Science Fair Basics "The Good, the Bad and the Ugly"

Thanks to Terik Daly, Amber Hess and Dr. Grant Mason

2011-2012

The UGLY:
Rules & Paperwork

Science Fair Rules

- CUSEF and SLVSEF are affiliates of the Intel International Science & Engineering Fair and as such we are required to abide by the experimental rules they have established.
- These rules were developed to help pre-college student researchers adhere to federal regulations governing professional scientists and to, therefore, protect the welfare of the test subjects and the student researchers. See http://www.societyforscience.org/isef/rulesandguidelines
- Rules specifically apply to:
  - Human Subjects, Vertebrate Animals, Controlled Substances, Potentially Hazardous Biological Agents, and Hazardous Substances or Devises

Science Fair Paperwork

- As an affiliate to the Intel ISEF, we are required to document that all of our students are abiding by the rules established for pre-college researchers. The documentation is handled through a variety of science fair forms. See http://www.societyforscience.org/document.doc?id=11
- Students must write up a research plan and obtain pre-approval and signatures **BEFORE** the student begins experimentation. **See handout, "Science Fair Paperwork – 5 Simple Steps".**
- Additional forms are needed for projects that involve Human Subjects, Vertebrate animals, Controlled Substances, Potentially Hazardous Biological Agents and Hazardous Substances or Devices. These will need to be approved **BEFORE** the student begins experimentation.

The Good & Bad:
Science Projects – Advice and Tips

How to Improve the "Process"

Scientific Method

Standard Student Outline

Question

Research

Hypothesis

Experimental Design/Methods

Data Analysis/Results

Conclusion

Scientific Method Process

Topic/Idea/Question

Research → **Testable Question**

Research Plan
=Methods
=Data Analysis "How Many"

Hypothesis
= Why?

