

Crystal Radio Science Fair Project

Project Guidebook

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By Aurora Lipper

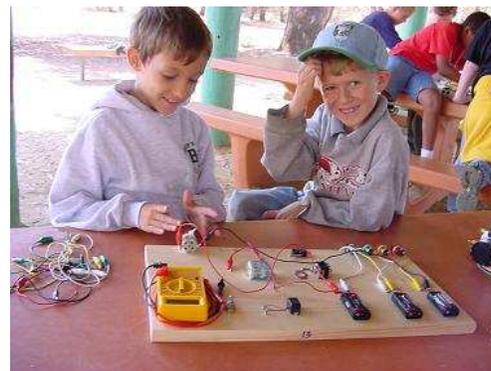
Table of Contents

How to Use This Book:	3
Materials List.....	5
Create a Science Fair Project with Crystal Radios.....	6
Sample Data Sheet	13
Sample Report	14
Exhibit Display Board.....	28
Oral Presentation	32



How to Use This Book:

Welcome to the world of Supercharged Science! In just a moment, you'll be building an ultra-cool science project, taking data, and transforming your great ideas into an outstanding science fair project! Whether you're looking to blow away the competition or happy just get a decent grade, you've got the keys to a successful science fair project in your hands right now. The tools you'll find in this manual answer the basic question: **"How can I create a science fair project and enjoy the process?"**



We're going to walk step-by-step through every aspect of creating a science fair project from start to finish, and we'll have fun doing it. All you need to do is follow these instructions, watch the video, and do the steps we've outlined here. We've taken care of the tricky parts and handed you a recipe for success.

Who am I? My name is Aurora, and I am a mechanical engineer, university instructor, airplane pilot, astronomer, and I worked for NASA during high school and college. I have a BS and MS in mechanical engineering, and for the past decade have toured the country getting kids wildly excited about doing *real* science.



What do the kids I teach learn? After a day or two, my students are building working radios from toilet paper tubes, laser light show from tupperware, and real robots from junk. And they're crazy-wild excited about doing it.

One of the problems kids have, however, is taking their idea and fitting it into something acceptable by science fairs or other technical competitions designed to get kids thinking like a real scientist.

Another problem kids often face is applying the scientific method to their science project. Although the scientific method is not the primary method of investigation by industry, it *is* widely used by formal science academia as well as scientific researchers. For most people, it's a real jump to figure out not only how to do a

decent project, but also how to go about formulating a scientific question and investigate answers methodically like a real scientist. Presenting the results in a meaningful way via “exhibit board” ... well, that’s just more of a stretch that most kids aren’t really ready for. And from my research, there isn’t a whole lot of information available on how to do it by the people who really know how.

This report is designed to show you how to do a cool project, walk you through the steps of theorizing, hypothesizing, experimentation, and iterating toward a conclusion the way a real engineer or scientist does. And we’ll also cover communicating your ideas to your audience using a display board *and* the oral presentation using top tips and tricks from real scientists.

For years, Supercharged Science has served as the bridge between the scientific community and the rest of the world. This is yet another step we have taken on to help serve as many families as possible. Thank you for your support and interest... and let’s get started!

Materials List

Before we start, you'll need to gather items that may not be around your house right now. Take a minute to take inventory of what you already have and what you'll need.

- Toilet paper tube
- Magnet wire – Radio Shack part #278-1345
- Germanium diode (1N34A) – Radio Shack part #276-1123
- Telephone handset or get a crystal earphone from C. Crane at (800) 522-8863 (part #EKI)
- Alligator clip test leads – Radio Shack part #278-1157
- 100' stranded insulated wire (for the antenna)
- Camera to document project
- Composition or spiral-bound notebook to take notes
- Display board (the three-panel kind with wings), about 48" wide by 36" tall
- Paper for the printer (and photo paper for printing out your photos from the camera)
- Computer and printer



Electricity flows in this direction

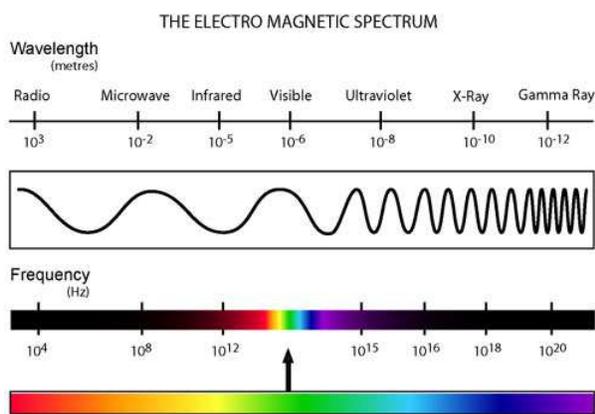
Create a Science Fair Project with Crystal Radios

Before we start diving into experimenting, researching, or even writing about the project, we first need to get a general overview of what the topic is all about. Here's a quick snippet about the science of radio waves... which is really the electromagnetic spectrum.

