Name____________________
English _______
Date ___________________-

PCA Science Fair – Project Guidelines

Providence Christian Academy holds an in-house science fair. Winners from the PCA science fair will move on to compete in the Fauquier County Science Fair. A student of PCA won the science fair logo contest and her logo will be used to promote the Fauquier County Science Fair. In previous years PCA competed in the Prince William Science Fair with the following results: several students placed and were invited to participate at higher level science fairs.

The following pages provide important information students will need as they prepare and present their science fair projects. The science fair project will contain three major parts: research project, experiment, and display board.

Participating in a science fair benefits the student in several ways. An obvious benefit is learning more about a particular aspect of science; another is applying the scientific method of question, hypothesis, experimentation, and conclusion. Two less obvious benefits, but ones that are equally important, are learning the research process and following a schedule; both of these benefits are important skills for further education and for life.

Science Fair Project Steps

Step 1: Selecting a Topic

A. **Choose a subject that you consider interesting.** You will be spending a lot of time on it, so you do not want your project to be about something that does not interest you.

- Look around you. What interests you? What do you want to know more about? Try to think of a topic for which you can easily find materials and which will fit into your budget – both money and time.
- Select three possible topics. Each student will be working on a different project. If several students duplicate an idea, one or more will have to move to another topic.
- Your topic must be approved by your science teacher to be certain that it is an acceptable, affordable, and safe project.

B. **Research your topic.** Find out all you can about it. Look for information that will help you understand your topic and that will help you design your investigation.

- Include a minimum of three reliable sources on your topic, including at least one hard copy source. You want to build on the experience of others. Although you may want to read an encyclopedia article for background information before beginning your research, <u>you may not use encyclopedias – including those online – as your sources</u>.
- You MUST take notes on the information that you find. It is important that your research is accurate and thorough and that you give proper credit to your sources so that you avoid plagiarism of any kind. You will follow instructions given in your English class.
- Write a paper based upon your research. Paper length will be assigned by grade. This paper will be completed before you begin your experiment and will provide the background information for your experiment.

- **You will use MLA format to record your source information. This method will be covered in your English class.**
- Absolutely **all work must be your own work. You are not to copy any experiment that you may find on an internet site, or through any other venues. This is YOUR project where YOU are to find or the answers to YOUR questions and to see if YOUR hypothesis was correct.**

Step 2: Selecting (or confirming) your experiment

Once you complete your research paper, you will need to re-evaluate your experiment choice. Keeping in mind what you have learned during the research process, determine if your original plan is viable or if it needs to be tweaked or changed. As you finalize your experiment choice, consider the following points.

A. **Avoid (do not select!)** a topic that is a preference or a choice. An example of this would be "Which tastes better: Coke or Pepsi?" Such experiments do not involve the kind of numerical measurements necessary in a science fair project. This is more of a survey than an experiment.

B. **Establish factors that you can easily measure, using a number such as time, length, weight, or speed.** If you cannot measure the results of your experiment, then you are not doing science!

C. **You will keep a detailed log** as you conduct your experiment. It will include the following elements; these elements will also be included in a written report and a display board. Organization of the log, the report, and the display board will follow the order given below. In addition, the report will be prefaced with an abstract, which we will discuss and complete in English class.

- Question
- Hypothesis
- Variables
- Materials
- Procedures
- Safety Procedures
- Results ¶ and Graph(s)
- Conclusion and Reflection
- Biblical Integration

Step 3: Problem or Question

Ask yourself: Is my question testable? Can I get an answer to my question by doing an experiment? Can I measure the results using numbers? Can this investigation be done in a reasonable amount of time? A few different ways that you can word this question would be as follows.

- How does ________ affect ________?
- In what way could ________ improve the performance of ________?
- What type of relationship exists between ________ and ________?

As you decide on your topic, there are endless possibilities as to what type of test you will be performing. Having a question will help to focus your thoughts and energy to one ascertainable goal.

Example: I choose the topic of magnets. Here are a few questions that I may ask…

- How do magnetic fields affect the rate of flow of water?
- What type of effect does temperature have on magnets?
- How does the number of coils affect the strength of a magnet?
- How does a bar magnet's field interact with the earth's magnetic field?
- What type of relationship exists between Neodymium magnets, Ferrite magnets, and electromagnets?

