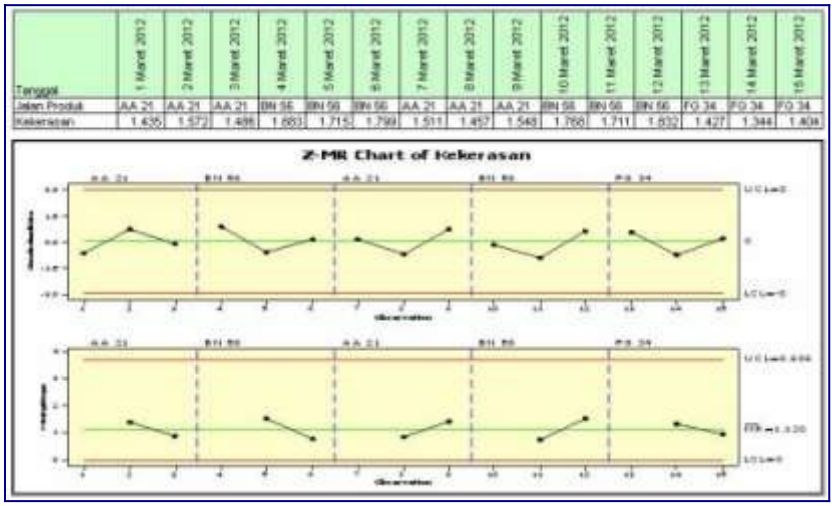
How to dominate science fair

One of the questions I often get from students is how they can do well in the science fair. This is a fair question (pun intended) and since I hate bad science fair projects, I'll give you the full scoop on how you can be a science fair professional. Or at least look like one.

Let's read on…

What's a science fair?

You probably think that the science fair is something where a bunch of nerds do a bunch of projects because their teacher is making them. These projects can be pretty much anything, provided that they're science-like and have a lot of numbers and graphs. While nice, this is not true.



"As the data show, I'm totally a science guy."

A science fair project is your way of studying something cool. Maybe you've always wondered why something happens, or have thought that you could design something better than the current models. The science fair is your chance to do some cool experiments to learn about these things.

There are two types of science fair project:

- **Science projects** involve testing a hypothesis. Do you want to figure out whether your neighbor's mailbox blew up because it was hit by lightning? Do an experiment to test the hypothesis that it did. Do you think that soaking yourself in motor oil will keep you warm on a cold day? Try it out!

Better yet, get your pets involved!

- **Engineering projects** involve building something. I had a student who built a robotic exoskeleton using inexpensive materials. This exoskeleton was as good as the best stuff around, and cost almost nothing. This new approach to making something work is the essence of an engineering project.

I am programmed to win the science fair at any cost.

That said…

How do you pick a project?

It's easy to come up with a science fair project, but surprisingly hard to come up with one that's actually worth doing. This is true for a couple of reasons:

Your parents probably don't know what they're talking about. If your parents aren't scientists, they probably don't understand what the point of a science fair project is and will tell you to "do something with cat litter." If your parents are scientists, they probably think you're going to build a nuclear magnetic resonance machine in the basement using Legos and aluminum foil. This isn't to say that your parents are dumb – just that they won't give you a good project.

How about you test how long it takes to get me another Budweiser?

You don't know anything yet. Well, OK… you do know *something*. However, when it comes to science, you've really just gotten started. You know what interests you and what doesn't, but when it comes to chemistry, you may not know enough to come up with compelling research. If you think that reading an article in the paper about squirrels will allow you to study them, think again.