Imagine tossing a rock into a still pond and watching the circles of ripples form and spread out into rings. Now look at the ripples in the water... notice how they spread out. What makes the ripples move outward is *energy*, and there are different kinds of energy, such as electrical (like the stuff from your wall socket), mechanical (when you shove someone), and others.

The ripples are like light. Notice the waves are not really moving the water from one side of the pond to the other, but rather move energy across the surface of the water. To put it another way, energy travels across the pond in a wave. Light works the same way – light travels as energy waves. Only light doesn't need water to travel through the way the water waves do... it can travel through a vacuum (like outer space).

Light can change speed the same way sound vibrations change speed. (Think of how your voice changes when you inhale helium and then try to talk.) The “speed limit” of light is 186,000 miles per second – that's fast enough to circle the Earth seven times every second, but that's



also inside a vacuum. You can get light going slower by aiming it through different gases. In our own atmosphere, light travels slower than it does in space.

Point in the diagram (image left) where the “visible light” section is, indicated by the arrow. This small area shows the light that you can actually see with your eyeballs. Note that the “rainbow of colors” that make up our entire visible world only make up a small part of all

the light zooming around the countryside. That means you're constantly being smacked into by waves of all kinds... and you may not even know it. (Sun block, anyone?)

Our eyeballs can see in the 400-700 nm (nanometer) range, which is only a small part of the entire spectrum of light... so we need special detectors to find the rest of the photons zipping around. Radio signals are picked up using an antenna (similar to your satellite dish in the backyard). X-rays are more difficult to detect, because they would rather go *through* the detector than bounce off of it, so we use complicated mathematics and the shadows of the

photons to “see” x-rays. Gamma rays are the toughest to detect – they are *very* highly energized packets of light that would rather zoom through mirrors than be detected.

The waves in the electromagnetic spectrum that carry low amounts of energy (radio and microwave) are low frequency and long wavelength. One radio wave can be the size of a football field! The higher amounts of energy (gamma and x-ray) are carried by the short wavelengths and higher frequencies.

How does light turn into sound? Imagine asking a friend to bang a drum for you. You can hear the pounding, each beat happening one at a time. This is a very low frequency sound that reaches your ear. Now imagine putting Superman at the drum... and asking him to pound it 1,000 times each second. It's still the same drum, but the beats blur together so you hear a constant sound at a higher pitch.

Sound is made by things vibrating back and forth, whether it's a guitar string, drum head, or clarinet. The back and forth motion of an object (like the drum head) creates a sound wave in the air that looks a lot like a ripple in a pond after you throw a rock in. It radiates outward, vibrating its neighboring air molecules until they are moving around, too. This chain reaction keeps happening until it reaches your ears, where your "sound detectors" pick up the vibration and work with your brain to turn it into sound.

The sound waves travel through the air to reach your ear... and can travel through solids, liquids, and gases, but it does so at different speeds. It can rustle through trees at 770 MPH (miles per hour), echo through the ocean at 3,270 MPH, and resonate through solid rock at 8,600 MPH.

Sound can change according to the speed at which it travels. Another word for sound speed is pitch. When the sound speed slows, the pitch lowers. With clarinet reeds, it's high. Guitar strings can do both, as they are adjustable. If you look carefully at guitar strings, you can actually see the low pitch strings vibrate back and forth, but the high pitch strings move so quickly it's difficult to see. But you can detect both high and low pitch with your ears.

Your voice is a vibration, and you can feel it when you place a hand on your throat when you speak. As long as there are molecules around, sound will be traveling through them by smacking into each other. That's why if you put an alarm clock inside a glass jar and remove the air, there's no sound from the clock. There's nothing to transfer the vibrational energy to – nothing to smack into to transfer the sound. It's like trying to grab hold of fog – there's nothing to hold on to.

What is a crystal radio? A crystal radio is among the simplest of radio receivers... there's no battery or power source, and nearly no moving parts. The crystal radio picked up radio signals by having a long antenna (yours will be about 100') to "catch" the waves.

A crystal radio is made up of a tuning coil (magnet wire wrapped around a toilet paper tube), a detector (germanium diode) and crystal earphones, and an antenna wire. There is no amplifier, advanced circuitry, or power sources to get in the way of a satisfyingly simple but scientifically elegant project. The crystal radio turns the radio signal directly into a signal that the human ear can detect. Since the radio does not use external power, the source of power comes directly from the radio waves themselves. Your crystal radio detects in the AM band that have been traveling from stations (transmitters) thousands of miles away. Here's a quick overview of the different parts we're going to use and how they work:

The radio's antenna is attached (as a tap) to the coil in the center. This is the part that 'catches' the radio waves and through electromagnetism, induces current to flow through the wire.

Diodes are a 'one-way street' for electricity. We use one on our radio to cut the signal in half ("rectify" the signal), so the wave doesn't cancel itself out so you wouldn't hear anything.