Maybe I am trying to see how magnets affect other sources…

- Is plant growth affected be the presence of a magnetic field? Is seed germination affected by the presence of a magnetic field?
- What type of a relationship exists between the magnetic fields given off by a computer, wall current, power lines, etc.?
- If you change magnetic field orientation, does it have an effect on organisms? (fruit fly, meal worm, planaria, etc.)

Possibly you are trying to do an experiment on magnetism, which metals are magnetic and why – the list goes on and on. This is the reason it is so important to have a well-thought out, concise question for your science project.

Step 4: Hypothesis

After having thoroughly researched your question, you should have some educated guess about how things work. This educated guess about the answer to your question is called the **hypothesis.**

The **hypothesis** must be worded so that it can be tested in your experiment. Do this by expressing the hypothesis using your independent variable (the variable you change during your experiment) and your dependent variable (the variable you observe) Remember, changes in the dependent variable depend on changes in the independent variable). The hypothesis **MUST** be written as an "**If . . . then . . ." statement.** Do not start your hypothesis with the words "I think" or "I hope" because it should be stated as fact.

Step 5: Variables

Scientists use an experiment to search for **cause and effect** relationships in nature. In other words, they design an experiment so that changes to one item cause something else to vary in a predictable way. These changing quantities are called **variables**. <u>A variable is any factor, trait, or condition that can exist in differing amounts or types.</u> An experiment usually has three kinds of variables: independent, dependent, and controlled.

A. The **independent variable** is the one that is changed by the scientist. To insure a fair test, a good experiment has only one independent variable. As the scientist changes the independent variable, he or she **observes** what happens.

B. The scientist focuses his or her observations on the **dependent variable** to see how it responds to the change made to the independent variable. The new value of the dependent variable is caused by and depends on the value of the independent variable.

   - For example, if you open a faucet (the independent variable), the quantity of water flowing (dependent variable) changes in response–you observe that the water flow increases. The number of dependent variables in an experiment varies, but there is often more than one.

C. Experiments also have **controlled variables**. Controlled variables are quantities that a scientist wants to remain constant, and he must observe them as carefully as the dependent variables. For example, if we want to measure how much water flow increases when we open a faucet, it is important to make sure that the water pressure (the controlled variable) is held constant. That's because both the water pressure and the opening of a faucet have an impact on how much water flows. If we change both of them at the same time, we cannot be sure how much of the change in water flow is because of the faucet opening and how much because of the water pressure. In other words, it would not be a fair test. Most experiments have more than one controlled variable. Some people refer to controlled variables as "**constant variables**."

In a good experiment, the scientist must be able to **measure** the values for each variable. Weight or mass is an example of a variable that is very easy to measure. However, imagine trying to do an experiment where one of the variables is love. There is no such thing as a "love-meter." You might have a **belief** that someone is in love, but you cannot really be sure, and you would probably have friends that don't agree with you. So, love is not measurable in a scientific sense; therefore, it would be a poor variable to use in an experiment.

Step 6: Materials

Now that you have a hypothesis, you will need to write a list of all the materials you will need and use in your investigation. A good materials list will tell the size, quantity, or amount of **ALL** items that will be used. (See example on the next page.)

Materials List Examples

A GOOD Materials List is very specific:	A POOR Materials List is vague:
• 500 ml of de-ionized water	• water
• stopwatch with 0.1 sec accuracy	• clock
• AA alkaline battery	• battery

Step 7: Procedures and Safety Procedures

Now you need to develop an experimental procedure for testing whether your hypothesis is true or false.

1. 1he first step of designing your experimental procedure involves planning how you will change your independent variable and how you will measure the impact that this change has on the dependent variable. To guarantee a fair test when you are conducting your experiment, you need to make sure that the only thing you change is the independent variable. ALL the controlled variables must remain constant. Only then can you be sure that the change you make to the independent variable actually caused the changes you observe in the dependent variable.

2. **Scientists run experiments more than once to verify that results are consistent.** In other words, you must verify that you obtain essentially the same results every time you repeat the experiment with the same value for your independent variable. This insures that the answer to your question is not just an accident. Each time that you perform your experiment is called a **run** or a **trial**. For this reason, your experimental procedure should also specify how many trials you intend to run. Most teachers want you to **repeat your experiment a minimum of three times**. Repeating your experiment more than three times is even better, and doing so may even be required to measure very small changes in some experiments. In some experiments you can run the trials all at once. For example, if you are growing plants, you can put three identical plants (or seeds) in three separate pots and that would count as three trials.

