Project Idea Guide

November 2008

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Dear Volunteer

Welcome to the Science Buddies Project Idea Guide! This guide will help you write creative, consistent, and comprehensive Project Ideas that meet both Science Buddies' and students' high standards. Inside, you will learn how to write a Project Idea from start to finish. Please review each section carefully.

We hope this guide helps you in your quest to create a wonderful Project Idea to serve students and teachers everywhere. Please contact Science Buddies if you have any questions at: scibuddy@sciencebuddies.org.

Sincerely,

The Science Buddies Editorial Team

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1. Science Fair Projects Overview

A. What Is a Science Fair Project?

Conceptually, a science fair project is very straightforward. A student chooses a scientific question he or she would like to answer. Then, library and Web research on the question gives the student the background information he or she needs to formulate a hypothesis and design an experiment. After writing a report to summarize this research, the student performs the experiment, draws his or her conclusions, and presents the results to teachers and classmates, using a display board. Most students do their projects for a school science fair, but in many cases, students can enter that same project in fairs at the city or county level. This is the first step in competitions that lead up to the international level, where prizes total over $3,000,000 and the top winners take home $50,000 scholarships.

B. The Scientific Method as Practiced by Student Science Fairs

Every practicing scientist knows that “real science” occurs in many different ways, and engineering projects follow another methodology entirely (more on this later). Nonetheless, science fair projects traditionally follow a common series of steps. Like most science fairs, Science Buddies advises students to proceed in this fashion:

1. **Ask a Question:** What is it that you are trying to find out from your experiment? What are the goals that you are trying to achieve?
2. **Prepare a “Library” Research Plan and Bibliography.**
3. **Research the Topic:** Investigate what others have already learned about your question. Gather information that will help you perform your experiment.
4. **Identify the Independent, Dependent, and Controlled Variables.**
5. **Formulate a Hypothesis:** After having thoroughly researched a topic, you should have some prediction about what you think will happen in your experiment. This educated guess concerning the outcome is called your hypothesis. You must state your hypothesis in a way that you can readily measure.
6. **Prepare a Materials List and Experimental Procedure:** Now that you have come up with a hypothesis, you need to develop a procedure for testing whether it is true or false. This involves changing one variable and measuring the impact that this change has on other variables. When you are conducting your experiment, you need to make sure that you are only measuring the impact of a single change.
7. **Test the Hypothesis by Doing an Experiment:** Scientists run experiments more than once to verify that results are consistent. Each time that you perform your experiment is called a **run** or a **trial**.
8. **Analyze the Results:** At this stage, you want to be organizing and analyzing the data that you have collected during the course of your experiment in order to summarize what your experiment has shown you.

9. **Draw a Conclusion:** This is your opportunity to explain the meaning of your results. Did your experiment support your hypothesis? Does additional research need to be conducted? How did your experiment address your initial question and purpose?
10. **Report Results and Conclusion:** Since you are performing an experiment for the science fair, you will write a report and prepare a display board so that others can share in your discoveries.

It is also important to note what a science fair project is NOT:

- Projects that are merely demonstrations, display collections, and literature searches are generally not acceptable. In order to be considered a science fair project, the student must use the demonstration, collection, or search results, to extract new information not previously known to the student.
- Generally, a project is not an unfocused exploration (even though some "real science" occurs that way).

Any project written up for the Science Buddies website must take into account the above considerations of what a science project is and is not.

C. The Engineering Method

Scientists study how nature works; engineers and computer programmers create new things, such as machines, software, and techniques. Because engineers and computer programmers have different objectives than those of scientists, they follow a different process in their work (see below).

Comparison of a Scientific Method and the Engineering Method

Traditional Science Fair Project	Typical Engineering Project
Ask a question	Define a need
Search literature	Search literature
Formulate a hypothesis, identify variables	Establish design criteria
Design experiment, establish procedure	Prepare preliminary designs
Test hypothesis through experimentation	Build and test a prototype
Draw conclusions & rerun experiments as necessary	Retest and redesign as necessary
Present results	Present results

Some science fairs have separate engineering categories, and judge engineering projects according to the engineering method. Unfortunately, this is not always the case. Often, an engineering project can be "morphed" into the traditional science fair model by stating a hypothesis in this form: "I hypothesize that I can build an X that does Y."

D. The “Project Idea” Concept

For most students, selecting what to work on is one of the most difficult parts of doing a science fair project. That’s why one of Science Buddies’ primary missions is to improve the quality of science fair projects. A mutually beneficial solution is to help students find a project that interests them AND at the same time represents better science than what they might come up with on their own.

Our Topic Selection Wizard first helps students identify an area of science that is inherently interesting to them. Then it presents some representative “Project Ideas.” Each Project Idea has several objectives:

1. Attract the student and capture his or her imagination.
2. Provide enough background information and guidance to get the student off to a great start.
3. Suggest variations on the primary idea, so that the student has plenty of room for creativity.

Thus, a Project Idea should be true to its name (it provides a start); it is not a cookbook. At the same time, a good Project Idea takes recognition of the fact that the intended user is a young student with far less experience than the author.

E. Project Originality

Truly original research is common only at the highest levels of science fair competition (high school projects competing at the state and national levels). In fact, repeating a historical experiment or utilizing a Science Buddies Project Idea can be a wonderful learning experience for a young student, especially if the student adds his or her own innovations to the process.

2. Before You Start

A. Science Buddies Objectives

To achieve its goals of utilizing science fairs to improve science literacy, Science Buddies has several objectives specifically related to Project Ideas:

Our first objective is to <u>save our users time, while guiding them to a successful outcome.</u> You can write a Project Idea that will accomplish this in a number of ways:

- Provide appropriate and readily available sources to jump-start background research.
- Minimize the difficulty of obtaining supplies. Be specific about required materials, and if any old thing will do, say so. Suggest specific vendors for any supplies that are not readily available, and general sources for available, but uncommon, materials (e.g., where would one get "dry ice"). Minimize the number of vendors for any given experiment.
- Provide clear, accurate, and vetted experimental procedures.