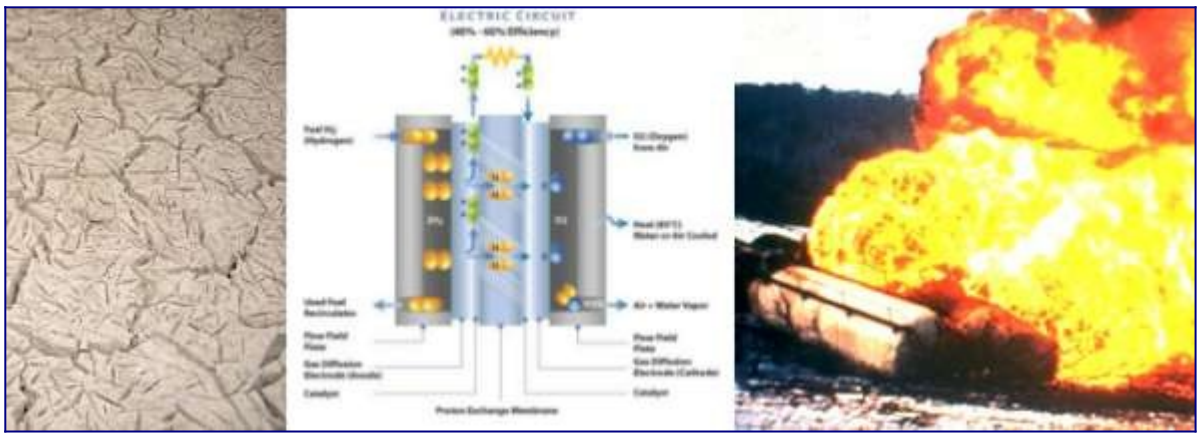
Given these problems, you might think that there's no way to come up with a good project. Well, think again: Even *you* (and yes, I can see you this very minute) can come up with a science fair project that will cause Uncle Merle to "wet hisself."

Too late.

In any case, let's find a good science fair project. Because you already know that I like putting everything in bulleted lists, I'll just go ahead and do that again:

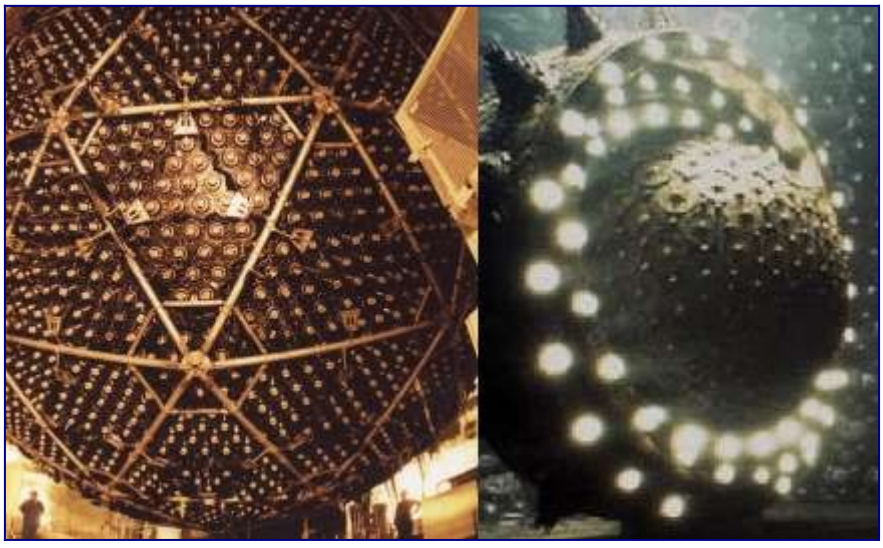
How to come up with a good science fair project:

- **Don't get your idea directly from a website:** I just did a quick search and found this site, which gave me a whole list of science fair ideas. Unfortunately, these ideas are all too simple for a science fair, and the answers to each of these questions are obvious (see footnote 1 below). More about this later.
- **Find inspiration wherever you can:** The best place to find inspiration is in your daily life. I had some students who were interested in helping people in third-world countries, so they came up with a very inexpensive way of purifying water. I had one student who liked paintball, so he tested paintballs for effectiveness. If you have no inspiration at all, consider things that you've wondered about in your everyday life. You've undoubtedly had something interesting happen today – test it!
- **Study something cool:** If you think your project is boring before you get started, just wait until you're done. If you're going to spend hours working on something, make sure that it's something you won't hate.



Left to right: Not cool, cool, too cool.

