *(student signature required)*

O **Research Plan**

Save ORIGINALS and place in Project Data Notebook.

Display Board Label

Cut out and **temporarily** mount this information on the **back** of the display board of your project on the **upper left corner**.

Name(s): _____

School: _____

Grade: _____

Teacher: _____

Title: _____

_____

If you enter your project in the Denver Metro Science Fair (grades 6–12), this label **must** be removed, as name identification is **not** allowed in their rules.

Abstract Form

Title of Project:

Student Name:

School and City:

Abstract (250 words or less):

As a part of this research project, student directly handled, manipulated, or interacted with (check all that apply):

O	human subjects	O	non-human vertebrate animals
O	pathogenic agents	O	controlled substances
O	recombinant DNA	O	human/animal tissue

Do not bring any of above materials to the Science Fair. Students are allowed to bring only tri-fold presentations.

Student independently performed all procedures as outlined in this abstract.	O Yes	O No
This project was conducted at a Registered Research Institution.	O Yes	O No
Is this project a continuation?	O Yes	O No

Category:

I hereby certify that the above statements are correct and the information provided in this Abstract is the result of one year's research. I also attest that the above property reflects my/our own work.

Student Signature Date

Kindergarten–Grade 5 Research Plan Instructions

A complete typed or handwritten Research Plan is required and must be attached to your cover sheet.

Research plans for ALL projects must include the following. Note: Vertebrate animal experimentation is discouraged.

A. **Question or Problem being addressed**

B. **Prediction/Hypothesis/Engineering Goals**

C. **Detailed Description of method or procedures:** Important and key items below should be included when formulating ***any and all*** research plans.

- **Procedures:** Detail all procedures and experimental design used for data collection.

- **Data Analysis:** Describe procedures—claims and evidence—used to analyze data that answer research question or hypothesis.

D. **Bibliography:** List at least two references (e.g., science journal articles, books, Internet sites) from your literature review.

- Choose one style and use it consistently to reference literature used in research plan. See details in the *International Science and Engineering Fair Student Handbook*.

Additional Information for Adult Project Supervisors

Items 1–4 below are guidelines to be followed when applicable.

1. **Human subjects research** (see instructions in International Rules)
   - **Subjects.** Describe who will participate in your study (e.g,, age range, gender, racial/ethnic composition). Identify vulnerable populations (e.g., minors, pregnant women, prisoners, mentally disabled, economically disadvantaged).
   - **Recruitment.** Where will you find your subjects? How will they be invited to participate?
   - **Methods.** What will participants be asked to do? Will you use any surveys, questionnaires, or tests? What is the frequency and length of time involved for each subject?
   - **Risks.** What are risks or potential discomforts (e.g., physical, psychological, time involved, social, legal) to participants? How will you minimize risks?
   - **Benefits.** List any benefits to society or each participant.
   - **Protection of privacy.** Will any identifiable information (e.g., names, telephone numbers, birthdates, email addresses) be collected? Will data be confidential or anonymous? If anonymous, describe how data will be collected anonymously. If not anonymous, what procedures are in place to safeguard confidentiality? Where will data be stored? Who will have access to data? What will you do with data at the end of the study?
   - **Informed consent process.** Describe how you will inform participants about the purpose of the study, what they will be asked to do, that their participation is voluntary, and they have the right to stop at any time.
2. **Vertebrate animal research** (see instructions in International Rules)
   - Briefly **discuss POTENTIAL ALTERNATIVES** and present detailed justification for use of vertebrate animals.
   - Explain **potential** impact or contribution this research may have.
   - Detail all **procedures** to be used. **Include** methods used to minimize potential discomfort, distress, pain, and injury to animals during the course of **experiment.** Include detailed chemical concentrations and drug dosages.
   - Detail animal numbers, species, strain, sex, age, etc. Include **justification** of numbers planned for the research.
   - **Describe** housing and oversight of daily care.
   - Discuss animals' disposition at the termination of the study.
3. **Potentially hazardous biological agents** (see instructions in International Rules)
   - Describe Biosafety Level Assessment process and resultant BSL determination.
   - Give source of agent, source of specific cell line, etc.
   - Detail safety precautions.
   - Discuss disposal methods.
4. **Hazardous chemicals, activities, and devices** (see instructions in International Rules)
   - Describe risk assessment process and results.
   - Detail chemical concentrations and drug dosages.
   - Describe safety precautions and procedures to minimize risk.
   - Discuss disposal methods.

The full text of the International Rules and copies of forms are available at http://student.societyforscience.org/forms.