The crystal (or ceramic) earphone is a piezoelectric device that in effect changes size when a voltage is applied, enabling us to transform an electrical pulse into a mechanical sound vibration.

The ground connection is where we will connect the circuit to a grounding source, like a metal pipe or a metal part of a lamp.

Your first step: Doing Research. Why do you want to do this project? What originally got you interested radios? Is it the idea of battery-free electronics? Or does the name of the project just *sound* cool? Do you like the idea of catching invisible waves and hearing their secrets?

Take a walk to your local library, flip through magazines, and surf online for information you can find about electromagnetic spectrum, frequency, wavelength, piezoelectric devices, tuning coils, a cat's whisker (the electronic type, not the furry kind), AM bands, and antennas. Learn what other people have already figured (like Pickard, Bose, and Tesla) out before you start re-inventing the wheel!

Flip open your science journal and write down things you've find out. Your journal is just for you, so don't be shy about jotting ideas or interesting tidbits down. Also keep track of which books you found interesting. You'll need these titles later in case you need to refer back for

something, and also for your bibliography, which needs to have *at least* three sources that are not from the internet.

Your next step: Define what it is that you really want to do. In this project, we're going to walk you step by step through building a complete crystal radio using simple parts. Go shopping and gather your equipment together now, picking up a few extra diodes, wires, and earphones so you can test out different designs before taking data.

Playing with the experiment: Now it's time to build a crystal radio. Jump online and watch the video now. When you've got your crystal radio working, take a look at the next step.

Formulate your Question or Hypothesis: You'll need to nail down ONE question or statement you want to test. Be careful with this experiment - you can easily have several variables running around and messing up your data if you're not careful. Here are a few possible questions:



- “Does the tube diameter matter?”
- “Does magnet wire diameter (gauge) matter?”
- “Which diode (germanium, silicone, none...) works best?”
- “Does antenna length matter?”
- “Which ground source gives the clearest signal?”
- “Does antenna location matter?”
- “Which type of crystal radio gives the clearest signal?”

Once you've got your question, you'll need to identify the *variable*. For the question: “*Does tube diameter matter?*”, your variable is the diameter of the cardboard tube, keeping everything else constant (amount or length of wire wrapped around the tube, design of radio, earphone type, etc...)

If you wanted to ask the question: “Does it matter how long the antenna is?”, your hypothesis might be: “*An antenna twice the length gives twice the signal strength.*” You can estimate the signal strength with your ear from 1 to 5 using the following guidelines:

- 1 – No Signal: you can’t hear any signal at all
- 2 –Inaudible Sound: you can barely hear a signal, but can’t make out any words
- 3 – Weak Signal: you can hear a few words here and there, but nothing that makes sense
- 4 – Medium Signal: you can hear most words, but it still sounds scratchy
- 5 – Strong Signal: you can clearly hear words or songs

Getting Clear on the Question and Hypothesis: You’ll need to ask a specific question and attach your best guess in order to transform your question into a hypothesis. Here’s an example:

Question “*Which type of crystal radio gives the clearest signal?*”

Hypothesis “*I think that the tunable capacitor radio gives the clearest signal.*”

Taking Data: Here’s how to record data: Grab a sheet of paper, and across the top, write down your background information, such as your name, date, time of day, circuit design (including diode type, earphone type, antenna length, etc.), *where* you placed your radio, and anything else you’d need to know if you wanted to repeat this experiment *exactly* the same way on a different day. Include a photograph of your invention also, so you’ll see exactly what your project looks like.



To create your data log, write across your paper the column headers listed below, including the units in parentheses. Note: there is a sample data sheet following this section.

- Trial #
- Antenna Length (feet) – the independent variable
- Signal Strength (minimum to maximum on a scale from 1 to 5) – the dependent variable

Be sure to run your experiment a few times before taking actual data, to be sure you’ve got everything running smoothly. Have someone snap a photo of *you*, getting ready to test, to enter later onto your display board.

Analyze your data. Time to take a hard look at your numbers! What did you find? Does your data support your original hypothesis, or not?

Make yourself a grid (or use graph paper), and plot the *Signal Strength* versus the *Antenna Length*. In this case, the *Signal Strength* goes on the vertical axis (dependent variable), and *Antenna Length* (independent variable) goes on the horizontal axis. Using a computer, enter in your data into an Excel spreadsheet and plot a graph. Label your axes (include units!) and add a title.

Conclusion: So - what did you find out? What is the best antenna length? Does it matter? Which type of crystal radio gives the clearest signal? Does a larger wire diameter give a clearer sound? Is it what you originally guessed?

Science is one of the only fields where people actually *throw a party* when stuff works out differently than they expected! Scientists are investigators, and they get *really* excited when they get to scratch their heads and learn something new.