- **Know your paperwork:** Regulations make it nearly impossible to do experiments with living creatures (no matter how harmless), so consider the paperwork involved before doing it. It's not that you *can't* do a project involving nearly anything, because you can do nearly anything you can imagine. However, the paperwork for some of these projects are horrible, so you might want to steer clear of toxic chemicals and living things.
- **Know the cost:** If you need something that costs a ton, clear it with your parents before submitting the idea. Remember, you'll need to do many, many repetitions of your experiment, and the costs can add up.
- **Know the facilities you'll need:** If you "just need" something to do your experiment, make sure that it's something that you can get your hands on. If you need a simple lab, ask your teacher if it's OK before starting. If you need a big fancy lab, make sure that Dr. Awesome at the University of Yourtown has given it the thumbs-up.



One of these is the Sudbury Neutrino Detector, and the other is the Gravity Drive/portal to Hell from the U.S.S. Event Horizon. Neither are available for science fair projects.

- **Know how long it will take:** If you have two months to do your experiment and it takes three, you should choose something else. On the other hand, if you can do your experiment in an afternoon, it's probably not complex enough to be worthwhile.
- **If all else fails, check those dumb science fair websites:** The site I mentioned before suggests that you can use the list of ideas for inspiration. While the ideas themselves aren't

great, that doesn't mean that they can't be modified to be OK or start you thinking about something else. I suspect that's why Science Bob (the guy who runs it) is in business – not because he expects you to use these ideas, but because he expects to inspire you.

Paperwork: The hidden monster

Before you can even start research, you have to file an impressive list of papers provided by the ISEF folks who run things. There are a lot of these papers (I'll explain what all of them are in footnote 2 at the bottom of the page), but for your information have included a series of questions to help you figure out which forms you'll need:

1) Are you doing a science fair project? Of course you are. Fill out:

- Form 1: Adult sponsor checklist
- Form 1a: Student checklist
- Form 1b: Research plan/project summary
- Form 1c: Approval form (a separate one is needed for each group member)
- Form 3: Risk assessment form (not technically required, but a good idea anyway)

2) Are you continuing your project from last year? If yes, fill out Form 7: Research continuation form.

3) Are you doing your experiment somewhere other than your home, school, or outdoors? If yes, fill out Form 1c: Regulated research institution form.

4) Does your project include chemicals, animals, pathogens, proteins, human subjects, or anything else that's dangerous? If yes, fill out Form 2: Qualified scientist form.

5) Will you be doing research that in any way, shape, or form involves somebody other than your group members? If yes, fill out:

- Form 4: Human participants form
- Human informed consent form (one copy per subject).

6) Will you be doing research with vertebrate animals? If yes, fill out Forms 5a, 5b: Vertebrate animal forms.

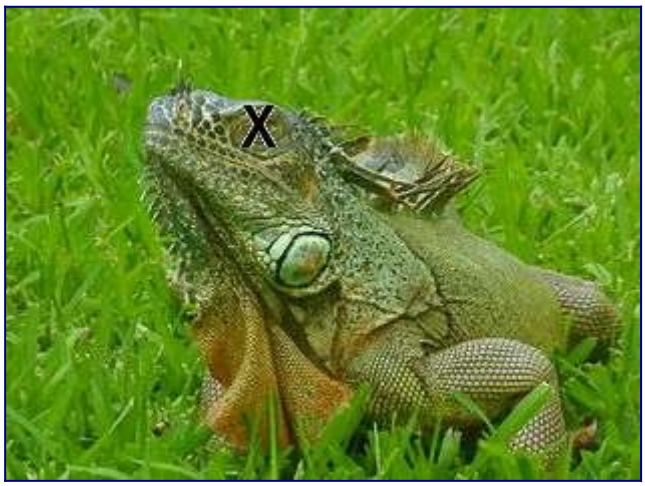
7) Will you be working with biological materials of any kind? (This includes proteins and other materials, even if they haven't actually been inside of a living creature). If yes, fill out Forms 6a and 6b: Human and biological hazardous agents forms.

Many of these forms require approval from people in various school and research buildings, so get started early if you need a lot of them. It's not uncommon in my experience for students to get started on this experience only to find that they are approved too late for anything to be done. Personally, when my students do science fair, I give them the option of either doing the forms (and being able to move through the science fair) or not doing the forms (and not being able to do the official science fair). I'll let you guess which choice is most popular.

An aside: Why so many forms?