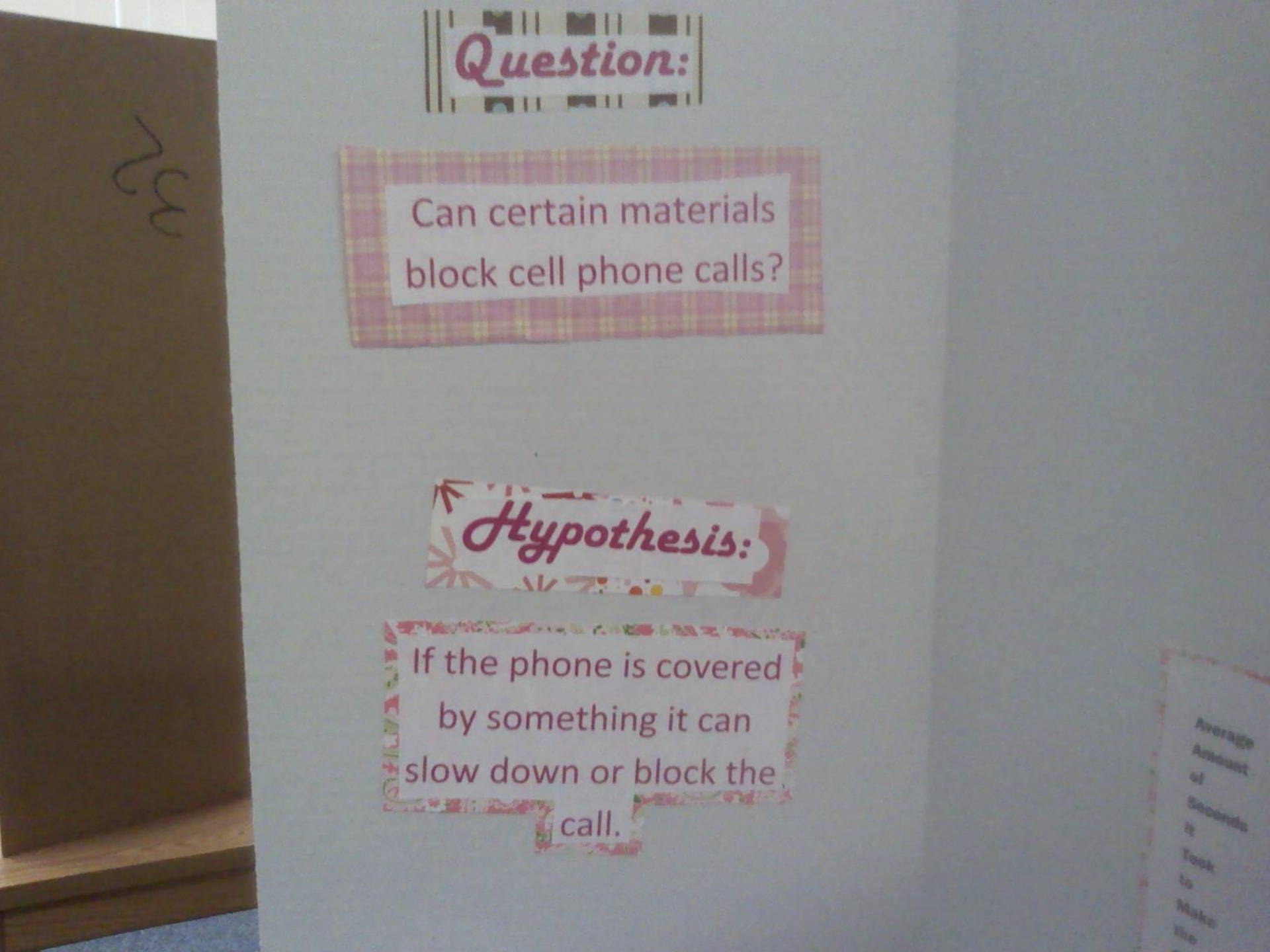
Experiment

Data Analysis - Results

Conclusion

The Question

- A good science fair question is:
  - testable and measurable.
  - is specific.
  - is motivated by a “why”.
- Real scientists dive into the scientific literature and look for gaps in understanding. They then formulate questions to address those gaps of knowledge.


Question:
Can certain materials block cell phone calls?
Hypothesis:
If the phone is covered by something it can slow down or block the call.

Question

Which kind of material will conduct sound the best when used for a string telephone?

Hypothesis

If the string used between the cups is thin and flexible, then the sound will be loudest because sound waves travel better through thin, flexible materials rather than stiffer, thicker materials.

PROBLEM

Which hydroponic fertilizer solution will most increase the growth of Beefsteak Tomatoes according to height?

Which hydroponic solution provides for the quickest plant growth according to height?

The Effects of Different Hydroponic Solutions On Plant Growth

HYPOTHESIS

Our hypothesis states that fertilizer solution C will increase the height of the seedlings faster than any of the other solutions. The reason we think this is because the higher amount of phosphorous will help the roots develop faster, which in turn will cause the plant to grow faster. Nitrogen causes plants' leaves to turn green and helps to increase the growth of the plant. Phosphorous promotes root growth and ensure that leaves are not blotchy or discolored. Potassium also helps keep plant leaves green and helps leave not to curl up and dry out.

Background Research

"Students need to understand why their question matters, and that involves understanding the scientific context for their problem. Background research is needed to understand the scientific context of a question. In some ways, answering a scientific question is like joining a conversation. If you don't know what has been said before, or why people are talking at all, then you will probably join the conversation awkwardly. If, however, you know what the conversation has been about, and where it will probably be headed, you can join the conversation in an intelligent way".

Terik Daly

RESEARCH

There wasn't really any research on anything about my topic at all. No one had really conducted the experiment so I guess that makes us special. The only thing that is a little related to what we are doing is the theories that listening to a certain type of music makes you smarter. Some scientists did believe that music didn't affect the brain as much as it affected the ears. for example, when your ears hear music, they release chemicals that are either pleasing or displeasing showing that ears have more of a part than the brain

Background Research

- Your understanding of the scientific context for your project is very important, especially at the top competitions. You need to know what other people have done, the directions of current research, and the "so what" of your question. Digging into the literature will help you with all of these things.
- Start simple and work to the more complex. Wikipedia is a great place to start, but NEVER cite Wikipedia as a source. It is a beneficial starting point, but it is not a formal reference.
- Science Buddies has articles on how to read scientific papers http://sciencebuddies.org/science-fair-projects/top_science-fair_how_to_read_a_scientific_paper.shtml and http://sciencebuddies.org/science-fair-projects/top_science-fair_finding_scientific_papers.shtml)