Our writers should put themselves in the shoes of a parent supervising a child doing the project they are writing. Would they be pleased if their own child was doing the project?

Our Project Guide supports all of our Project Ideas, filling in the details of how to put together a great science fair project. By reducing the hassles of doing a science fair project, Science Buddies aspires to improve project quality and increase science fair participation, turning a good learning experience into a great one.

At the same time, the better the fit between a student's interests and the Project Idea we recommend, the more likely it is that the student will become excited about doing the project and learning as much as he or she can. Consequently, our second objective is to provide a broad spectrum of intriguing Project Ideas at all levels of difficulty.

Since most students do a science fair project only if the teacher requires them to do so, our third important objective is to support the teacher by making the classroom management of science fair projects as easy and productive as possible. The first two objectives both support this goal, but we also provide guidance and productivity tools specifically for teachers.

By offering a wide variety of Project Ideas to capture the imagination of every student, and by improving the productivity of students and teachers alike, we believe we also will slowly but steadily increase science fair participation. At its current stage of development, Science Buddies wants to focus on these objectives, so we consciously avoid being drawn into debates about curriculum and other educational policies and politics.

B. Important Project Idea Requirements

Science Buddies has spent a lot of time studying and developing methods that best serve the students and teachers. Therefore, we strongly encourage you to observe the following requirements when writing Project Ideas.

- Generally, the experiment should provide positive results with a measurable change (which is not equal to zero). Admittedly, many scientists actually design an experiment hoping to find a negative outcome; however, our experience tells us that this is a bad approach for young students, due to disappointment issues. For a novice we want an exciting conclusion, not a big let down. This is about feelings and the satisfaction of discovery.

- Make sure that the Project Idea clearly has a single independent variable and a significant outcome.

- Utilize quantitative measures. For an experiment with categorical variables (nominal or ordinal scales), guide the student to a quantitative summary. For example, provide a rating scale with information on how to use it.

- Discuss and suggest an appropriate number of trials. The rule of thumb for a science fair is three trials, but a larger number is certainly ok. An experiment that requires many trials might not be appropriate for a science fair project.

- For projects that involve surveys, the measured effect should be prominent enough that it can be detected with the very small sample sizes that a student would typically work with. Only the most energetic students would exceed 10 or 15 subjects. Talk about an appropriate sample size in your Background and Procedure sections.

- Stay away from projects that will trigger IRB (Institutional Review Board) concerns. Also, for low-difficulty projects targeted to K-5 students, stay away from projects that require SRC approval.

- Familiarize yourself with our difficulty scale by simply clicking "Difficulty" on any Project Idea in the Project Idea Directory. This will help you write appropriately based on grade level. There should be a significant difference between writing for K-5 and writing for high school.

- We advocate the use of active voice, whenever possible, over passive voice.

3. Project Ideas from Start to Finish

A. Project Idea Overview

Each Project Idea has a structure that looks like this:

- A title, which is essentially the headline for the Project Idea.
- A short description, including a brief abstract that serves as a "brochure," if you will, for the potential experiment.
- A list of key scientific concepts/terms that will be covered in the project.
- A table showing some key parameters for the project, such as appropriate grade level and time required.
- Background information, including a bibliography and terms and questions, that gets the student started on the right foot.
- Experimental procedures.
- A list of possible variations on the experiment.

Categories

Science Buddies will categorize each Project Idea into the most relevant field of science or engineering to make sure that the Topic Selection Wizard presents it to the proper and most interested students.

i. Project Idea Volunteer Template

The Project Idea Volunteer Template is a Word document that you will use to fill out and submit your Project Ideas to Science Buddies.

B. The Title and Abstract

i. Writing a Title

The title and the abstract (described below) are essentially what help "sell" a project to a student. They will not click into a project if these two elements don't compel them. The title should catch their attention by making clear and exciting connections between the real world and science. While being "cute" with the title is one way to go, sometimes just disclosing the topic is intriguing. The title is also important because the search engines will pick it up as the headline for the search results page. Here are a few good examples: "Does a Cell Phone Conversation Affect Reaction Time?," "Nothing But Net: The Science of Shooting Hoops," "What Is Home Sweet Home to a Bug?," and "Bomb's Away! A Ping Pong Catapult."

ii. Writing an Abstract

The abstract is displayed after the Project Idea title, within the Project Ideas directory. It should be less than one-quarter page in length (100 words or less). Students will pick an experiment based on the abstract, so it should be written in a manner that attracts them and captures their imagination. Feel free to include a key Web link, if appropriate.

An abstract should include the following key components:

- The **objective or goal**, generally at a high level of abstraction, which the student will refine and make more specific. For example, "…compare the same gene across different species," which the student would refine to something like "A comparison of the cystic fibrosis gene in humans and chimpanzees."
- The **experimental procedure**, a very brief description of what the student would do in carrying out the experiment. Focus on the "fun" parts of the procedure to help entice the students; such as mixing chemicals, building models, and digging in the dirt.
- **What the student will learn.**

An abstract should meet the following objectives:

- **Entice the student to linger and explore.**
  The abstract should entice the student to click through to linger and explore the full Project Idea; however, don't make the abstract itself so long that it requires lingering and exploration! Think of it as an ad for a Project Idea.
- **Minimize reading for the student while he or she is in the exploratory stage.**
  The abstract conveys more information about the project than the title alone. It should tell enough about the project so that the student can decide whether or not to read further. In general, abstracts should be brief since there are many per Project Idea page, all competing for the student's attention.

A compact image that conveys an important aspect of the project is optional, but useful when available. As an engineer friend of mine used to put it, "A word is worth a millipicture."

iii. Sample Abstracts

This abstract tries to catch the interest of basketball fans. This one is just the right length, with a nice balance of sports and science:

<u>Nothing but Net: The Science of Shooting Hoops</u>
Swish! What a great sound when you hit the perfect shot and get nothing but net. Here's a project to get you thinking about how you can make that perfect shot more often.