Hot Tip on Being a Cool Scientist One of the biggest mistakes you can ever make is to fudge your data so it matches what you wanted to have happen. Don't *ever* be tempted to do this... science is based on observational fact. Think of it this way: the laws of the universe are still working, and it's your chance to learn something new!

Recommendations: This is where you need to come up with a few ideas for further experimentation. If someone else was to take your results and data, and wanted to do more with it, what would they do? Here are a few spins on the original experiment:

- Vary the tuning wire type (magnet wire, insulated, and sizes of both)
- Vary the number of tuning coils connect together in series
- Vary the earpiece (crystal earphone, telephone handsets, etc.)

Make the display board. Fire up the computer, stick paper in the printer, and print out the stuff you need for your science board. Here are the highlights:

- **Catchy Title:** This should encompass your basic question (or hypothesis).
- **Purpose and Introduction:** Why study this topic?
- **Results and Analysis** (You can use your actual data sheet if it's neat enough, otherwise print one out.)
- **Methods & Materials:** What did you use and how did you do it? (Print out photos of you and your experiment.)
- **Conclusion:** One sentence tells all. What did you find out?
- **Recommendations:** For further study.
- **References:** Who else has done work like this?

Outline your presentation. People are going to want to see you demonstrate your project, and you'll need to be prepared to answer any questions they have. We'll detail more of this in the later section of this guidebook, but the main idea is to talk about the different sections of your display board in a friendly, knowledgeable way that gets your point across quickly and easily. Test drive your presentation on friends and relatives beforehand and you'll be smoothly polished for the big day.

Sample Report

In this next section, we've written a sample report for you to look over and use as a guide. Be sure to insert your own words, data, and ideas in addition to charts, photos, and models!



Title of Project

(Your title can be catchy and clever, but make sure it is as descriptively accurate as possible. Center and make your title the LARGEST font on the page.)

by Aurora Lipper

123 Main Street,
Sacramento, CA 10101

Carmel Valley Grade School
6th grade

Table of Contents

Abstract.....	1
Introduction.....	2
State of Purpose.....	3
Hypothesis.....	5
Materials.....	7
Procedures.....	9
Results.....	12
Conclusion.....	15
Bibliography.....	16
Acknowledgements.....	21

Abstract

This is a *summary* of your entire project. Always write this section LAST, as you need to include a brief description of your background research, hypothesis, materials, experiment setup and procedure, results, and conclusions. Keep it short, concise, and less than 250 words.

Here's a sample from Aurora's report:

What effect does antenna length have on an AM band crystal radio? After researching the electromagnetic spectrum, frequency, quartz crystals, wavelength, radio circuitry, sonic vibrations, and how the human ear detects sound, I realized I had all the basics for building a small radio. But which antenna length would produce the best signal?

I hypothesized that the longer antenna would give strongest and clearest radio signals. After a quick trip to Radio Shack, I built a crystal radio to test. I ran ten trials varying the type of radio and estimated the signal strength using a sound scale from 1 to 5.

I found that my initial hypothesis (the longer the antenna, the stronger the signal in the crystal radio) was supported by the data, but not in the way I had expected. My best guess was that an antenna of 100' would produce a clear enough signal to hear distinct words and songs. I found that **an antenna length of 60' and above all gave clear, strong signal results.**

For further study, I recommend running an experiment to test the various gauges of wire, tube diameter, different types of grounding sources, and types of diodes (such as germanium, zener, and silicon) as each diode cuts the signal strength by a different amount.

Introduction/Research

This is where all your background research goes. When you initially wrote in your science journal, what did you find out? Write down a few paragraphs about interesting things you learned that eventually led up to your main hypothesis (or question).

Here is a sample from Aurora's report:

Which antenna length gives the best radio signal? After researching the electromagnetic spectrum, frequency, wavelength, quartz crystals, and radios, I realized I had all the basics for picking up AM radio stations using simple equipment from Radio Shack. But which antenna length would produce the clearest, strongest radio signal in my crystal radio?

A crystal radio is among the simplest of radio receivers... there's no battery or power source, and nearly no moving parts. The radio is made up of a tuning coil (magnet wire wrapped around a toilet paper tube), a detector (germanium diode) and crystal earphones, and an antenna wire. The crystal radio turns the radio signal directly into a signal that the human ear can detect. Since the radio does not use external power, the source of power comes directly from the radio waves themselves. This radio detects in the AM band that have been traveling from stations (transmitters) thousands of miles away.

One of the biggest challenges with detecting low-power radio waves is that there is no amplifier on the radio to boost the signal strength. I had to find the quietest spot in my house away from any transmitters (and loud noises) that might interfere with the reception.

When designing the experiment, I had to take into account the finer details, such as the width of the wire, whether to use magnet or plastic-insulated wire, the type of diode, and the tube diameter. In addition, I also needed to find an adequate grounding source (I used a metal water pipe) and have enough space to spread out my antenna, which ranged from 10' to 100'.

Purpose

Why are you doing this science fair project at all? What got you interested in this topic? How can you use what you learn here in the future? Why is this important to you?