Somebody did something stupid and the science fair folks overreacted and created some new paperwork so that they wouldn't get sued if it happened again. The other solution, of course, would be to just ban certain dumb projects, but apparently the ISEF folks think that you aren't good with reading rules and will eat rat poison unless a committee agrees that you shouldn't.

That said, there *are* idiots out there who allow absolutely terrible things to happen, though it's unlikely that paperwork will stop them. An example: I saw a junior high science experiment in which a kid tested to see whether smoking was hazardous to iguanas by putting lit cigarettes into a Plexiglas box with one and leaving the other one to breathe air. The one in the smoke died, which wasn't really surprising. Despite the fact that he concluded smoking was dangerous, the experiment wasn't even rigorous enough to say that much. Yes, I actually had to tell a student with an iguana who'd died of smoke inhalation that his hypothesis hadn't been proved.



On the other hand, the experiment proved the hypothesis that dead animals have little "X"s over their eyes.

Doing your experiment:

Now that you've filled out a million sheets of paper and nobody thinks you're a psychopath who wants to build gas chambers for iguanas, it's time to get started with the research! The following are some things you need to keep in mind if you want a good project:

1. **You need lots of repeated trials**. If you do something five times, this is not going to cut it in the world of experimental science. If you think you should do something five times, do it ten times (link). If you think you should do it ten times, do it twenty times. And if you do something once, don't bother turning it in. If you can't do the required number of trials due to cost or time constraints, you should probably do another project.
2. **You need to control your variables**. This is harder than it sounds, because just about anything can throw off your results. If you're growing plants, did the soil come from the same bag? Did the seed come from the same bag? Were identical amounts of water and dirt used for each plant? Were the light sources identical, and do the plants have identical exposure to the light? Is the temperature identical for each plant? And, most of all, can you prove all of these things if asked. As a rule, you'll get better results if the variables are easier to control.

3. **You need to write everything down**. Everything. The rule in science is that if you didn't write it down, it never happened. If you write everything down in a notebook, you'd better be prepared to show people that exact notebook if asked, because these are the original data in your project. That's not to say that you can't also include the data on a computerized chart – just that you should have the original notebook, too. (For the record, it's no big deal if your notebook is messy-looking, as long as the data are legible and no pages are missing that might indicate you destroyed data).
4. **If you take data, you have to use it**. Unless you have a very compelling reason to discard some bit of data, you have to use it when doing your analysis. If you're doing something with plants and your dog eats one of them, it's clearly OK to eliminate this datum. However, if one of your plants is just really scraggly looking and you don't know why, you have to include it anyway. There are statistical ways of eliminating weird points, but something has to be *really* weird before you can dump it (link).
5. **Assume you're wrong**. If you assume that your hypothesis is correct, you will find that it is correct. If you assume it's wrong, then you'll only accept it if the data are conclusively correct. This is a handy way of making sure that you interpret your data correctly.

If necessary, protesters for hire can provide a surprisingly affordable way to be reminded that you're doing everything wrong.

6. **Accept criticism and make appropriate changes**. If, during the course of the experiment, somebody tells you that you're screwing something up, listen to them and make an objective determination about whether or not they're right. If they're right, analyze the situation and see if you can do something to minimize the problem. Note: Once you start an experiment, many things can't be changed without invalidating the experiment, so make sure you know what you're doing!

Presenting your results: The backboard

You probably already know that the backboard you use when presenting your project is important. What you may not know is what judges actually think is important, and what things they ignore. Because I want you to win the International Science Fair, here's what you need to do to get an awesome backboard:

1. **It must be tidy.** Everything should be centered and everything should be professional-looking. All papers must be completely adhered to the board such that they don't curl at the

edges. ProTip: If you print out images on regular paper, it looks far neater than if you try to glue photographs to the board.