Here are a couple more examples:

<u>Rocket Aerodynamics</u>
Have you ever heard the expression, “Well, it’s not exactly rocket science…”? For your science fair project, you can *be* a rocket scientist. Here’s how. This example introduces geomagnetic storms relating them to more familiar weather systems on earth. The eye-catching graphic is from the NOAA Space Environment Center website.

<u>Candy Confusion: Can Small Children Mistake Medicine for Candy?</u>
Many medicines come in bottles with special childproof caps so that small children can't accidentally open the bottle and eat the pills. To a small child who can't read the label, the pills might look just like candy. What cues do we use to tell the difference between medicine and candy? At what age can we tell them apart? This project can show you how to find out.

C. Project Summary Table

The first key item in the Project Idea is a summary table that helps a student compare projects using a common set of criteria. Note that most fields have a standardized entry, as shown below:

Difficulty	For an average student, the following table is a good guideline: Difficulty: 1 2 3 4 5 6 7 8 9 10 Grades K-5 (1–4) Grades 6-8 (4–7) Grades 9-12 (6–10) Easy — Hard Thus, for a typical student in grades 6 - 8, an easy project would be a 4 and a challenging project would be a 7. Try an easier project if you have a weak background in science, or a harder one if you are especially good. http://www.sciencebuddies.com/science-fair-projects/project_ideas/help_project_difficulty.shtml
Time required	Combination of calendar and actual experimental time. <u>DO</u> take time it takes to order supplies into account. <u>DO NOT</u> include time for research, reports, etc. • Very Short (a day or less) • Short (several days)

	• Average (about a week) • Long (a couple of weeks) • Very Long (several weeks to months)
Prerequisites	Courses, knowledge, or facility access that is a prerequisite for understanding and/or performing the experiment.
Material Availability	Note: This box is just to categorize the project. A detailed materials & equipment list appears in a different section. Here is where you should also list specific big-ticket items that they should *already* have, such as hockey equipment, a gaming console, or a musical instrument. You do not need to name a computer. • Readily available = Household items, materials commonly available at a drug, grocery, or hardware store. • Specialty items = Available for sale to individuals (including students), but through a specialty retailer or catalog. • Require sponsor = Items such as chemicals and agar plates that must be purchased by a teacher or another professional, typically through the purchasing department of an organization such as a school. PLAN AHEAD for these items. • ContResearch Paperled = Stuff that kids cannot and should not have. Don't propose experiments that require this.
Cost	Don't include items like a display board, which every project requires. Also, do not include expensive items they should already have, which should be mentioned in Material Availability. • Very Low (under $20) • Low ($20–$50) • Average ($50–$100) • High ($100–$150) • Very High (over $150)
Safety	<u>Levels of safety concern:</u> • No hazards • Minor injury possible • Requires adult supervision • Requires adult supervision in a special facility <u>The SRC</u> The acronym SRC stands for Scientific Review Committee. Please indicate whether the project is likely to require SRC approval (Science Buddies' staff can help you make this determination). In general, projects involving any of the following will require SRC approval: • Human subjects, including projects involving the use of psychological surveys • Nonhuman vertebrate animals • Pathogenic and potentially-pathogenic agents • Controlled substances, such as alcohol and drugs • Recombinant DNA (rDNA) • Human and nonhuman vertebrate animal tissue • Hazardous substances or devices, including model rockets and many chemicals

Here's an example:

Difficulty 2-3
Time required: Very Short (a day or less)
Prerequisites: You should have access to a sunny location where your structures will not be disturbed for several days.
Material Availability: Readily available
Cost: Very Low (under $20)
Safety: Always use caution when working with power tools. Be sure to wear safety goggles. Adult supervision is required.

D. Writing an Objective

This should consist of one or two simple, declarative, succinct sentences that state the objective or goal of the project. Here's an example:

> *In this project, you will use a special, free, Web-based computer tool called BLAST to analyze and estimate the effectiveness of different flu vaccines.*

If there are multiple goals, they can be listed as in the following two examples:

Example 1:
This project has two objectives:

1. Write a mathematical proof for the construction of a circle inscribed in a triangle.
2. Illustrate the proof with a dynamic figure created with the Geometry Applet.

Example 2:
The objective of this project is to write a JavaScript program to make the following basic measurements on a block of text:

- Number of sentences contained in the text
- Number of words in each sentence
- Number of letters in each word
- Average number of words per sentence

E. Writing an Introduction

The introduction expands on the abstract to provide students with the background they need to decide if this is a good project for them, as well as to give them a head start preparing a Research Paper.

Here's an example:

Influenza is caused by a virus that attacks the upper respiratory tract (e.g., the nose, the throat and the lungs). Cold and dry weather allows the virus to survive longer outside the body than in warm weather. Therefore, in temperate regions like North America, when we are planning to enjoy Halloween, Thanksgiving, or Christmas, it is also the time when we or our family members have a higher chance of getting the flu.

There are three types of influenza virus: A, B, and C. Type A can infect humans, other mammals, and birds and can spread fast and affect many people. Types B and C affect only humans, and type C causes only a mild infection. Influenza type A viruses are sub-typed into two categories based on the proteins (H and N) on the surface of the virus. The virus uses the H protein molecule to latch on to the host's cell and uses the N protein molecule to spread the infection. Types A and B continue to evolve genetically, and thus prevent the hosts from enjoying any prolonged protection against the virus. Aren't they smart?

The influenza vaccine typically contains three virus strains, two are subtypes of type A and one is of type B. Every February, the World Health Organization (WHO) will decide what influenza virus strains to include in the vaccine for the new year, based on the analysis of various laboratories across the globe,.