Background Research

- Scientists in different fields collect data differently, analyze data differently, present results differently, and write differently
- Format your research after what you see in the peer-reviewed literature
- Sources: college textbooks, professional encyclopedias, review articles, journal articles, monographs
- How to find them?
  - Google Scholar
  - College/University libraries
  - ADS and arXiv; PubMed; PNAS; NAP
  - Web of Science, Compendex, SciFinder

Hypothesis

- The "theory" of the project
- A statement/prediction based upon research
- Should include a "why"

Ideally, the hypotheses represent the "theory" side of physics (in my case). There should be some reason based (usually) on an underlying mechanism that is a basis for believing at the outset that the hypothesis is true or false. When one addresses the hypothesis directly, one should also be addressing that implied underlying theory.– Dr Grant Mason, BYU

HYPOTHESIS

You run faster when you drink coke, than when you don't drink coke.

HYPOTHESIS

The drinking fountain will be the dirtiest.

Hypothesis

Well, yes and no, I could carry a flash light put what if I can't afford a flash light. I could may be find the materials I need just laying around somewhere so then I can just carry the Ultra- Simple Electric Generator in my pocket, but not in my back pocket.

Question

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Methods

- Follow standard procedures for your field – ask a professional
- Look at how peer-reviewed articles are doing their work
- Do enough replicates to be able to meaningfully analyze your data (30 is a good ballpark number). Design your experiments with data analysis in mind
- **Understand everything** that you do, or that you have someone else do
- Control everything that you can
- Be as descriptive as possible
- Make sure that your methods allow you to collect the data you need

Experiment Description

So pretty much what we did is get 1 white candle & 4 colored ones and see which burned faster, the white one or one or one of the colored ones (red, orange, green, blue)

Science Fair Experiment Description!

What I did for my science experiment, was I got a bin, some rocks, wood, ruler, stopwatch, and a camera. I filled the bucket with a certain amount of water. Dropped the piece of wood into the container on the end and timed how long it took for the water to come back and settle. Then for the second test I would put in a few big rocks and drop the piece of wood and time it. Then for the third test I would take out the rocks and put in a piece of wood laying flat down, and would time it. After I did those two tests, I would add more water and would do the same thing, and I would also take pictures of all the supplies and all the stuff that I did to show some extra stuff! This test shows that even with only a centimeter of water, it can cross in less 2 seconds and settle in 10 seconds. In tsunamis you have millions and millions of centimeters so this test shows how fast everything can happen and with almost no warning at all!

Soda Explosion!

HYPOTHESIS

PROBLEM

Which flavor of soda sprays the farthest and looses the most liquid after being shaken or dropped.

