Make sure to read (and FREQUENTLY CONSULT/ REREAD) this entire document so you are clear on the summer expectations. Create a google folder called 2022 Summer Work-YourName; all of your summer work should be copied to your folder. Share the folder with your science research teachers.

This assignment is due the first day of school – NO EXCEPTIONS.

1) EXPERIMENTAL RESEARCH PROJECT

Ways to accomplish the experimental research project.

- MENTORED PROJECT. If you have a mentor, you should spend at least 50 hours working in her/his research facility. During your time at the research facility, you should shadow your mentor, observing what takes place on a daily basis, how certain techniques work, how data analysis is conducted, and what is expected from a researcher; take notes on what you are taught in your research journal. Remember that you are working with professionals. Make sure to conduct yourself as one, both in the lab and out. You represent not only yourself, but also this program. Future research students might want to work with your mentor and your actions will influence the mentor's decision to host future research.
- MENTORED / REMOTE PROJECT. It is possible to split time between a research facility and your home if your mentor agrees to this arrangement or do a remote project with a mentor. If possible, you should spend roughly half of the hours at the research facility (no less than 24 hours). The other hours can be spent completing work assigned to you by your mentor. This means you need to ask your mentor for work to do
- INDEPENDENT PROJECT. If you do not have a mentor, you can carry out an independent research project or you can take the LHS research summer course and be mentored by a teacher.

Requirements of the experimental research project. You are required to spend at least 50 hours on your EXPERIMENTAL WORK (see below) PLUS time on background work:

a) BACKGROUND WORK - Complete at least 4 articles summaries related to your topic of interest and your subsequent experimental work for the summer. Additionally, watch/read and take notes on technical tutorials, blogs, YouTubes, text books to EDUCATE YOURSELF about your research topic and its analysis. Record the references/links to each source and take detailed notes in your **Research Journal**.

b) EXPERIMENTAL WORK – Based on a topic of interest to you and related to work you have done in Science Research this year, you will design an original experiment, collect and analyze the data and make conclusions. The experiment can involve your own measurements or be based on data from a public database (here is a link to a list of some of the many databases for SR available). Because you have learned so much about science research, we expect your experimental work to be more substantial than the work you did last summer; the research question should be specific, researchable, and quantifiable and your data analysis should incorporate appropriate statistical analyses in order to make statistically significant conclusions. We hope that you will pick a research project that you can continue

and expand on if you don't find a mentor or if you become very interested in the topic. IMPORTANT NOTE: DO NOT COPY an experiment you find on the web. You can use existing experiments as inspiration or as a starting point, but you must make the work your own by changing something.

Below is an outline of an **EXPERIMENTAL DESIGN STRATEGY** you should follow. As you perform your research project, every element below should be recorded in a **Research Journal.**

- Develop a RESEARCH QUESTION. It should satisfy the 5 elements of a "good research question." This is the objective of your experiment. You should discuss and submit your research question to all the science research teachers **before you start on the research**. As you carry out your experiment, your research question may change/evolve; that is OK.
- EXPERIMENTAL DESIGN: To design the experiment, decide which variable is independent and which is dependent. If the variable cannot be measured directly with accuracy, measure something else that can be used to determine or calculate that variable. For each variable, describe what and how it's measured. Control and document other variables. If a measurement has a lot of uncertainty (variability), repeat and average a few identical trials. Measure at least 6 independent data points (6 different pairs of independent, dependent variables).
  Think about and record sources of error and limitations as you do and analyze the experiments.
- DATA: Record and present data in a well-organized and logical data tables. Measurements should be repeated at least three times when possible. The descriptive statistics for each repeatedly measured variable should be in the data table (mean and standard deviation); if a variable has > 20 repetitions, present the distribution of the variable (frequency distribution or box and whiskers plot) in the data section. CITE the source if not using your own data.

