Dear NASP Science Fair participant,

Scientific investigation is a dynamic and open-ended process that scientists and engineers like you use when trying to answer a question or solve a problem. It is not a rigid series of prescribed steps to prove a hypothesis. Instead, it's a general strategy that should guide your investigation, in a systematic way. And while all researchers use some version of the Scientific Process, they might not use all the steps sequentially; it largely depends on the type of science being applied and the laws governing that branch of science. For example, a scientist might make observations and collect data about a subject that interests him or her for years before formulating a hypothesis.

DEFINING A QUESTION TO INVESTIGATE

As you conduct your research, I encourage you to make observations and collect data, however insignificant you think they may be at the time. These seemingly trivial observations and data often lead us to ask a question, which is the first step in the scientific method. Your question should include one of the key starters: how, what, when, why, where, who or which. It should also be measurable and answerable through experimentation. Once you have a good question to investigate, you should begin to think of ways to answer it.

PERFORM ENOUGH RESEARCH TO MAKE PREDICTIONS

With our question formulated, the next step is for you to conduct preliminary background research to prepare yourself for your experiment. You can find information through online searches or in your local library, depending on the question you are asking and the nature of the background data. You may also find previous studies and experiments that can help with your process and conclusions.

The next step is for you to formulate a hypothesis based on your research and observations. A hypothesis is an educated guess which answers a question and that can be systematically tested and challenged. A hypothesis tries to describe what you *think* the outcome of your investigation will be. It is based on your own observations, existing theories, and information you gather from other sources.

GATHERING DATA

Evidence is needed to test your hypothesis. There are several strategies for collecting evidence, or data. Us scientists can gather data by observing the natural world, performing an experiment in a laboratory, or by running a model. Scientists like us often decide to combine different strategies to gather evidence. It's important that you make sure your procedure can be repeated, so that other scientists can confirm your findings.

Well-designed experiments include variables, constants, and controls. They are also able to be repeated!

<u>Variables</u> are the aspects of the experiment that change.

- Dependent Variables – These are the variables that will change as a result of your tests. You should not change these, but I encourage you to keep track of them as they often indicate the results for which we are looking.
- Independent Variables – These are the variables that YOU will change in your experiment. Us scientists try to have only one independent variable at a time in our tests, so we know for certain that the results we are seeing are caused by the one change we made. Simultaneously changing too many variables in a single experiment makes it difficult to analyze your data and draw accurate conclusions.

<u>Constants</u> are the conditions that will remain the same during your experiment. It's important to note what stayed the same in your experiment so you know that the results you are seeing are not caused by these factors.

<u>Controls</u> are a group that you are exposing to "normal" conditions. In your experimental group, you are changing an independent variable, but in the control group you are making no such change. That way you can compare your experimental group and control group to each other and know that the results you are seeing are actually caused by the change in the independent variable. If you didn't have a control group, you might think that something changed because

of the independent variable when in fact it was just because of other factors you hadn't even noticed that were affecting everything.

ANALYZING THE DATA

Variables and constants are part of your experimental group (the group on which you are testing). And the control is a separate group on which no testing is occurring but is still being observed. If you observe the same changes in your experimental and control groups, it means that the changes were not a result of our independent variable. As scientists, we often organize our data in tables, graphs, or diagrams to look for patterns or differences. When possible, we include relevant data from other sources too. We look for patterns that show connections between important variables in the hypothesis we are testing.

DRAWING CONCLUSIONS

Based on whether your prediction came true, scientists like us can then decide whether the evidence clearly supports or does not support our hypothesis. Drawing a conclusion means determining whether what you believed would happen did happen. If it did not happen, the good news is that you can create a new hypothesis and conduct a new experiment to prove your new theory. If what you hypothesized happened during the experimentation phase, the final step is compiling your findings and presenting them to others in the scientific community. Often, the conclusions drawn from these experiments lead to new questions to answer, and this is the allure of science!

PRESENTING YOUR CONCLUSIONS AND FINDINGS

Really good scientists can communicate their research to others in a clear coherent way. Creating tables, charts, and pictures is a very effective way to communicate complex ideas to others. After all, a picture is worth a thousand words!

I hope this helps guide you through the scientific method. Please reach out to me or anybody on the NASP team if you have any questions or would like to chat about your project. Good luck with your projects!

Sincerely,

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Sources used for motivation:

https://www.amnh.org

https://www.indeed.com

https://static.nsta.org