MATERIALS

PROCEDURE

COLLECTING

SEPARATING

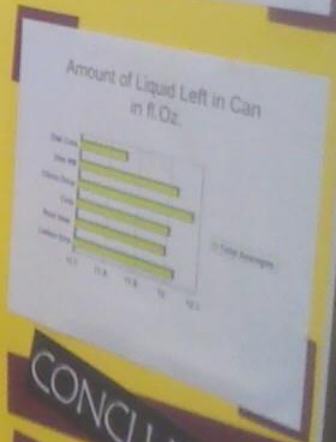
LABELING

BUILDING

LAUNCHING

RECORDING RESULTS

RESULTS

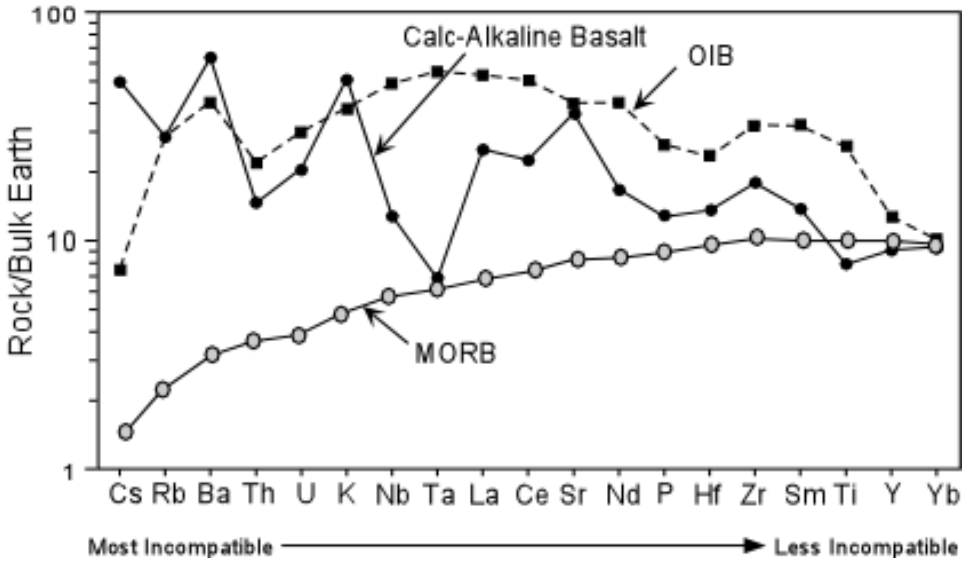


CONCLUSION

Which soda is most explosive?

Presenting Data

- Pay attention to how workers in your area present their data



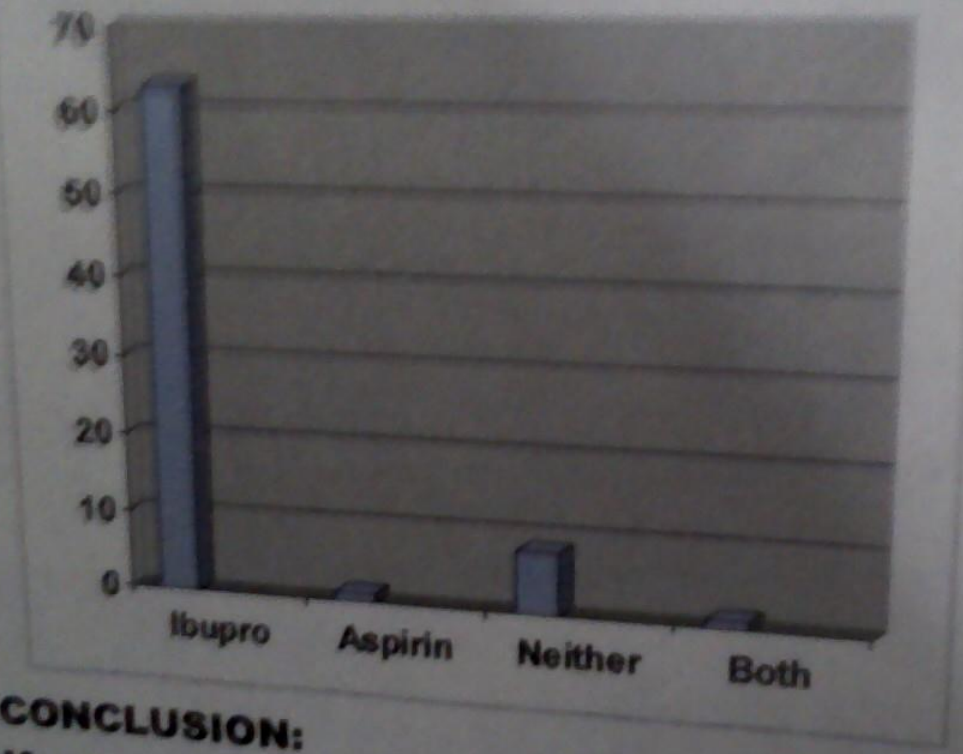
"Put your data in the formats used by other scientists within your field. The competition judges will be science professionals with an expectation about how data in a particular field is communicated. In general, you should emulate the types of graphs, figures, and data tables you see in top journals within the area of science in which you're working. Your mentor will also be a good source of constructive criticism on this subject." - Amber