Come up with your own story and ideas about why you're interested in this topic. Write a few sentences to a few paragraphs in this section.

Hypothesis

This is where you write down your speculation about the project – what you think will happen when you run your experiment. Be sure to include *why* you came up with this educated guess. Be sure to write at least two full sentences.

Here's a sample from Aurora's report:

I hypothesized that the longer the antenna, the stronger the signal in the crystal radio. My best guess is that an antenna of 100' would produce a clear enough signal to hear distinct words and songs.

Materials

What did you use to do your project? Make sure you list *everything* you used, even equipment you measured with (rulers, stopwatch, etc.) If you need specific amounts of materials, make sure you list those, too! Check with your school to see which unit system you should use. (Metric or SI = millimeters, meters, kilograms. English or US = inches, feet, pounds.)

Here's a sample from Aurora's report:

- Toilet paper tube
- Magnet wire – Radio Shack part #278-1345
- Germanium diode (1N34A) – Radio Shack part #276-1123
- Telephone handset or get a crystal earphone from C. Crane at (800) 522-8863 (part #EKI)
- Alligator clip test leads – Radio Shack part #278-1157
- 100' stranded insulated wire (for the antenna)
- Camera to document project
- Composition or spiral-bound notebook to take notes
- Display board (the three-panel kind with wings), about 48" wide by 36" tall
- Paper for the printer (and photo paper for printing out your photos from the camera)
- Computer and printer

Procedures

This is the place to write a highly detailed description of what you did to perform your experiment. Write this as if you were telling someone else how to do your exact experiment and reproduce the same results you achieved. If you think you're overdoing the detail, you're probably just at the right level. Diagrams, photos, etc. are a great addition (NOT a substitution) to writing your description.

Here's a sample from Aurora's report:

First, I became familiar with the experiment and setup. After raiding Radio Shack for magnet wire, diodes and earphones, I created a simple crystal radio that could detect AM radio waves without the use of a battery. I ran ten trials varying the length of the antenna and estimated the signal strength using the following scale:

- 1 – No Signal: you can't hear any signal at all
- 2 –Inaudible Sound: you can barely hear a signal, but can't make out any words
- 3 – Weak Signal: you can hear a few words here and there, but nothing that makes sense
- 4 – Medium Signal: you can hear most words, but it still sounds scratchy
- 5 – Strong Signal: you can clearly hear words or songs

I made myself a data logger in my science journal. I placed the crystal radio in a spot clear from noise, obstructions, and interference from nearby transmitters and connected the ground wire to the metal pipe and strung the antenna along the ground. I then listened to on the earphone and connected up different antenna lengths to get a better feel for judging the scale for signal strength from 1 to 5. Once I finished the pre-tests, I ran ten trials, varying the antenna length in increments of 10', recording the signal strength with each trial run.

Results

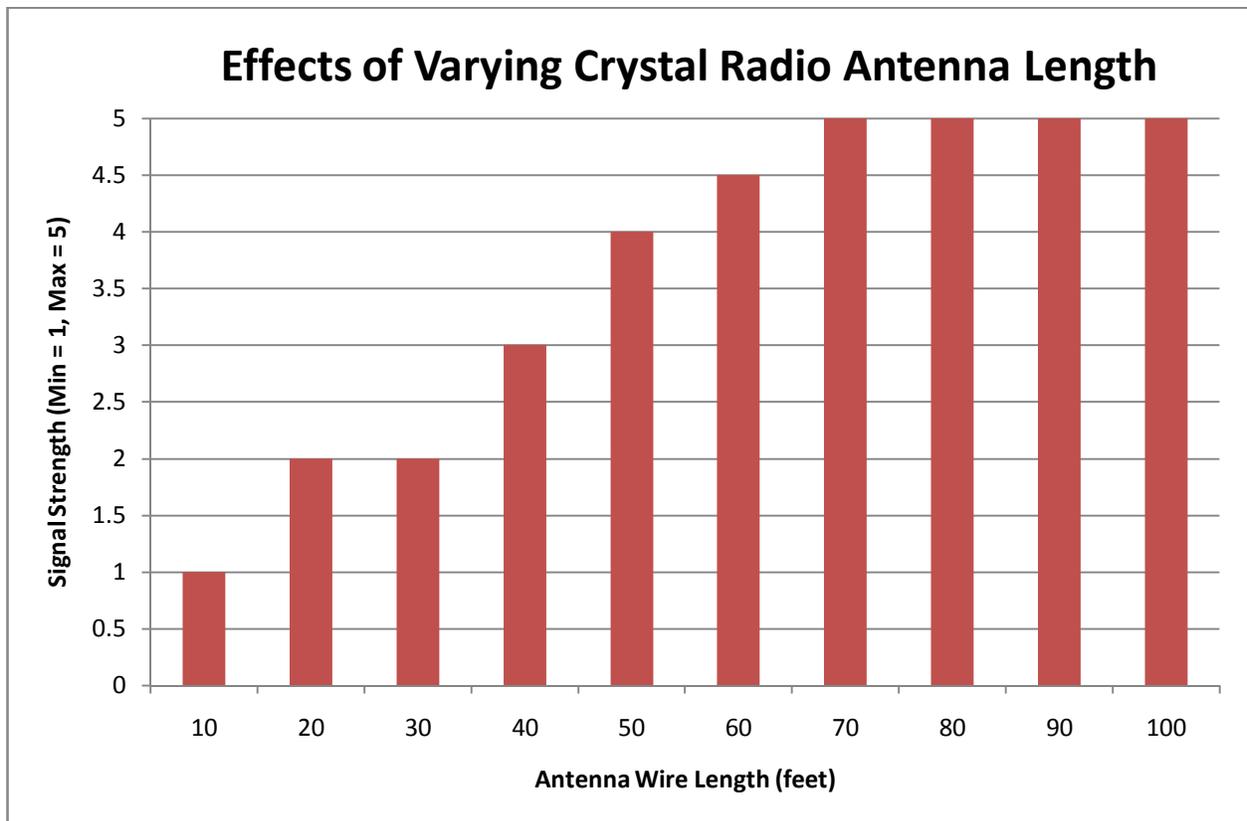
This is the data you logged in your Science Journal. Include a chart or graph – whichever suits your data the best, or both if that works for you. Use a scatter or bar graph, label the axes with units, and title the graph with something more descriptive than “Y vs. X or Y as a function of X”. On the vertical (y-axis) goes your dependent variable (the one you recorded), and the horizontal (x-axis) holds the independent variable (the one you changed).