3. Every good experiment also **compares** different groups of trials with each other. Such a comparison helps insure that the changes you see when you change the independent variable are in fact caused by the independent variable. There are two types of trial groups: **experimental groups** and **control groups**.

4. The **experimental group** consists of the trials where you change the independent variable. For example, if your question asks whether fertilizer makes a plant grow bigger, then the experimental group consists of all trials in which the plants receive fertilizer.

5. In many experiments it is important to perform a trial with the independent variable in a special setting for comparison with the other trials. This trial is referred to as a **control group**. The control group consists of all those trials where you leave the independent variable in its natural state. In our example, it would be important to run some trials in which the plants get no fertilizer at all. These trials with no fertilizer provide a basis for comparison, and would insure that any changes you see when you add fertilizer are in fact caused by the fertilizer and not by something else.

6. However, not every experiment is like our fertilizer example. In another kind of experiment, many groups of trials are performed at different values of the independent variable. For example, if your question asks whether an electric motor turns faster if you increase the voltage, you might do an experimental group of three trials at 1.5 volts, another group of three trials at 2.0 volts, three trials at 2.5 volts, and so on. In such an experiment you are comparing the experimental groups to each other, rather than comparing them to a single control group. You must evaluate whether your experiment is more like the fertilizer example, which requires a special control group, or more like the motor example, which does not.

7. Whether or not your experiment has a control group, remember that every experiment has a number of controlled variables. Controlled variables are those variables that we don’t want to change while we

conduct our experiment, and they must be the same in every trial and every group of trials. In our fertilizer example, we would want to make sure that every trial received the same amount of water, light, and warmth. Even though an experiment measuring the effect of voltage on the motor's speed of rotation may not have a control group, it still has controlled variables: the same motor is used for every trial and the load on the motor (the work it does) is kept the same.

8. A little advance preparation can ensure that your experiment will run smoothly and that you will not encounter any unexpected surprises at the last minute. **You will need to prepare a detailed experimental procedure for your experiment so you can ensure consistency from beginning to end**. Think about it as writing a recipe for your experiment. This also makes it much easier for someone else to test your experiment if they are interested in seeing how you got your results. **Use imperative sentences with present tense verbs** since you are preparing this list **BEFORE**, not after, you conduct your experiment.

9. **Do NOT forget to include any safety procedures necessary for your experiment. These procedures should also be numbered. If no safety procedures are required – and be very careful about this! – state that in a sentence.**

Example: Experimental Procedure

1. Number each battery so you can tell them apart.
2. Measure each battery's voltage by using the voltmeter.
3. Put the same battery into one of the devices and turn it on.
4. Let the device run for thirty minutes before measuring its voltage again. (Record the voltage in a table every time it is measured.)
5. Repeat #4 until the battery is at 0.9 volts or until the device stops.
6. Do steps 1-5 again, three trials for each brand of battery in each experimental group.
7. For the camera flash push the flash button every 30 seconds and measure the voltage every 5 minutes.
8. For the flashlights rotate each battery brand so each one has a turn in each flashlight.
9. For the CD player repeat the same song at the same volume throughout the tests.

Step 8: Complete Your Investigation

Now you are ready to do the actual experiment! You CANNOT make observations only at the beginning of the investigation and at the end. **You will need to make frequent observations throughout the entire investigation** and **write these observations in a journaling format as you complete your project**. Make sure that you observe specific details and changes as you proceed through the experiment. **Date each journal entry. It is VERY important that you keep accurate records of your experiment; both your science and English teachers will be checking your log on a regular basis.**

- Obtain a marble composition notebook to record all of your observations during your experiment. Again, **date each journal entry.** You will copy these observations when you have completed your display on your project board.
- Beginning with your experiment approval (the question), you will include all steps of the experiment process in your log.
- Use ink for all entries. Make neat corrections (manuscript rules!) when needed. Do **NOT** tear out any pages. As stated earlier, date all entries.
- Before starting your experiment, prepare a data table in your journal/log, so you can quickly write down your measurements as you observe and make them. A data table contains both the independent and dependent variables.
- Follow your experimental procedure exactly. If you need to make changes in the procedure (which often happens), write down the changes exactly as you made them. Do **NOT** delete the original plan.