Analysis

- Without data analysis you don't know what your data really mean. In other words, you can't draw conclusions without doing data analysis.
- Figure out **what** happened and explain **why** it happened
- Apply your background research – analyze your data the way they analyze their data.
- Error analysis (std. deviation, reproducibility, error prorogation)
- Data analysis involves making graphs (bar charts, histograms, scatterplots, box and whisker plots, etc.). It isn't wise to crunch numbers without first looking at a graph.
- After making your graph, calculate some descriptive statistics, in accordance with your grade level

Results

After testing this multiple, MULTIPLE times
I came to the conclusion that it does not matte
how big the bubble is because it melts almost a
soon as you touch it or remove it from the dry
ice. Whenever I blew big bubbles into the bowl,
they hovered but eventually melted when they



CONCLUSION:

If more people prefer Ibuprophen, it must work better.

CONCLUSION

The BB shot with one pump penetrated 0.56 of an inch. The diameter of a full-grown human eye is about one inch. This shot would not only have penetrated an eye, but would have gone over halfway through! I thought it would take 1 pump to penetrate the eye, and 3 pumps to go through the eye. I was right about 1 pump penetrating an eye, but 2 pumps would have gone right through. With 10 pumps though, the BB went in 3.75 inches. That is a 670% increase in penetration from 1-10 pumps.

While doing this experiment, I wondered if glasses would make a difference. I used regular sunglasses with lenses that were 0.09 inches thick and placed them 0.81 inches away from the gelatin. When shot with one pump, the BB broke the lens, and penetrated 0.1 of an inch, and pieces of the lens went in 0.05 of an inch. When shot with 10 pumps, the BB went in the gelatin 2.44 inches and shrapnel from the lens went in 1.19 inches!

If I were to do this experiment again, I would shoot at different distances. I learned that BB guns are not toys to play with and they CAN seriously injure you. A BB gun can definitely shoot your eye out!

samples remaining undetected. This could have affected cell death although due to the [illegible] response this seems unlikely.

- **Cell counting errors:**
- Imaging - pictures may not be a representative view due to the focal plane
- The sampling method used for counting cells in ImageJ
- Misidentified cells could have altered the cell counts.
- When macrophages die, they detach from the surface and may have been aspirated.
- Cells may have adhered to the bone when it was removed.

Experimental errors were minimized by using 6 replicates for each condition.

Conclusions

In this study it has been shown that rifampicin released from a PCL-coated βTCP synthetic bone graft has the unfortunate side effect of killing macrophages. Interestingly, this may in fact be due to the presence of the polymer not the antibiotic as there was no significant difference in the number of live cells between these two groups. The group with synthetic bone only was also significantly different from the no treatment control; however, this may be due to the fact that some cells adhered to the crouton when it was removed from the well prior to imaging and counting. Regardless of the underlying reasons, this study indicates that polymer-coated implants, with or without drug, could have disastrous consequences for biological processes that require normal macrophage function. This study hints to an important biological interaction between normal wound healing processes and medical interventions. Future experiments should include a source of infection to make the experiment more realistic.

References

(1)Amanda E. Brooks, Benjamin D. Brooks, Sherry N. Davidgoff, Brent P. Call Paul C. Hogrebe, Bruce G. Evans, Mark Fisher, David W. Grainger. *Polymer-Controlled Release of Tobraycin from Allograft Bone Void Filler.* (In Process), (2)Justin O. Sevy, Matthew H. Slawson, David W. Grainger, Amanda E. Brooks. (2010)*Assay Method For Polymer-Controlled Antibiotic Release From Allograft Bone To Target Orthopaedic Infections.* Biomed. Sci. Instrum. (Vol. 46 Pg. 134-141), (3)Wikipedia(Dec. 24, 2010) Rifampicin. Visited Dec. 30, 2010 www.en.wikipedia.org/wiki/Rifampicin (4)American Society of Heath-System. (October 1, 2010) *Riframpicin.* Visited Jan 10, 2011. www.ncibi.nim.nin.gov/pubmedhealth/PHM0000675 Biomet (2010) Pro Osteon 500R. Visited Dec. 30, 2010www.biomet.com/trauma/products.cfm?pdid=48&macid=17&prodid=164 (5) Sherry N. Davidoff, Brent P. Call, Paul C. Hogrebe, David W. Grainger, Amanda E. Brooks. (2010) *A Robust Method to Coat Allograft Bone with A Drug-Releasing Polymer Shell.* Biomed. Sci. Instrum. (Vol. 46 Pg. 184-189). (6)Wikipedia. (Jan. 9, 2011) Macrophages. Visited Jan 10, 2011. www.en.wikipedia.org/wiki/Macrophage (7) Sherry N. Davidoff, Justin O. Sevy, Benjamin D. Brooks, David W. Grainger, Amanda E. Brooks. (2011) *Evaluating Antibiotic Release Profiles as a Function of Polymer Coating Formation.* Biomed. Sci. Instrum. (Vol. 47 Pg. In Process), (8) Unknown. Rifampicin. Visited Jan 10, 2011. www.[illegible]