Crystal Radio Data Sheet

Name *Aurora Lipper* Antenna wire gauge *24g*
Date *Nov. 28, 2009* Tube wire gauge *28g magnet*
Time *12:45pm* Diode type *germanium*

Trial #	Antenna Length (feet)	Signal Strength (Min = 1, Max =5)
1	10	1
2	20	2
3	30	2
4	40	3
5	50	4
6	60	4.5
7	70	5
8	80	5
9	90	5
10	100	5

NOTE: The numbers above are NOT real! Be sure to input your own.



- 1 – No Signal: you can't hear any signal at all
- 2 –Inaudible Sound: you can barely hear a signal, but can't make out any words
- 3 – Weak Signal: you can hear a few words here and there, but nothing that makes sense
- 4 – Medium Signal: you can hear most words, but it still sounds scratchy
- 5 – Strong Signal: you can clearly hear words or songs

NOTE: The numbers above are NOT real! Be sure to input your own.

Conclusion

Conclusions are the place to state what you found. Compare your results with your initial hypothesis or question – do your results support or not support your hypothesis? Avoid using the words “right”, “wrong”, and “prove” here. Instead, focus on what problems you ran into as well as why (or why not) your data supported (not supported) your initial hypothesis. Are there any places you may have made mistakes or not done a careful job? How could you improve this for next time? Don’t be shy – let everyone know what you learned!

Here’s a sample from Aurora’s report:

I found that my initial hypothesis (the longer the antenna, the stronger the signal in the crystal radio) was supported by the data, but not in the way I had expected. My best guess was that an antenna of 100’ would produce a clear enough signal to hear distinct words and songs. I found that **an antenna length of 60’ and above all gave clear, strong signal results.**

For further study, I recommend running an experiment to test the various gauges of wire, tube diameter, and types of grounding sources. This experiment was a lot of fun!

Bibliography

Every source of information you collected and used for your project gets listed here. Most of the time, people like to see at least five sources of information listed, with a maximum of two being from the internet. If you're short on sources, don't forget to look through magazines, books, encyclopedias, journals, newsletters... and you can also list personal interviews.

Here's an example from Aurora's report on Rocketry:

(The first four are book references, and the last one is a journal reference.)

Fox, McDonald, Pritchard. Introduction to Fluid Mechanics, Wiley, 2005.

Hickam, Homer. Rocket Boys, Dell Publishing, 1998.

Gurstelle, William. Backyard Ballistics, Chicago Review Press, 2001.

Turner, Martin. Rocket and Spacecraft Propulsion. Springer Praxis Books, 2001.

Eisfeld, Rainer. "The Life of Wernher von Braun." Journal of Military History Vol 70 No. 4. October 2006: 1177-1178.

Acknowledgements

This is your big chance to thank anyone and everyone who have helped you with your science fair project. Don't forget about parents, siblings, teachers, helpers, assistants, friends...

Formatting notes for your report: Keep it straight and simple: 12 point font in Times new Roman, margins set at 1" on each side, single or 1.5 spaced, label all pages with a number and total number of pages (see bottom of page for sample), and put standard information in the header or footer on every page in case the report gets mixed up in the shuffle (but if you bind your report, you won't need to worry about this). Create the table of contents at the end of the report, so you can insert the correct page numbers when you're finished.