The genetic material in the flu vaccine is a fragment of DNA from each strain. If you imagine that you can hold the DNA fragment with both hands and stretch it out, you will then have a linear DNA sequence in your hands. The DNA sequence holds the genetic instructions for an organism. Unlike the English alphabet, which has 26 letters, the DNA alphabet has only four letters (A, C, T, G) and, while each English word is made of one to many letters, the genetic word (each of which specifies an amino acid) is always made up of three DNA letters.

It is easy to align two English words and compare their spellings. Even so, there is often more than one possible alignment:

For example, Alignment #1 (with red showing where the letters match)

s	t	r	a	w	b	e	r	r	y
b	l	u	e	b	e	r	r	y	_

or, Alignment #2 (shifting the word blueberry to the right by one character)

s	t	r	a	w	b	e	r	r	y
_	b	l	u	e	b	e	r	r	y

For the two words chosen above, Alignment #2 gives us a better result than Alignment #1. Similarly, you can take two genetic sequences and compare their spellings; this is called sequence alignment in bioinformatics. If they are very much alike, they may hold similar genetic instructions for the organism.

The alignment example above is simple enough that we can do it manually. However, when we want to align two DNA sequences, they can be over 1000 letters long and with only four letters, so it is much more difficult and more time-consuming to do it manually. Luckily, bioinformatics comes to the rescue. Bioinformatics is the collection and analysis of large amounts of biological data using computers and computational/statistical methods.

BLAST stands for Basic Local Alignment Search Tool. It is a powerful Web-based tool for sequence alignment. It aligns your query sequence of interest to a collection of sequences stored in the computer and compares the results, telling you which sequences contain regions or segments that are similar to your sequence.

All else being equal, we would expect that a strong match between the DNA sequence in a vaccine and a virus in the "wild" results in good protection against that virus. On the other hand, a poor match would result in weak protection against the virus. By using BLAST to measure the quality of the match, we can estimate the effectiveness of a vaccine against different viruses.

F. Terms, Concepts, and Questions to Start Background Research

The Science Buddies website tab, called "Project Guide," includes a section that outlines what each student should include in his or her Research Paper. Keeping this information in mind as you prepare to write these parts of your Project Idea, you can and should go beyond the Research Paper general guidelines and offer the student some specific guidance based on the proposed question. The research and actual Research Paper are both key to ensuring the students understand the science behind their experiments. Use your experience to anticipate what the student will need in order to understand and to confidently design and carry out his or her experiment, then make appropriate suggestions to ensure the conducted research covers the key elements of the experiment that he or she will perform.

- Specifically identify some important terms and key concepts that the student should research.
- Specify aspects of the underlying theory sufficient to predict results (***including relevant equations or mathematical relationships***). For example, if a student's project involves electric motors, you might ask him or her to research the relationship between the load on the motor and the current it draws. For a student working with cleaning products you might say, "Among other points that I'm sure you'll find important, your Research Paper should include a description of what dirt is, and how soaps and detergents work to remove it." The student does the work, but receives specific guidance.
- Ask the student to study relevant equipment, if any. The student should investigate what the equipment does, how it works, and why it is used.

The student still does the work, but with a guiding hand. Without this tailored guidance, many students' research will be all over the map and their learning experience will be compromised.

Please note that questions should be in the form of complete sentences, with normal capitalization and punctuation.

Here's an example:

Terms, Concepts and Questions to Start Background Research

To do this type of experiment, you should know what the following terms mean. Have an adult help you search the Internet, or take you to your local library to find out more.

- Perception
- Apparent motion
- Optical illusion
- Flip-book
- Thaumatrope
- Phenakistiscope
- Zoetrope

Questions

- Why do we perceive apparent motion of stationary objects?
- How is the brain tricked into filling in the blanks?
- Are there limits to our perception of apparent motion?

G. Bibliography

The Bibliography section is a list of suggested resources to give students a good start on their background research. If you cite references in the text of your Project Idea, include the citation reference in the Bibliography. Image credits are on their own part of the website, so no need to include those in the Bibliography. Use the Credits section to credit yourself, contributors, and sources from which you directly based your Project Idea on, as well as trademarks.

It's okay and entirely expected that you will direct students to specific sources, just like a professor, mentor, or colleague might have at one time directed you. Make sure that the student has sources that will enable him or her to complete a first-class research paper. Of course, we expect that the student will add sources of his or her own. Carefully consider your suggested resources before including them. For instance, a subscription-only academic journal is not a realistic resource for the vast majority of students.

Format the Bibliography as a bulleted list. Bibliography items should be formatted in the MLA/APA format that we recommend on our Project Guide pages: http://www.sciencebuddies.org/science-fair-projects/project_bibliography.shtml.

H. Materials and Equipment

List required materials and equipment. Be specific enough that a student can ensure they obtain the proper items, and include a source if the item is not easily available. For example, if any voltmeter will do, say so. If the voltmeter must accurately read 10 millivolts, say that instead.

As often as possible, try to make use of readily available materials and equipment. For example, where normally in the lab you would reach for a beaker, an empty jelly jar will probably do just fine for a science fair project. If your project requires a sodium chloride solution, ordinary table salt will probably do just fine.

Weighing small quantities can also be problematic in the home, so where appropriate, give equivalent volumes, as in a cooking recipe (1/4 teaspoon of salt in a cup of water for normal saline solution, for example). Obviously you would not suggest this manner of measuring for chemicals not ordinarily found in the kitchen!

Go through your list and try to find similar substitutes for any specialty lab items. The more specialty items your project requires, the smaller your potential audience becomes.

Ideally, we want tight specs on items in the materials list, unless we have verified that something "close" is good enough. Specifically,

- We will build/try ***all*** new electricity and electronics projects before posting. In addition to verifying specifically which parts work satisfactorily, if not best, building the projects will be an excellent source of photographs.
- We will use our judgment in other project areas as to whether the project should be tried before posting.
- Electricity and electronics parts should be specific (full spec and/or an actual part number from one of our approved suppliers, if available).
- Specify where a user can purchase a part if it is not obvious or commonly available. Specify a specific supplier(s) if the part has limited availability.*
- On the other hand, over-specifying a part can be just as bad as under-specifying. We want to save our users time, so it's just as bad to be looking for a specific part when any will do, as it is to purchase the wrong part because we were not specific enough. For example, if any magnet will work, don't specify an iron magnet.
- Always minimize the number of suppliers required to purchase a complete set of materials from the materials list. However, whenever possible, list multiple suppliers for each item.