Lab Notebooks

- Arguably the most important part of your project
- If it's not in the lab book, you have no proof that you did it
- **Everything** you think, plan, or do goes in the book
- Multiple lab books, binders, folders are OK
- Lab book important even though you might not be judged in person until the end
- **See Handout, "Lab Notebook Guidelines".**

"Keep a detailed and up-to-date lab notebook with you at all times . . . the lab notebook should show detailed thought processes, notes, procedures, etc. Your lab notebook should go everywhere with you so you can jot down ideas on a whim." - Amber

Display Boards

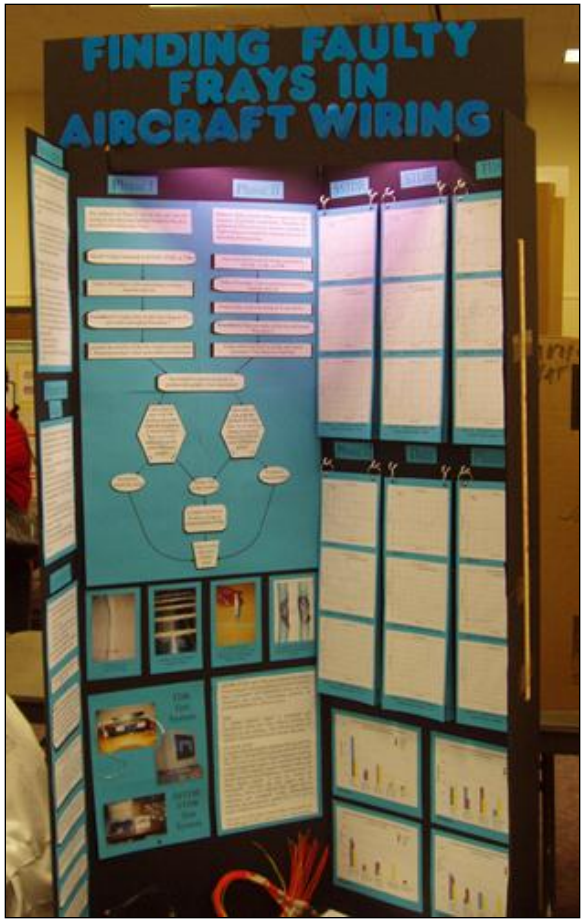
- Titles should be descriptive and should include the question/problem being addressed or the subject, independent variable and dependent variables.
- When including information on the display board students should be as concise and precise as possible. This is especially important when writing the question, hypothesis, methods, analysis/conclusion. The display board should be able to "speak for itself".
- Proof read and spell check.
- Don't overwhelm the judges with data. Include the most important aspects on the display board and put everything else in a data book.
- **See Handout, "Display Board Tips".**