Add a photo of your experiment in action to the title page for a dynamic front page!

Exhibit Display Board

Your display board holds the key to communicating your science project quickly and efficiently with others. You'll need to find a tri-fold cardboard or foam-core board with three panels or "wings" on both sides. The board, when outstretched, measures three feet high and four feet long.

Your display board contains *all* the different parts of your report (research, abstract, hypothesis, experiment, results, conclusion, etc.), so it's important to write the report *first*. Once you've completed your report, you'll take the best parts of each section and print it out in a format that's easy to read and understand. You'll need to present your information in a way that people can stroll by and not only get hooked into learning more, but can easily figure out what you're trying to explain. Organize the information the way museums do, or even magazines or newspapers.

How to Write for your Display Board Clarity and neatness are your top tips to keep in mind. The only reason for having a board is to communicate your work with the rest of the world. Here are the simple steps you need to know:

Using your computer, create text for your board from your different report sections. You'll need to write text for the title, a purpose statement, an abstract, your hypothesis, the procedure, data and results with charts, graphs, analysis, and your conclusions. And the best part is - it's all in your report! All you need to do is copy the words and paste into a fresh document so you can play with the formatting.

The title of your project stands out at the very top, and can even have its own 'shingle' propped up above the display board. The title should be in Times New Roman or Arial, at least 60 pt font... something strong, bold, and easy to read from across the room. The title has to accurately describe your experiment *and* grab people's attention. Here are some ideas to get you started:

- Battery-Free Radios: How to 'Catch the Wave' with Minimal Equipment
- AM Bands: Studying the Effect of Zener, Germanium, and Silicon Diodes
- How Big is Your Wire? Investigating the Effect of Antenna Length on Signal Strength

On the left panel at the top, place your abstract in 16-18 pt font. Underneath, post your purpose, followed by your hypothesis in 24 point font. Your list of materials or background research can go at the bottom section of the left panel. If you're cramped for space, put the purpose in the center of the board under the title.

In the central portion of the board, post your title in large lettering (24-60 pt. font). (You can alternatively make the title on a separate board and attach to the top of the display board... which is *great* if you really want to stand out!) Under the title, write a one-sentence description of what your project is really about in smaller font size (24-48 pt. font) Under the title, you'll need to include highlights from your background research (if you haven't put it on the left panel already) as well as your experimental setup and procedures. Use photos to help describe your process.

The right panel holds your results with prominent graphs and/or charts, and clear and concise conclusions. You can add tips for further study (recommendations) and acknowledgements beneath the conclusions in addition to your name, school, and even a photo of yourself doing your project.

Use white copy paper (*not* glossy, or you'll have a glare problem) and 18 point Times New Roman, Arial, or Verdana font. Although this seems obvious, spell-check and grammar-check each sentence, as sometimes the computer does make mistakes! Cardstock (instead of white copy paper) won't wrinkle in areas of high humidity.

Cut out each description neatly and frame with different colored paper (place a slightly larger piece of paper behind the white paper and glue in place. Trim border after the glue has dried. Use small amounts of white glue or hot glue in the corners of each sheet, or tape together with double-sided sticky tape. Before you glue the framed text descriptions to your board, arrange them in different patterns to find the best one that works for your work. Make sure to test out the position of the titles, photos, and text together before gluing into place!

In addition to words, be sure to post as many photos as is pleasing to the eye and also helps get your point across to an audience. The best photos are of *you* taking real data, doing real science. Keep the pictures clean, neat, and with a matte finish. Photos look great when bordered with different colored paper (stick a slightly larger piece of paper behind the photo for a framing effect). If you want to add a caption, print the caption on a sheet of white paper, cut it out, and place it near the top or bottom edge of the photo, so your audience clearly can tell which photo the caption belongs to. Don't add text directly to your photo (like in

Photoshop), as photos are rich in color, and text requires a solid color background for proper reading.

Check over your board as you work and see if your display makes a clear statement of your hypothesis or question, the background (research) behind your experiment, the experimental method itself, and a clear and compelling statement of your results (conclusion). Select the text you write with care, making sure to add in charts, graphics, and photos where you need to in order to get your point across as efficiently as possible. Test drive your board on unsuspecting friends and relatives to see if they can tell you what your project is about by just reading over your display board.

How to Stand Out in a Crowd Ever try to decide on a new brand of cereal? Which box do you choose? All the boxes are competing for your attention... and out of about a hundred, you pick *one*. This is how your board is going to look to the rest of the audience – as just one of the crowd. So, how do you stand out and get noticed?

