HOW TO WRITE A RESEARCH REPORT

NOTE: I HAVE COPIES OF REPORTS DONE BY STUDENTS OVER THE LAST FEW YEARS. YOU ARE WELCOME TO COME TO CLASS ANY TIME TO LOOK AT THEM. I WILL GIVE YOU ONE TO TAKE HOME TO USE AS A GUIDE. YOU CAN SEE HOW THE REPORT IS SET OUT.

DEFINITION:

The research paper is a written report describing original research results in science, mathematics, or engineering. The paper should rely on previously published literature primarily for background and comparative purposes.

CONTENTS

The research paper is organized as follows:

- Title page
- Table of contents

} **The title page and table of contents are not numbered.**

- Abstract
- Introduction
- Objective, hypothesis or problem statement
- Materials and methods
- Results
- Discussion and Conclusions
- Acknowledgements
- Future research
- References (or literature cited)
- Appendices (Optional)

Comment: You will format your research paper according to the guidelines listed here. The MLA format will be used for citations and references. Refer to this website for the MLA format when citing references. Brief instructions using MLA format have been given to you in the "Introduction" section.

http://owl.english.purdue.edu/handouts/research/r_mla.html

Do not include your name in headers/footers on each page.

THIS IS HOW YOUR RESEARCH REPORT SHOULD BE ORGANIZED

TITLE PAGE (SEE EXAMPLE OF TITLE PAGE BELOW)

What to have The title page should contain the title, author, school, and the date. The title page **is not** numbered.

Definition The title is a concise identification of the main topic of the paper. Make sure your title accurately reflects the content of the paper.

Description A title is
- concise
- descriptive, and
- informative

Rules When writing a title:
- ***do not*** write the title as a question
- ***do not*** use abbreviations
- avoid "excess" words such as ***a, an,*** or ***the***, or phrases such as ***a study of*** or ***investigations of***
- consider its length. A two or three word title may be too short, but a 14 or 15 word title is probably too wordy.

Example
Poor: Bugs and Drugs
Fair: Effects of Antibiotics on Bacteria
Good: Effects of Penicillin on Gram Negative Bacteria
Best: Lysis of Gram Negative Bacteria by Penicillin

The **first example** is concise, but neither informative nor descriptive. It is not scientific style.
The **second example** is concise but too general. What effects? What antibiotics? What bacteria?
The **third example** is more specific, both in describing the antibiotic and the bacteria, but it still lacks description.
The fourth example is written in scientific style.

TABLE OF CONTENTS

A Table of Contents is not considered a part of a typical scientific research paper and ***is not*** a numbered page.

Definition A **Table of Contents** is an outline that indicates the location of the sections and subsections of the paper.

Purpose The main purpose of a Table of Contents is to enable the reader to quickly find any section of the paper.

Rules When making a Table of Contents:
- Use a header to indicate the page number. If you do not know how to use a header, come and see me or check the "HELP" function on your word document. There is a header on this page. Look at it. Pagination occurs at the top of the page and aligned with the right margin (just like on this page).
- List only the number of the first page of any section, e.g., "1" not "1-4".
- Consider using leaders, a series of horizontal dots, to "lead" the eye across the page to the right number (just like on this page above).
- ***Do not*** use the word "page" with the number. It is self-explanatory.

ABSTRACT

Introduction The **abstract** is the reader's first encounter with your paper. Reviews will form first impressions of your research by reading the abstract. Day (1994) states, "Usually, a good abstract is followed by a good paper; a poor abstract is a harbinger of woes to come."

Sequence ***Write the abstract after the paper is completed. Make sure it accurately reflects the paper's contents.***

Definition The **abstract** is a:

- brief summary of the principal findings of the paper.
- preview of the paper.
- stand-alone, self-contained document that can be read independent of the paper.

Contents The **abstract** should briefly convey:

(a) The purpose of the research or the research problem.
(b) A general overview of the procedures used
(c) The principal findings from the data
(d) Conclusions

While it is difficult to be both concise and descriptive at the same time, That is exactly what you should strive for when writing an abstract. Say only what is essential, using no more words than necessary to convey the meaning.