  TIP: As you collect data or use a database to address your research question, keep in mind that **you can/should expand your study to address multiple related questions and you should try to include negative and/or positive controls**. A journal article often reports on multiple related results in the results section, not just one.
  Example1 - If RQ is about the effect of *gender (IV)* on *sleep quality (DV)*, and you find a database with the data from a group of subjects (or you collect the data), chances are that the database also recorded other variables such as subject age, health, exercise, socioeconomic class, education, …. (or if you collect data, it would be essential to collect data on other confounding variables). Again, a single dataset can answer many related research questions.
  Example2 – If RQ is about the effect of *light/dark cycle (IV)* on *ant tunneling (DV)*, dont just measure the independent variable related to circadian cycle; also measure (and keep constant if possible) temperature, humidity, light intensity, number of ants, volume of soil, ... anything you can think of and anything you can measure. Whatever variables you cant keep constant, look at the effect on those on tunneling activity as well.
- ANALYSIS: Depending on the type of study you do, make a scatter graph (with dependent variable on y axis and independent variable on x-axis), or bar chart of the data. Carry out the appropriate inferential statistical analysis of your data. Consult and review the statistics resources in your OneNote Book, this Statistics Toolbox Summary, the STATs TUTORIAL google sheet (you should already have this), and reach out to the Science Research teachers if you have questions.
  TIP: Not only can you address multiple related research questions using a dataset (as described

above), but **you can and should also analyze the same data in different ways to emphasize different interpretations**.

Example – If RQ is to explore the association/correlation/effect of *host age (IV)* on *mosquito preference (DV)* and mosquito preference is a continuous variable like a count, then the data could be analyzed in multiple ways:

1. Correlation analysis: make a scatter plot of *host age* and *host preference* (both quantitative variables) and it looks somewhat linear, do a correlation analysis to quantify the correlation between the 2 variables
2. Regression analysis (curve fit): make a scatter plot of *host age* and *host preference* (both quantitative variables) and fit the data with a curve of best fit to generate a predictive model equation. Then try to interpret the coefficients of the fit.
3. T-test or ANOVA: It may be meaningful to treat the *independent variable (host age)* as a categorical variable based on what age would mean in terms of the *independent variable (host preference)*. Could look at different groupings of the dependent variable, age. For example:
   - child (ages x-y) group and adult (>y years) group and do T-test
   - child, adolescent, and adult groups and do ANOVA Test
   - groupings of 10 or 20 or ... years

- CONCLUSIONS: Based on the results of your analysis, think about and write down as many possible conclusions and explanations for the results that you can think of. Are there major sources of errors or limitations that you can correct? Is so, redesign, improve and/or repeat your experiment.

  Do your results lead you to a new or modified research question that you can better address? Remember that research is recursive, not linear process and so the research question and experimental design evolve as you do the research and analysis.

c) RESEARCH JOURNAL - document every step of your research experience in a lab notebook (here is a good one from Amazon) or in a digital Research Journal. The Research Journal should be detailed and reflective (not simply a diary).

Research Journal EXPECTATIONS:

- Keep a log of the dates and hours spent on your research.
- For each date entry, take detailed notes of what you did, what you observed, how things work, data collected, articles relevant to the research, useful websites, curiosity and Research questions considered, changes considered and made to your RQ, data, analysis and thoughts, etc. REMEMBER THAT RESEARCH IS A RECURSIVE, NOT LINEAR, PROCESS AND YOUR JOURNAL SHOULD SHOW THE DETAOLS OF THE ENTIRE PROCESS. THIS IS WHERE YOU TAKE ALL YOUR NOTES AND DOCUMENT ALL YOUR METHODS AN FINDINGS EVEN IF SOME LEAD TO A DEAD END OR DETOUR TO ANOTHER AVENUE. Be quantitative, record amounts, numbers, specifics
- Take pictures and draw diagrams of equipment, techniques, results, etc, as applicable.
- Be reflective of the research process. What is going well? What is difficult? What are you proud of? Where can you improve and how will you accomplish this? What skills can you help you refine this coming year? Etc, etc
- ***If you worked with a mentor, have the mentor sign your Research Journal***