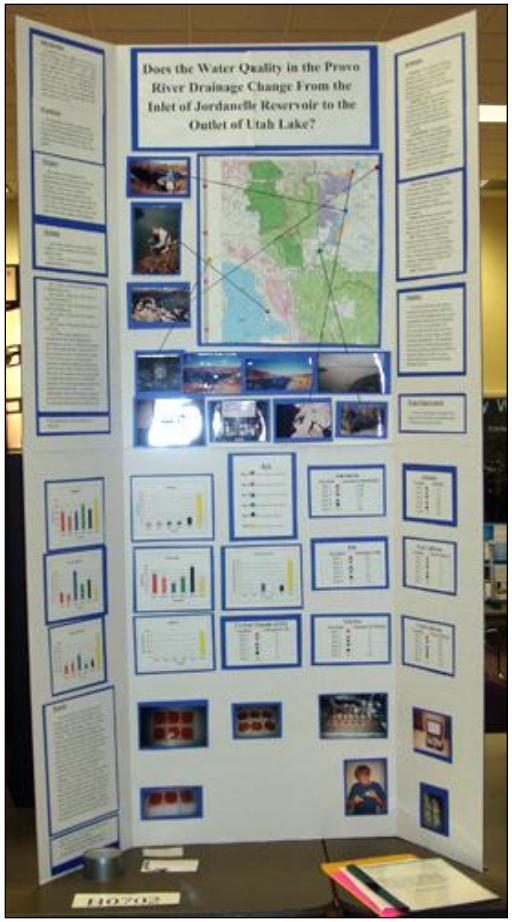

Parachutes, What a Drag!
My QUESTION:
Hypothesis:
RESULTS

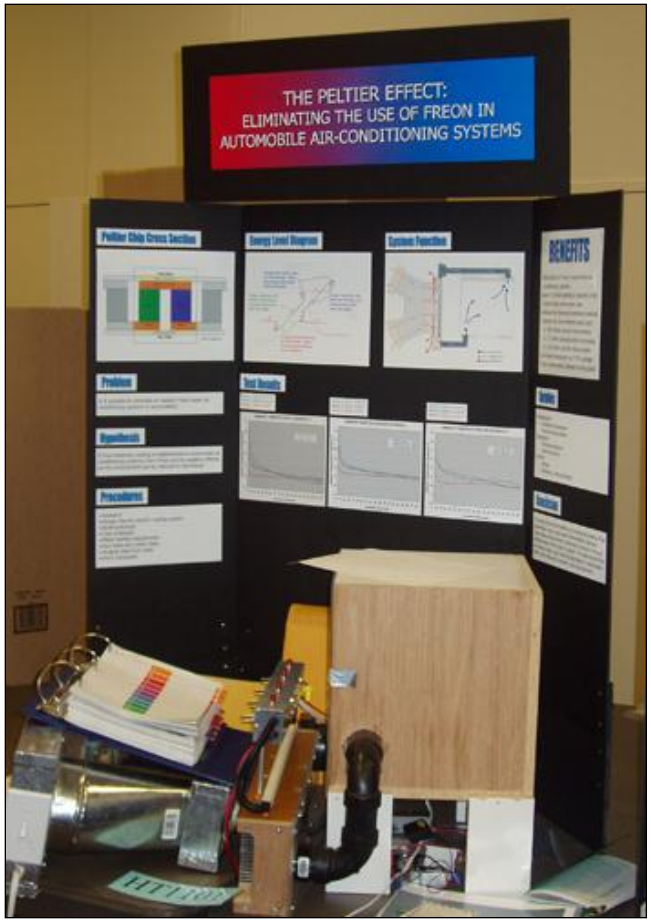

ARE YOU DRINKING WHAT YOU'RE THINKING?


Conclusion
PARTICIPANT


AIR PRESSURE IN TIRES
BY: ALEX STRONG
Table for Pete Trucking


FINDING FAULTY FRAYS IN AIRCRAFT WIRING


Does the Water Quality in the Provo River Drainage Change From the Inlet of Jordanelle Reservoir to the Outlet of Utah Lake?


THE PELTIER EFFECT:
ELIMINATING THE USE OF FREON IN AUTOMOBILE AIR-CONDITIONING SYSTEMS
Peltier Chip Cross Section
Energy Level Diagram
Equivalent Capacitance
BENEFITS
Problem
Test Results
Hypothesis
Procedures

Abstracts

- An abstract is a brief, written description of your project that explains your project's purpose, procedures, data, and conclusions. It is a self-contained summary that tells the reader why they should care about your project and what you found out. The abstract is concise, but complete—it communicates the essence of your project.

- Just like scientists, science fair judges read your abstract and may make preliminary judging decisions based on your abstract. A good abstract is like a good first impression—it goes a long way.

- 250 Word limit – **See Handout, "A Quick Guide to Abstracts"**