2. I**t must contain *only* the important stuff.** Even if you type everything and make it very neat, nobody will be able to follow what you've done if you dump every bit of experimental data on them. Only the things that are necessary to understand the project should be on the board – other miscellaneous diagrams and raw data can be left in a notebook.
3. **Graphs must be meaningful.** Bar graphs aren't appropriate for science (see this tutorial to explain why) and line graphs have very particular rules that must be followed (seriously, visit this tutorial). Above all, don't put graphs up on the board if they're not necessary, because that just annoys everybody.
4. **The board should have some visually-appealing elements.** There must be something that contains color on the board, even if it's only the board itself. Cute clip art is occasionally OK, as long as you don't overdo it. If you want to write the title in some cutesy colorful way, make sure that it looks professional and not like you were goofing off with a bunch of pens.
5. **The font you use matters.** The classic fonts you can use are the ones that look just like this text you're reading now: Times New Roman is the standard, but anything that doesn't look gimmicky will do. If you find yourself using Comic Sans, seek professional help (or at least read this).
6. **Your project should have a memorable name.** "The effect of [something] on [something else]" will be seen as boring by most folks. If you can incorporate a clever play on words, you should do so. If you can't think of anything good, then just go with "The effect…", as it will always get the job done.

And, for the record, there is such a thing as "too memorable" a name.

Presenting your results: Dressing well for the judges

If you want to look good to the judges, you have to look good. And "good", in this context, means "appropriate." And appropriate usually means "boring." Here are some tips for how you can make yourself look good:

Boys: Neat and tidy

Wear a button-down shirt and tan slacks, and a tie would be nice. Wear brown or black dress shoes with brown or black socks – keep the sneakers at home. Your shirt should be tucked into your pants. Your hair should be neatly combed or pulled back if very long. The key for dressing well is to simply look neat and tidy, so put away your ratty clothes and buy something nice for a change.

Girls: Dress like it's 1899

Think conservative. Science fair judges tend to be old and have very traditional ideas about what's reasonable. You don't have to wear a dress or skirt (things aren't that bad), but you do have to make sure that whatever you wear makes you look like the librarian's boring sister. Wear flats and not heels because you'll be standing a long time.

Things to avoid:

- Boys: A suit is overkill – a sport coat is OK, but a suit just looks odd. Anything "interesting" such as fedoras, long duster coats, or odd shoes will make you appear unprofessional and will cause people to take you less seriously. If you wear a T-shirt with a slogan on it, your project had better successfully cure cancer. Don't wear cologne.
- Girls: As I mentioned above, science fair judges tend to be old and old people tend to be conservative. Make sure that anything you wear would make your grandma happy if you wore it to her funeral. You can feel free to wear jewelry, but make sure it's fairly understated. Don't wear perfume.

A special case: The unusual young scientist

If you're one of those kids with blue hair and facial piercings, you're not out of luck. Just follow the suggestions above and you'll be fine. Scientists usually don't care about how you look as long as you have made an effort to look respectful and are taking the science fair seriously. If you've got a nose ring and blue hair, but have gone to the trouble of wearing classy clothes, you'll be fine.

So, James, tell me about your robotics project.

Meet your judges!

Before we discuss the talk itself, it's probably a good idea if we discuss the types of judges who will be determining your awesomeness during science fair. Let's take a look:

The actual scientist: The actual scientist is somebody who really and truly does science for a living. Characteristics include:

- Clothing: Conservative and uninteresting. This person's clothes would garner exactly zero attention in an airport anywhere in the world.
- Attitude: Polite and friendly. The actual scientist is interested in figuring out what you did and why it's interesting. If the actual scientist seems unfriendly, it's probably because he or she is just thinking about the presentation and what it means.

Don't worry about it – I can listen to your presentation and decant at the same time.

- Types of questions asked: The actual scientist will ask questions that reflect his or her general interest in science. If he/she knows what your field of study is, the questions may be somewhat esoteric, but with a reasonable expectation of how much you should know. If they don't know your field of study, seemingly random questions will be asked in an effort to help him or he figure out what your project means. Questions will become increasingly harder until they either lose interest or the limits of your knowledge are determined – these hard questions don't indicate disapproval, so don't feel bad about it.
- Their basis for judging your project: "Did this person actually know what he or she was doing? Is this project useful for anything? Does this person understand what it means?"
- How to make them like you: Tell the truth. If you know something, talk about it. If you don't, admit it. There's no wrong answer and you'll get a fair hearing from the real scientist.

The pretend scientist: The pretend scientist is somebody who studied one of the sciences back in college, or even worse, refers to the humanities as "social sciences." The pretend scientist has watched the Discovery Channel on TV, but focused mainly on the entertainment shows. The pretend scientist is more interested in looking smart than he or she is in learning anything.