First, make sure you have a BIG title – something that can be clearly seen from across the room. Use color to add flair without being too gaudy. Pick two colors to be your “color scheme”, adding a third for highlights. For example, a black/red/gold theme would look like: a black cardboard display board with text boxes framed with red, and a title bar with a black background with red lettering highlighted with gold (using two sets of “sticky” letters offset from each other). Or a blue/yellow scheme might look like: royal blue foam core display board with textboxes framed with strong yellow. Add color photographs and color charts for depth. Don’t forget that the white in your textboxes is going to add to your color scheme, too, so you’ll need to balance the color out with a few darker shades as you go along.

It’s important to note that while stars, glitter, and sparkles may attract the eye, they may also detract from displaying that you are about ‘real science’. Keep a professional look to your display as you play with colors and shades. If you add something to your board, make sure it’s there to help the viewer get a better feel for your work.

For a crystal radio exhibit, you can add zooming radio waves or lightning up the edges of your display board and around the top of your board in gold or blue. Add an extra test radio specimen at the top of your board as an attention-getter. Have a crystal radio on display (use an old telephone handset for a more hygienic way for the public to ‘hear’ your experiment, or hook it up to an oscilloscope if you have an engineering friend with the right tools) so people can see your experiment in action.

If you're stuck for ideas, here are a few that you might be able to use for your display board. Be sure to check with your local science fair regulations, to be sure these ideas are allowed on your board:

- Your name and photo of yourself taking data on the display board
- Captions that include the source for every picture or image
- Acknowledgements of people who helped you in the lower right panel
- Your scientific journal or engineer's notebook
- The experimental equipment used to take data and do real science
- Photo album of your progress (captions with each photo)

Oral Presentation

You're now the expert of the Crystal Radio Science Experiment... you've researched the topic, thought up a question, formulated a hypothesis, done the experiment, worked through challenges, taken data, finalized your results into conclusions, written the report, and build a display board worthy of a museum exhibit. Now all you need is to prep for the questions people are going to ask. There are two main types of presentations: one for the casual observer, and one for the judges.

The Informal Talk In the first case, you'll need quick and easy answers for the people who stroll by and ask, "What's this about?" The answers to these questions are short and straight-forward – they don't want a highly detailed explanation, just something to appease their curiosity. Remember that people learn new ideas quickly when you can relate it to something they already know or have experience with. And if you can do it elegantly through a story, it will come off as polished and professional.

The Formal Presentation The second talk is the one you'll need to spend time on. This is the place where you need to talk about everything in your report without putting the judges to sleep. Remember, they're hearing from tons of kids all day long. The more interesting you are, the more memorable you'll be.



Tips & Tricks for Presentations: Be sure to include professionalism, clarity, neatness, and 'real-ness' in your presentation of the project. You want to show the judges how you did 'real' science – you had a question you wanted answered, you found out all you could about the topic, you planned a project around a basic question, you observed what happened and figured out a conclusion.

Referring back to your written report, write down the highlights from each section onto an index card. (You should have one card for each section.) What's the most important idea you want the judges to realize in each section? Here's an example:

Research Card: What effect does antenna length have on an AM band crystal radio? After researching the electromagnetic spectrum, frequency, quartz crystals, wavelength, radio circuitry, sonic vibrations, and how the human ear detects sound, I realized I had all the basics for building a small radio. But which antenna length would produce the best signal?

Question/Hypothesis Card: I hypothesized that the longest antenna would give strongest and clearest radio signals.

Procedure/Experiment Card: After a quick trip to Radio Shack, I built a crystal radio to test. I ran ten trials varying the type of radio and estimated the signal strength using a sound scale from 1 to 5.

Results/Conclusion Card: I found that my initial hypothesis (the longer the antenna, the stronger the signal in the crystal radio) was supported by the data, but not in the way I had expected. I found that **an antenna length of 60' and above all gave clear, strong signal results.**

Recommendations Card: For further study, I recommend running an experiment to test the various gauges of wire, tube diameter, different types of grounding sources, and types of diodes (such as germanium, zener, and silicon) as each diode cuts the signal strength by a different amount.

Acknowledgements Card: I want to express my thanks to mom for keeping extra toilet paper rolls for me to experiment with, for my teacher who encourages me to go further than I really think I can go, for my friends for helping me string the antenna between our houses, for dad for helping me wind hundreds of feet of magnet wire, and for Uncle Henry for helping me wire up the oscilloscope to my radio so I could 'see' my radio waves!

Putting it all together... Did you notice how the content of the cards were already in your report, in the abstract section? The written report is such a vital piece to your science fair project, and by writing it first, it makes the rest of the work a lot easier. You can do the tougher pieces (like the oral presentation) later because you took care of the report upstream.

As you practice your oral presentation, try to get your notes down to only one index card. Shuffling through papers onstage detracts from your clean, professional look. While you don't need to memorize exactly what you're going to say, you certainly can speak with confidence because you've done every step of this project yourself.

You're done! Congratulations!! Be sure to take lots of photos, and send us one! We'd love to see what you've done and how you've done it. If you have any suggestions, comments, or feedback, let us know! We're a small company staffed entirely human beings, and we're happy to help you strive higher!