I. Experimental Procedure

Describe the experimental procedure in enough detail for the student to succeed, leaving room for variation and creativity to the extent appropriate. Obviously, the proper amount of detail represents a balancing act. If you need to describe how to use a specialized tool, this is the place to do it. All safety issues should be described in full or refer the student to a page within our Project Guide that might already cover a certain safety or specialty procedure (such as disposal of chemicals or how to use a breadboard).

Here's an example of an Experimental Procedure:

1. *Obtain a pack of petri dishes (20 per pack) and fill halfway with liquid LB agar. Let plates solidify.*
2. *Identify nine different locations where you would like to assess biodiversity. Suggested sites could include the bathroom, kitchen, locations near heating vents, bedrooms, the refrigerator, the backyard, the garage, etc.*
3. *Place two petri dishes per site. Leave dishes open and exposed for a period of 48 hours.*
4. *An additional two plates should be unopened and used as negative controls. In other words, you'll study what grows on these plates even though you never expose them to the air. (Hopefully, very little, if anything, will grow!)*
5. *At the end of 48 hours, seal plates with strapping or heavy-duty tape.*
6. *Allow the plates to incubate by placing all of them in one single location that has a fairly constant room temperature (about 22 degrees Celsius) for 1-3 weeks, until distinct bacterial colonies can be observed. (Don't forget to put the two, unopened control plates in this same location.)*
7. *Collect data over the course of the three weeks. Every other day, note the number of colonies, the color, and the size.*
8. *After the end of the three-week period, make various graphs of the data. Suggestions include, but are not limited to:*
    a. *Colony counts on each plate.*
    b. *Colony counts at each location (take an average of two plates).*
    c. *Different types of microorganisms, based upon:*
        i. *Size*
        ii. *Color*
        iii. *Shape*
9. *Keep the microbial plates during the duration of your project, and while you are writing up your paper. You will want to make many observations.*
10. *When you are completely done with the experimental write-up, decontaminate the plates by carefully opening, and pouring a generous amount of 10 percent bleach onto the agar surface. (You can make a 10 percent bleach solution by mixing one part of regular laundry bleach [e.g. Clorox] with nine parts of water.)*
11. *The sterilized, decontaminated plates can be disposed of in your regular household garbage, but ONLY after sterilization, as described in the previous step.*

Address likely failure modes for a Project Idea in advance, and be sure to provide a troubleshooting section, if appropriate. There's a balance between the length of the primary instructions (too long and they are less likely to be read/followed) and covering every contingency. In some cases, it might be better to cover some of the contingencies in a separate section at the bottom of the instructions. This decision is a judgment call by the staff scientists.

The experimental procedure should be formatted as a numbered list. The procedure should be written in complete sentences, using the active voice. For some projects, the material is best presented as a series of major tasks, which are then broken down into subtasks. Use nested alphabetized lists in outline format for the subtasks.

<u>A few important notes:</u>
* Carefully review the Data Table Guidelines below.
* Please check out our lab techniques before rewriting a common procedure. You might be able to reference a particular page on our site for how to grow bacteria, clean up after using bacteria, etc., rather than reinventing the wheel.

i. Data Table Guidelines:

- If the need for a data table presents itself in the experiment, you
    1. Must include a sample for Difficulty levels 1-4.
    2. May include a sample for Difficulty levels 5 and 6.
    3. Should *not* include a sample for Difficulty levels 7-10.
- Title-cap headings of columns.
- Only cap the first letter of sample data.
- Include unit abbreviations in parentheses.
- Confirm numbers are decimal-aligned when you see the html version in the Project Editor.
- Refer to it as a *data table,* not as a *data chart.*

J. Possible Variations

Identify variations on the suggested experiment. For example, many physical processes are temperature-dependent. One possible variation on an experiment measuring the capacity of a battery would be to make temperature the independent variable.

The list of possible variations provides a great means for students to demonstrate creativity and to truly make the experiment their own.

Here is an example, but it is a short list. More is better! In fact, 5-10 variations is ideal, giving the student several ways to make the experiment their own.

> *Here are two potential experiments you can perform using sequence alignment techniques on influenza viruses. Pick a past year for which you have data on the DNA sequences in the flu vaccine, as well as information about the prevalent flu outbreaks. Better yet, pick several such years so you can compare one to another.*
>
> - *Based on sequence alignment, was the vaccine effective?*
> - *If you could travel back in time and redesign the flu vaccine for the year you pick, which flu virus strains would you use for the vaccine? Based on sequence alignment, if the choices of virus strains you suggest are not available, are there any alternative strains you can use and still have an effective vaccine?*

Variations should be formatted as an unordered, bulleted list. They should be written in complete sentences, with normal capitalization, and will often include, or take the form of, questions.

K. Photos and Diagrams

i. Copyright Information

Depending on the project, one or more photos or diagrams can be a great way to make the Project Idea more attractive. As a nonprofit, educational foundation, Science Buddies can, in most cases, use copyrighted diagrams and images as illustrations for a Project Idea, under the "Fair Use" provisions of U.S. Copyright law (U.S. Code, Title 17, Chapter 1, § 107). The copyright owner must be identified, and the source of the copyrighted diagram or illustration must be properly cited in the Project Idea. Science Buddies chooses not to use "for-profit" stock photography that someone is trying to use to make a living. Our preference is to use photos that are in the public domain.