- Clothing: Expensive suits or business attire.
- Attitude: Friendly with a superior attitude. The pretend scientist knows that he or she is smarter than the student with the project and wants to show this student the many ways in which the student is mistaken.

- Types of questions asked: The pretend scientist goes for the difficult questions and never lets up. These questions will frequently include isolated and nitpicking facts, or will reflect that this person wants to focus on the one thing they know about your subject. It's not uncommon for the pretend scientist to answer his or her own questions – letting them do so will be seen as a nod to their wisdom and appropriately rewarded.
- Their basis for judging your project: "Did the project use complicated-looking things? Was the presenter able to spout off the details of their project when asked? Can I understand what the presenter said?"
- How to make them like you: Acknowledge their brilliance. Nod politely and ask easy follow-up questions suggesting that you believe them to be wise beyond imagination.

The random teacher: The random teacher is somebody recruited from one of the other departments in the school, or a teacher from another school. The random teacher may not know much science, but has a basic understanding of the process.

- Clothing: Teacher clothing.
- Attitude: Teacher attitude. Is genuinely interested in the student's feelings as well as their project.
- Types of questions asked: The questions are usually very on point, focusing on the experiment and its details. There won't be much in the way of improvisation when you meet with them, and they'll have a limited interest in figuring out future applications of your project.
- Their basis for judging your project: The judges will be given a grading sheet and the basis for judging you will be based entirely on this rubric.
- How to make them like you: Be honest and forthcoming. Stick to script unless specifically asked otherwise. The random teacher is on your side.

OK… on line 14 it says you should have a procedure. If you can't find it, I'll come back.

The last-minute friend: The last-minute friend is somebody one of the science teachers found at the last minute because they didn't have enough judges. The last-minute friend will seem a little confused, but will generally be similar to the random teacher in attitude. Again: Straight talk will work well, as will sticking to script.

The wildcard: The wildcard is somebody who came from parts unknown. He or she wants to see if your project is interesting, and will continue questioning for as long as they think you have something cool to say. It may be unclear at first whether they're even a judge.

- Clothing: Casual but not sloppy – similar to the actual scientist.
- Attitude: Friendly in an absent way. Despite what you may think, this person has no particular interest in making you feel either good or bad – they just want to know what your project is and what it means.
- Types of questions asked: The initial questions will focus on the experimental results, and will extend from there into other applications of what you've done. This person will attentively listen to questions and may give recommendations on how to improve your project in some fashion – these suggestions may or may not be reasonable, but shouldn't be ignored.
- How to make them like you: Competence. The wildcard respects somebody who knows what they're doing, and will be patient with smart people even if they screw up.

If you can tell which type of judge you've got, do your best to play to their personality type. Otherwise, just do your best using the guidelines in the next section…

<u>Your talk for the judges</u>

Believe it or not, we're finally ready to talk about your actual presentation. Though the specifics of your presentation will obviously be different based on what your project is, here are some suggestions about how you can put your best foot forward:

- **Don't read anything:** You don't need to have a polished speech that you read off of cards. Instead of reciting a presentation, tell the story of what you did and why, and what happened as a result. Don't worry about forgetting something – if the judges want to know, they'll ask for more information.
- **Don't recite the data:** The data on your board are not meant to be recited. If you've done a study showing that the volume of your brother's screams are directly proportional to the voltage applied to his ears, just point to the chart and say "These data show that…" Your judges may want to know how the data were collected, but the chances of them actually wanting to see every plotted datum is zero.
- **Be friendly:** Greet the judges with "Good afternoon sir/ma'am" and shake their hand firmly. Just so you know, a bone-crushing handshake is not considered firm – it's considered the mark of a Grade A butthead.

Pictured at left: Not buttheads. Pictured at right: Buttheads.