- Be consistent, careful, and accurate when you take measurements, Number measurements are best.
- **Take pictures of your experiment for use on your display board if you can. Extra pictures may be included in your log.**

Step 9: Results: Paragraph and Graph(s)

Once you have completed your investigation and have collected all your data, you have to show what happened during your investigation.

A. There are two parts to this section that will be included in your log and on your display board: a graph and a summary paragraph (4-10 sentences). The graph will show your data one way while the summary paragraph will tell in words what your graph shows.

B. Make sure to clearly label all graphs. Include a title. Place your *independent variable on the x-axis* of your graph and the *dependent variable on the y-axis*. Include the units of measurement that were used.

Step 10: Conclusion and Reflection

Now that you have written up your results, it is time to draw conclusions and to reflect upon what you have learned. Your **conclusion** summarizes how your results support your hypothesis or do not support your hypothesis. Your **reflection** will evaluate your procedure to tell what you did right and what you might do differently if you were to do this experiment over again. Follow these steps to write a good paragraph of 4 to 10 sentences. You may divide the conclusion and reflection into two paragraphs of 4 to 10 sentences each.

A. You will need to restate your hypothesis exactly as it was written at the beginning of your experiment.

B. Tell whether your hypothesis was *correct* or *incorrect*. If the results of your experiment did not support your hypothesis, do not change your results or the hypothesis. Simply explain why things did not go as expected. (Professional scientists commonly find that results do not support their hypothesis, and they use those unexpected results as the first step in constructing a new hypothesis for a new investigation.)

C. Summarize your science fair project in a few sentences. **You may – and should - include facts from your background research to help explain your results**. If you can, talk about the relationship between the independent and dependent variables.

D. Reflect on what happened in your investigation. What went well? What did you have trouble with? This is the place where you can suggest changes in the experimental procedure or design if you were to do it again or for possible future study.

Example of a good conclusion

> My hypothesis stated that if an Energizer battery was used in a toy car, then the car will run for a longer period of time. My results do not support my hypothesis. Energizer batteries did not last as long as Duracell batteries in the same toy car. I think the tests that I did went smoothly, and I had no problems. I found out that the batteries regain some of their strength if they are not running constantly. This means that batteries would probably last longer if the device was turned off once in a while. I had to take measurements at shorter intervals because not all batteries last the same length of time. If I had to do this investigation again, I might try testing batteries at different temperatures to see how temperature affects the life of a battery.

Step 11: Biblical Integration

Biblical integration is NOT just giving a Bible verse. Rather it is looking at and evaluating your experiment and what you have learned from a Biblical perspective. After you have completed your experiment and have written your conclusion and reflection, ask yourself the following questions: How can I see God's attributes? How are the characteristics of God seen through the laws of science? Is God orderly? This section should be at least one paragraph (4-10 sentences) in length.

Step 12: Writing an Abstract

After finishing research and experimentation, you need to write an abstract. The abstract needs to be a maximum of 250 words on one page. An abstract should include the a) purpose of the experiment, b) procedures used, c) data, and conclusions. It also may include any possible research applications. Only minimal reference to previous work may be included. The abstract must focus on work done in the current year and should not include a) acknowledgments, or b) work or procedures done by the mentor. See below for an example of an appropriately written abstract.

Sample Abstract

> This project in its present form is the result of bioassay experimentation on the effects of two-cycle marine engine exhaust water on certain green algae. The initial idea was to determine the toxicity of outboard engine lubricant. Some success with lubricants eventually led to the formulation of "synthetic" exhaust water which, in turn, led to the use of actual two-cycle engine exhaust water as the test substance. Toxicity was determined by means of the standard bottle or "batch" bioassay technique. *Scenedesmus quadricauda* and *Ankistrodesmus* sp. were used as the test organisms. Toxicity was measured in terms of a decrease in the maximum standing crop. The effective concentration - 50% (EC50) for *Scenedesmus quadricauda* was found to be 3.75% exhaust water; for *Ankistrodesmus* sp. 3.1% exhaust water using the bottle technique. Anomalies in growth curves raised the suspicion that evaporation was affecting the results; therefore, a flow-through system was improvised utilizing the characteristics of a device called a Biomonitor. Use of a Biomonitor lessened the influence of evaporation, and the EC 50 was found to be 1.4% exhaust water using Ankistrodesmus sp. as the test organism. Mixed populations of various algae gave an EC 50 of 1.28% exhaust water. The contributions of this project are twofold. First, the toxicity of two-cycle marine engine exhaust was found to be considerably greater than reported in the literature (1.4% vs. 4.2%). Secondly, the benefits of a flow-through bioassay technique utilizing the Biomonitor was demonstrated.