2) WRITE A RESEARCH REPORT

Write a formal **REPORT** of your summer research project. You should write it in the standard format of a lab report (or journal article) with the following sections in the following order. Each section should have a heading (Introduction, Procedure, Data …). The report should be **self explanatory** (make sure to PROOFREAD your work). Do not assume the person reading your report knows what you are talking about or that a table, graph, or figure speaks for itself. Below outlines the organization of the research report:

- TITLE and NAME
- INTRODUCTION – provides background information on your topic (with references) that funnels from general to specific to a GAP to your RQ or objective. The background information should establish the relevance and context of your topic
- PROCEDURES – In a listed procedure, a clear and concise description of your experimental setup(s), quantities that were measured and determined, how it was measured/ determined, and with what instrument. Include clear diagram(s) and/or pictures of the experimental setup showing all measured AND determined quantities. Diagrams should be titled descriptively and well labeled. Include references if necessary.
- DATA - ALL raw, measured data as well as data determined from measured values should be in well-organized and logical data tables. Measurements should be repeated at least three times when possible and the descriptive stats to characterize each variable (mean and standard deviation) should be included in the data table. If one variable has more than 20 repetitions, present the distribution of the variable (frequency distribution or box and whiskers plot). CITE if not your own data.
- RESULTS - Depending on the type of study you do, your results will include figures of graphical analysis of the data or histograms or microscopic images or ….. along with the appropriate inferential statistical analysis. All tables and figures should be explained in the text of this section. Consult and review the statistics resources in your OneNote book, this Statistics Toolbox summary, and reach out to the Science Research teachers if you have questions about how to present the results.
  Do not leave it up to the reader to interpret the graphical results. In a paragraph or two before or after each result figure, explain the results in a 3 step process:
  1) Describe the graph/table/pic (egs. The graph shows the relationship between y and x
     OR the histogram shows the average value of y for 3 different groups)
  2) Describe the data (eg. There is a direct/linear/inverse/parabolic … relationship between y and x
     OR average value of variable y is max (mean±SD) for group x and min (mean±SD) for group z).
  3) Interpret the results including the statistical analysis (egs. The data were fit to … and the equation of the best fit is ….. The result agrees/ disagrees with the model of the relationship between y and x, which is …
     OR a T-test was performed to determine if the mean of variable y is significantly different in group x and z; The result of the test was T=_____ (df=... and p=… The result shows that ...).
- DISCUSSION AND CONCLUSIONS- Restate the overall conclusions; connect them to your research question and address whether or not your expectations/ hypothesis were met. Explain what is new and significant about your work in a larger context. Synthesize your results with other related work in the field by discussing the implications of your results (include references). Discuss major sources of error in your measurements and experiment and how they affect your results. Discuss limitations to your results and conclusions and address those limitations in proposing future work.

- BIBLIOGRAPHY - CSE format.

3) SEND US EMAIL UPDATES

You must update us twice on the progress of your summer assignment. Please be detailed and descriptive – work you have been doing, problems you have encountered, interesting discoveries in your reading, etc. Please format your subject line as "Firstname Lastname - Summer Update #1" to help us track and organize your messages.

- Email #1: Due no later than July 15th, 2020
- Email #2: Due no later than August 15, 2020
- Send emails to both Dr. Starace and Mr. Carey

What you need to TURN IN on the first day of school.

a) Research Journal – see the Research Journal expectations above

b) Article Summaries (4) and Reading/video notes – read and summarize journal articles (minimum of 4). The journal articles should be about any aspect of the experimental project you will be doing over the summer (background or methods).

c) Research Report (12 pt, double spaced). See expectations for the research Project (#1 above) and the Research Report (#2 above)

All summer work should be handed in the day we return to school. Please organize all materials in your 2022 Summer Work Google folder. If your Research Journal is digital, include it in your google folder. If your Research Journal is a physical notebook, hand it in on the first day of school.
Your summer work will be graded for excellence.
Be prepared to give a short presentation of your experiment and results within the first week of school.

Enjoy your summer!

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