- **Be prepared:** If at all possible, get somebody to listen to your presentation before the day of the science fair. Make sure these people will ask very hard questions, because if you ask your parents to quiz you they'll just throw softballs and tell you that you're doing a good job. If you've already been hit with the super-hard questions, the judges will seem easier.
- **Tell the truth:** Never cover up mistakes and never tell people that your results are definitive. It's intuitively obvious to everybody in the entire world that you have made mistakes (*everybody* makes mistakes!) and that science does not provide certainty. If you try to tell people otherwise, you'll just look dumb.
- **Admit it when you don't know something:** If your judge asks you what will happen if you were to [do something] and you don't know, don't give a knowledgeable-sounding answer to their question. If you're right, you'll sound good, but if you're wrong, you'll sound like a dimwit. There's a world of difference between "I know that [something]" and "I think that, based on my project [something] might happen." And if you just don't know something, admit it.

The aftermath

When the fair is over, you'll find either that you won or that you didn't. These things happen.

If you're one of the few lucky enough to win something, it's time to kick things up a bit. You may be wonderful enough to beat your classmates, but if you go on to a regional science fair, there will be higher standards that you have to meet. Take the advice you've gotten from the judges and make whatever changes you feel are reasonable.

If you lost, it's not the end of the world. Sometimes people do wonderful and amazing science and sometimes they don't. It doesn't mean that you're an idiot – just that you're learning what science is all about. If you're a perfectionist type who needs to win all the time, please don't be hard on yourself. Nobody's perfect, and everybody can try to improve the next time. Use the lessons you've learned here to make yourself more awesome in the future.

And, no matter what, remember that doing good science is hard. That's why so few people win Nobel Prizes. However, just because it's hard doesn't mean it's not worth doing – you may never become a Nobel laureate, but if you can make life easier for people, you've done well. Use your experience and become that person.

Footnotes:

1) The answers to each of the science fair questions on the page http://www.sciencebob.com/sciencefair/ideas.php are as follows: Yes, yes, plumbing, no, meat, who cares, too cold, same as seawater, yes, it depends, yes, yes, aspirin, yes, poop, yes, yes, who cares, yes, who cares, yes, yes, no, look it up, no, sugary, sun-like, yes, chemical, yes, no, who cares, teenager, you're an idiot, yes, look at the bag, depends. However, I make the point later in this list that science fair websites can give you inspiration for new experiments, so if you get totally stranded you might want to have a look anyway. Just as long as you don't use the projects as is.

2) What do these forms do? Here you go:

- Adult sponsor checklist (1): A checklist for your adult sponsor to confirm that you filled out all the forms to come.
- Student checklist (1a): Everything that's possible to know about your experiment. If you want to use animals, chemicals, pathogens, or anything else that could offend anybody, you need to add a special section justifying this..
- Approval form everybody must sign (1b): Parents, student, and teachers sign a form saying that they all understand form 1a and all it means. If there is anything unusual involved, a committee (usually at both the school and county level) needs to approve it, too.
- Institutional setting form (1c): If you do research anywhere that requires an expert, this form needs to be filled out by the expert that's required.
- Qualified scientist form (2): Despite the fact that institutional science has already been covered by 1c, any supervising scientist must also fill out a form indicating that the project honestly and truly won't kill anybody or anything.
- Risk assessment form (3): If you're using anything dangerous (fyi: *Everything* qualifies as dangerous to somebody), you need to fill this form out. Even if you're told that you don't need to fill it out, fill it out anyway.
- Human subjects form (4): If you're going to involve humans in your project (even to ask them questions), you need signatures from a doctor, your sponsor, your teacher, and your school administrator, all of whom will attest that the people won't be harmed. The subjects and their legal guardians each have to fill out a form saying that they understand the risks (even if they're being asked questions!) and that they're OK with it. Interestingly enough, the student doing the research doesn't need to sign these forms.
- Vertebrate animal form (5a): Want to use something with a spine? Fill this out. If one of your test subjects dies, you'll need a vet to do an investigation.
- Vertebrate animal form, part 2 (5b): The person supervising this research needs to fill out their own form (a letter isn't sufficient) approving it, too.
- Hazardous biological agents forms (6a and 6b): Working with anything originating inside of somebody? Or something that might be found inside of somebody even if it never was? Fill out this form explaining how you'll deal with everything properly, and get additional forms from the adult sponsors.
- Continuation projects form (7): If your project is continued from last year, you'll need this form filled out and approved by the school for some reason.