Contact Science Buddies if you have any questions: scibuddy@sciencebuddies.org

Please consider the following:

- Is the photo copyrighted or in public domain? (All U.S. government photos are in the public domain).
- If the photo is copyrighted, make sure you can provide the name of the copyright holder and a complete citation for the source of the photo.
- It is best if you can send us an image file as an attachment to your email submission, in addition to pasting the image into the photo/diagram chart in the Project Idea Template (a separate document you should have).

ii. Credits

Science Buddies can only post images in the public domain, for which the author holds the copyright, or for which they have obtained permission from the owner.

The Image Credits database, linked to on the bottom of all our webpages, contains copyright/credit information for the photos and images displayed on the website. If an image is not listed in the database, then those images are Copyright ©2002-2008 Kenneth Lafferty Hess Family Charitable Foundation. All Rights Reserved.

L. Projects Based on Public Domain Databases

i. Overview

There is a wide variety of real-time, scientific data available over the Internet. For example, data from the NASA Solar & Heliospheric Observatory (SOHO) satellite is archived and publicly available at http://sohowww.nascom.nasa.gov/. In some cases, students can actually control advanced scientific equipment, such as an electron microscope at the Beckman Institute and a number of telescopes worldwide, via the Internet. These data and tools can help students learn science in a more exciting, real-world, and meaningful way than traditional classroom lectures, demonstrations, and experiments.

Moreover, the cost of undertaking projects that utilize public domain data or tools is very low, making them appropriate for students from a wide variety of backgrounds.

ii. Background Information

Typically there will be important background information that is easily understood by the student, but not available in an age-appropriate or public domain format. For example, there may or may not be an existing write-up on why we share genes with other animals. The author will need to prepare these materials. Sometimes, portions of the background material must be written from scratch.

Often, public domain tools are written by and for graduate students and researchers. The Cutting-edge writer will need to prepare appropriate instructions for using such tools, if they are required.

iii. Special Cases

There are often a number of "flaws" in public domain data. For example, in genomics, sometimes a search for a specific gene may bring up a couple dozen "hits," some much better than others. The author will need to offer instruction on how to differentiate among the hits (and/or provide real-time mentoring to offer advice in our Ask an Expert Forum: http://www.sciencebuddies.com/science-fair-projects/ask_an_expert_intro.shtml).

iv. Additional Considerations

In some cases (e.g., experiments involving exploratory science), it might be difficult to develop the hypothesis if it requires an additional level of knowledge beyond the student's capability. In such cases, the author may want to go further than normal to assist the student in formulating a hypothesis.

4. Supplier Guidelines

A. Objectives

- Offer our visitors the options to buy all the parts in one place and, in turn, save people time and frustration.
- Increase the odds of project completion and success by eliminating the hurdles to finding and sourcing the right materials for a project.
- At the same time, we want multiple sources whenever possible to minimize the risk of out-of-stock situations.

B. Guidelines

- When developing a new Project Idea, identify suppliers that you would like to use from our list of Approved Suppliers: http://www.sciencebuddies.org/science-fair-projects/project_supplies.shtml (also found below). Make sure to check the online version, as we will keep it updated with any changes in our suppliers. While selecting a supplier, here are some things to consider:
    - Can they provide all or almost all of the parts required for this project? Whenever possible, one source is better than two.
    - It's not necessary to shop for the lowest price on each part, as long as the supplier is reasonably priced (having to place multiple orders with multiple shipping charges vs. one order from one supplier might outweigh the differences in cost).
    - We have a relationship with Home Training Tools and they may stock additional items for us. If their product line is missing something from what a project requires we can always check if they will add it.
- Ideally each Project Idea will offer our visitors a "one-stop shopping" option (e.g. The ability to buy all of the parts from a single supplier). Certain parts may need to be sourced from unique suppliers, which is OK, but we should try to keep this at a minimum.
- Sourcing the materials:
    - Identify the supplier.
    - Find the part number for each item in the materials list from the supplier.
    - For electronics projects, our rule is to order the part and try it. Writers should use their judgment for other project areas.

- It is imperative to provide information on tolerances and the acceptability of substitutes: What is the range of acceptable parts or materials? Must an exact part be used?

- Each Project Idea page should have a matrix that looks something like this so users can go to the supplier website, enter the part numbers, and check out. This is just an example of how the table might be completed. This project uses the parts list from the Cool Junctions Project Idea, but the data in the table is all made up just to show how the different columns might be used.

Materials Description	**DigiKey**	**Mouser**	**Joe's Electronics**	**Important Notes / Comments**
Digital or analog multimeter			JO-12-34-MM	You need a multimeter with a scale that reads from 0 – 10 or 15 milliamps.
1Kohm 1/2W resistor +/- 2% to control the voltage	#567890	M2 -1234		You can use a resistor with a tighter tolerance and/or a higher wattage rating.
Test leads with alligator clips	#345678	ME-1234		
A beaker or cup to hold ice or cold water				Available around the house or from local hardware store
Candle or other heat source				Available around the house or form local hardware store
Lengths of wire made of different metals, e.g., • iron • copper • constantan • aluminum				Available at local hardware store
9-V Battery				Available at most grocery, drug, and hardware stores

Appendix 1: What Is a Typical Student's Educational Background?

This table (based on California standards) is an attempt to summarize a typical middle school student's educational preparation. Students in a remedial situation will obviously be below these guidelines, while high school students should (but may not) surpass them. Links to standards in other states appear below the table.

Some highlights:

- At the 7th grade level, students will have had little if any previous exposure to the concept of an independent or dependent variable.
- The bibliography that Science Buddies requires will be the first ever for some students. Footnotes are generally first covered in 8th grade.
- The Review of Literature for a middle school science fair project will most likely be the longest paper the student has ever written. Indeed, California standards call for papers of only 1-2 pages in length through the 8th grade.

Clearly, the Science Buddies experience, in addressing these important aspects of learning, will be a key component of the student's education.