Step 13: Typing the report

The final two steps of the science fair project involve publishing your results. This part of the project will be completed as part of your English grade. As you will see in the science fair calendar and on the science fair deadline sheet, you will be typing copies of each element listed below. You will then print sections for your display board as well as putting the sections together in a project report, which will be placed with your research paper and display board during the science fair.

- Abstract (report only)
- Question
- Hypothesis
- Variables
- Materials
- Procedures
- Safety Procedures
- Results ¶ & Graph(s)
- Conclusion and Reflection
- Biblical Integration

Step 14: Displaying your Science Fair Project

A. Organize your information on a 36" tall by 48" wide standard, three-panel display board. We will be ordering the display boards and headers (for the title) from Geddes again this year. Order forms will be handed out later in the process.

B. Arrange your material so that your audience can follow the order of your experiment by reading **from top to bottom, then left to right**. The title of the project should be larger than the other labels of your display. Your name should be smaller and below the title in the middle section of your board.

C. Use colored construction paper to add accents to your display board. A common technique is to use colored sheets behind the white paper which contains your text. It is best to limit your color choices to two or three that are complementary. Too many colors become a distraction. If your board is colored, you may want to limit yourself to one complementary color for your construction paper.

D. Pictures or photographs can be added to your display board. Make sure these pertain to your experiment. ***Do not include people in any of the pictures your plan to include on your display board or in your log.***

TITLE OF PROJECT

Question (What effect does __________ have on __________ - for example.) **Hypothesis** This must be an If...Then...statement (Do not use pronouns in your hypothesis.) **Variables** Include the independent, dependent, and controlled variables.	**Materials** These must be listed using bulletin points. **Procedures** These must be listed using numbers. (Follow the guidelines from hand-outs.) **Safety Procedures** Follow guidelines stated in handout. **Observations** Displayed here are the pictures that you have taken to show your experiment. **No person should be in any picture.**	**Results** The results must be displayed using a graph with a summary of what the graph means. **Conclusion/Reflection** Restate your hypothesis. Tell whether or not your hypothesis was or was not correct. Write a reflection on what you have learned. **Biblical Integration** What does this project show about the nature of God?

SPECIAL NOTES

1. The date for the PCA Science Fair is Tuesday, February 27, 2018.
2. Much of the written work – source cards, note cards, research, and research paper – will be completed in the English classes. The goal is to have this part of the project completed in December before Christmas vacation. For that reason, it is **very important** that students meet all deadlines so that they can take advantage of the class time and teacher guidance provided. Since final copies must be typed, students will need to do that part at home.
3. Research supplies are due in English class on **Monday, October 9**. This will be the first deadline grade for the project. Both the folder and the composition book should have the student's name (first and last) neatly written in black marker on the front.
   a. a clean two-pocket folder
   b. a marble composition book
   c. 3x5 cards (minimum of 10)
   d. 4x6 cards (minimum of 20)
   e. blue or black ink pen
4. The science project folder will be used to keep all research materials, including these instructions, the deadline sheet, copies of online sources, note cards, source cards, and anything else pertaining to this project. Students may keep the science project calendars in the folder or may keep them at home.
5. The deadline sheet must accompany **ALL** deadlines, both for science class and for English.
6. To maintain consistency with display boards and to ensure that they all meet regulations, students will be purchasing their boards through the school again this year. Boards and title headers (which will hold the boards in place) will cost **about $6**, including tax and shipping. Order information will be sent home at a later date.
7. Copies of the PCA Science Fair Project Guidelines, the calendar, and the deadline sheet will be posted on the school web site.