	6th Grade Curriculum (or beginning 7th Grade)	**7th Grade Curriculum (or beginning 8th Grade)**	**8th Grade Curriculum (or beginning 9th Grade)**
Science Content	Focus on Earth Science • Plate Tectonics and Earth's Structure • Shaping Earth's Surface • Heat (Thermal Energy) • Energy in the Earth System • Ecology • Resources http://www.cde.ca.gov/standards/science/grade6.html	Focus on Life Science • Cell Biology • Genetics • Evolution • Earth and Life History • Structure and Function in Living Systems • Physical Principles in Living Systems http://www.cde.ca.gov/standards/science/grade7.html	Focus on Physical Science • Motion • Forces • Structure of Matter • Earth in the Solar System • Chemical Reactions • Chemistry of Living Systems • Periodic Table • Density and Buoyancy http://www.cde.ca.gov/standards/science/grade8.html

	6th Grade Curriculum (or beginning 7th Grade)	7th Grade Curriculum (or beginning 8th Grade)	8th Grade Curriculum (or beginning 9th Grade)
Investigation & Experimentation	Students able to: a. Develop a hypothesis. b. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data. c. Construct appropriate graphs from data and develop qualitative statements about the relationships between variables. d. Communicate the steps and results from an investigation in written reports and oral presentations. e. Recognize whether evidence is consistent with a proposed explanation. f. Read a topographic map and a geologic map for evidence provided on the maps and construct and interpret a simple scale map. g. Interpret events by sequence and time from natural phenomena (e.g., the relative ages of rocks and intrusions). h. Identify changes in natural phenomena over time without manipulating the phenomena (e.g., a tree limb, a grove of trees, a stream, a hill slope).	Students able to: a. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data. b. Use a variety of print and electronic resources (including the World Wide Web) to collect information and evidence as part of a research project. c. Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence. d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e. g., motion of Earth's plates and cell structure). e. Communicate the steps and results from an investigation in written reports and oral presentations.	Students able to: a. Plan and conduct a scientific investigation to test a hypothesis. b. Evaluate the accuracy and reproducibility of data. c. Distinguish between variable and controlled parameters in a test. d. Recognize the slope of the linear graph as the constant in the relationship y = kx and apply this principle in interpreting graphs constructed from data. e. Construct appropriate graphs from data and develop quantitative statements about the relationships between variables. f. Apply simple mathematic relationships to determine a missing quantity in a mathematic expression, given the two remaining terms (including speed = distance/time, density = mass/volume, force = pressure x area, volume = area x height). g. Distinguish between linear and nonlinear relationships on a graph of data.

	6th Grade Curriculum (or beginning 7th Grade)	7th Grade Curriculum (or beginning 8th Grade)	8th Grade Curriculum (or beginning 9th Grade)
Math	By the end of grade six, students have acquired the following math skills: Basic Math • Mastered addition, subtraction, multiplication and division with whole numbers, positive fractions, positive decimals, and positive and negative integers • Compute and solve problems Statistics and Probability • Understand the concepts of mean, median, and mode of data sets and how to calculate the range • Analyze data and sampling processes for possible bias and misleading conclusions • Use addition and multiplication of fractions routinely to calculate the probabilities for compound events Pre-Algebra • Conceptually understand and work with ratios and proportions; compute percentages (e.g., tax, tips, interest). • Solve one-step linear equations Geometry • Know about pi and the formulas for the circumference and area of a circle • Use letters for numbers in formulas involving geometric shapes and in ratios to represent an unknown part of an expression	By the end of grade seven, students have acquired the following math skills: Geometry • Know the Pythagorean theorem and solve problems in which they compute the length of an unknown side. • Compute the surface area and volume of basic three-dimensional objects and understand how area and volume change with a change in scale. Pre-Algebra • Are adept at manipulating numbers and equations and understand the general principles at work. • Understand and use factoring of numerators and denominators and properties of exponents. • Make conversions between different units of measurement. • Know and use different representations of fractional numbers (fractions, decimals, and percents) and are proficient at changing from one to another. • Increase their facility with ratio and proportion, compute percents of increase and decrease, and compute simple and compound interest • Graph linear functions and understand the idea of slope and its relation to ratio.	Symbolic reasoning and calculations with symbols are central in algebra. Through the study of algebra, a student develops an understanding of the symbolic language of mathematics and the sciences. In addition, algebraic skills and concepts are developed and used in a wide variety of problem-solving situations.

	6th Grade Curriculum (or beginning 7th Grade)	7th Grade Curriculum (or beginning 8th Grade)	8th Grade Curriculum (or beginning 9th Grade)
Writing (Research & Techniques)	a. Use organizational features of electronic text (e.g., bulletin boards, databases, keyword searches, e-mail addresses) to locate information. b. Compose documents with appropriate formatting by using word-processing skills and principles of design (e.g., margins, tabs, spacing, columns, page orientation).	a. Identify topics; ask and evaluate questions; and develop ideas leading to inquiry, investigation, and research. b. Give credit for both quoted and paraphrased information in a bibliography by using a consistent and sanctioned format and methodology for citations. c. Create documents by using word-processing skills and publishing programs; develop simple databases and spreadsheets to manage information and prepare reports.	a. Plan and conduct multiple-step information searches by using computer networks and modems. b. Achieve an effective balance between researched information and original ideas.
Writing (Research Reports)	Able to write research reports of 500-700 words (1-2 typed pages): a. Pose relevant questions with a scope narrow enough to be thoroughly covered. b. Support the main idea or ideas with facts, details, examples, and explanations from multiple authoritative sources (e.g., speakers, periodicals, online information searches). c. Include a bibliography.	Able to write research reports of 500-700 words (1-2 typed pages): a. Pose relevant and tightly drawn questions about the topic. b. Convey clear and accurate perspectives on the subject. c. Include evidence compiled through the formal research process (e.g., use of a card catalog, Reader's Guide to Periodical Literature, a computer catalog, magazines, newspapers, dictionaries). d. Document reference sources by means of footnotes and a bibliography.	Able to write research reports of 500-700 words (1-2 typed pages): a. Define a thesis. b. Record important ideas, concepts, and direct quotations from significant information sources and paraphrase and summarize all perspectives on the topic, as appropriate. c. Use a variety of primary and secondary sources and distinguish the nature and value of each. d. Organize and display information on charts, maps, and graphs. Write technical documents: a. Identify the sequence of activities needed to design a system, operate a tool, or explain the bylaws of an organization. b. Include all the factors and variables that need to be considered. c. Use formatting techniques (e.g., headings, differing fonts) to aid comprehension.

More on Educational Standards:
California: http://www.cde.ca.gov/standards/
New York: http://usny.nysed.gov/teachers/nyslearningstandards.html
Oregon: http://www.ode.state.or.us/cifs/
Virginia: http://www.pen.k12.va.us/VDOE/Superintendent/Sols/home.shtml

Appendix 2: Science Fair Project Expectations

Students participating in the Science Buddies Online Mentoring Program must meet the following MINIMUM requirements for their assignments. If the classroom requirements are lower, Science Buddies participants must still meet these minimums for the assignments submitted to the Assignment Folder. If the classroom requirements are higher, then students should follow their teacher's requirements.

Assignment	Minimum Requirement
Bibliography	Minimum of 3 offline sources, including at least one encyclopedia
Review of Literature	Minimum of 2 pages in length (700 words)
Repetitions	Minimum of 3 runs of an experiment If working with plants, should have a minimum of 3 plants per variable tested

We encourage students to exceed the minimums, and most Cutting Edge Projects would require substantially more effort in a Review of Literature. Of course, students working on their own, outside our Online Mentoring Program, will be working at a variety of different minimums or standards of performance.

This table gives an idea of the level of work expected at different levels of competition.

Expectations for Science Fair Projects	**Middle School Level (Grades 6-8)**		**High School Level (Grades 9-12)**	
Aspect of the Project	**School Science Fair**	**State Science Fair**	**State Science Fair**	**Intel Int'l Science & Engineering Fair**
Topic Overall, judges prefer a simple experiment wherein the student displays complete mastery of the underlying theory and can thoroughly explain why the experiment turns out the way it does over a more sophisticated project that the student understands poorly.		• Original scientific research rare at this age • OK to repeat an experiment first done 1, 10, or 100 years ago • Originality more often displayed in technique and presentation	• Original research more common than at middle school level • Some projects done in a university research setting under a college professor	• Majority of projects are original research • Many projects done in a university research setting under a college professor • 10-15% of participants file patents on their work • Many publish results in a scientific journal

Expectations for Science Fair Projects	Middle School Level (Grades 6-8)		High School Level (Grades 9-12)	
Aspect of the Project	**School Science Fair**	**State Science Fair**	**State Science Fair**	**Intel Int'l Science & Engineering Fair**
Background Research As the level of competition increases, judges expect, sources that are a bit beyond the student's years, information that stretches his or her thinking, but not too far. "…students are expected to have a thorough understanding of the work that they have done. The students must know why the experiments they have assembled and operated can provide the answers they seek." – CSSF	• Encyclopedias • Books targeted at a middle school audience • Appropriate Web resources	• Scientific *American* • American *Scientist* • High school textbooks • Appropriate Web resources • Research should be footnoted as appropriate.	• Scientific *American* • American *Scientist* • College textbooks • Scientific monographs • Peer-reviewed scientific journals • Appropriate Web resources • Research should be footnoted as appropriate.	• Scientific *American* • American *Scientist* • College textbooks • Scientific monographs • Peer-reviewed scientific journals • Appropriate Web resources • Research should be footnoted as appropriate.
Math Content The Review of Literature and subsequent data analysis should contain all the *relevant* math that the student is capable of understanding.	• Basic graphs that show relationship between variables • Qualitative description of relationship between variables	• Graphs that show relationship between variables • *Quantitative* statements about the relationships between variables (equations not generalities)		

Expectations for Science Fair Projects	**Middle School Level (Grades 6-8)**		**High School Level (Grades 9-12)**	
Aspect of the Project	**School Science Fair**	**State Science Fair**	**State Science Fair**	**Intel Int'l Science & Engineering Fair**
Experimental Procedures The methodology and experimental design should be appropriate for the student's grade and discipline.		• Experiments are appropriate to achieve the stated objective • The sample size and/or number of trials is sufficient to establish validity • The statistical analysis is appropriate for the students' grade and discipline		• Experimental procedures follow "best professional practices" typical of work to be published in a peer-reviewed journal
Display Board	Standard display boards (36" x 48" folding to 36" x 24") available at most office supply stores.	Larger boards common.	Larger boards common.	Larger boards the norm, up to 48" wide by 108" tall.
Judging The higher the level of competition, the more important the role of one-on-one interviews. Interviews are a highly effective means to ascertain the student's understanding of the work presented on the display board.	• Generally based only on the project notebook and backboard • Interviews rare	• One-on-one interviews by 5-10 judges key part of process	• One-on-one interviews by 5-10 judges key part of process	• One-on-one interviews by 5-10 judges • If project done under the supervision of a professional research scientist, his/her written comments vitally important

Expectations for Science Fair Projects	Middle School Level (Grades 6-8)		High School Level (Grades 9-12)	
Aspect of the Project	**School Science Fair**	**State Science Fair**	**State Science Fair**	**Intel Int'l Science & Engineering Fair**
Prizes	Typically, school fairs award ribbons and certificates.	For the California State Science Fair: 1st Place award of $250 2nd Place award of $150 3rd Place award of $100 in each of 19 different subject categories. Also various special awards.	For the California State Science Fair: 1st Place award of $500 2nd Place award of $250 3rd Place award of $125 in each of 15 different subject categories. Also various special awards.	Best of Category award of $5000 1st Place award of $3000 2nd Place award of $1500 3rd Place award of $1000 4th Place award of $ 500 in each of 15 categories. Additional awards worth over $1.5 million include tuition scholarships, summer internships, scientific field trips, and laboratory equipment. The top three students receive a $50,000 scholarship and a high-performance computer.