Exam ine every word carefully.

Rules ***The abstract should be:***

- four paragraphs for each of the above descriptive sections.
- 150 to 250 words in length.

The abstract should:

- ***not*** include subheadings such as "Purpose" or "Results".
- ***not*** use first person, ex. "I" Use the third person past tense.
  Say: "The height was measured using…..".
  Do not say: "I measured the height using……..". **(See the abstract example below.)**
- ***not*** include information or conclusions that are not stated in the paper.
- ***not*** emphasize minor details.
- ***not*** contain bibliographic references, figures, or tables.
- *not* use jargon or abbreviations (unless they are commonly used and do not require explanation, ex. DNA or UV light).

I have listed below some guidelines about how to write an abstract. I have also given you examples of each of the four sections. After the notes on each section, I have given you 3 different abstracts from 3 different projects. You can view hundreds of abstracts by going to edline and clicking on the link to PVPSEF abstracts. You will then be able to find an abstract for a project in the same area as yours. Now go to the next page.

Writing the Abstract
(250 word limit)

Your abstract will be read, ***prior to the Science Fair***, by persons assigned to judge your project. The abstract represents the first exposure the judges will have to your project research. Therefore, first impressions are very important!

The following items must be included in your abstract:

Objective or Goal:
State the objective, goal, or hypothesis upon which your project is based.
(See examples below.)

Materials and Methods:
Indicate the materials, methods, and experimental design used in your project. Briefly describe your experiment or engineering methods.
(See examples below.)

Results:
Summarize the results of your experiment and indicate how these results pertain to your objective.
(See examples below.)

Conclusion/Discussion:
Indicate if your results supported your hypothesis or enabled you to attain your objective. Discuss briefly how information from this project expands our knowledge about the category subject.
(See examples below.)

Examples of Objective or Goal:

1. This project was designed to discover the seed preferences of California scrub jays (*Aphelocoma californica*) visiting my backyard bird feeder.

2. My objective was to write a computer program for PC computers that would help a student memorize Spanish vocabulary words.

Examples of Materials and Methods Section:

1. Fifty-gram soil samples were collected from the A horizons of five 1 m square lawns, initially fertilized with WonderGrow Super Fertilizer. Similar samples were collected from five 1 m square lawns, initially fertilized with coffee grounds. The samples were analyzed for nitrogen, phosphorus, and potassium content. This comparison was repeated once a month for four months, between November and February. Changes in soil composition over time were compared.

2. I constructed a maglev track, using 40 neodymium magnets, spaced .5 cm apart and glued to a plywood board. The track was mounted at an angle of 10 degrees, forming a ramp. I then designed a balsa wood vehicle with 5 neodymium magnets below the wooden base. To test its weight-bearing capacity, the vehicle was loaded with different weights and tested at each weight ten times. The weights compared were: no load, 2g, 4g, 6g, and 8g. I used a ruler to measure how far down the track the vehicle was able to go, after being released at the top of the track.

3. A survey form was distributed during science classes, asking a total of 50 sixth, 50 seventh, and 50 eighth graders to estimate how long each of three musical pieces were played. Participants were asked to leave their names off of the surveys, to keep data anonymous. Results were then compared to see whether ability to estimate playing time improves with participant age.

Examples of Results Section:

1. Aluminum and wooden baseball bats were compared to see how far a regulation baseball would travel when struck. In all but one of the 25 trials, the baseball went further after being hit with an aluminum bat. On average, the ball traveled 4.5 cm further with the aluminum bat. In the one trial where the wooden bat made the ball go farther, the wind may have been blowing against the ball during part of the aluminum bat portion of the test.

2. The height of cookies made in 3 ways was compared after baking. Cookies made without baking powder were an average of 3 mm in height at their highest point. Cookies made with baking powder were an average of 10 mm at their highest point. Cookies made with my homemade rising formula rose an average of 4.5 mm. In this series of tests, baking powder was a much better leavening agent than my homemade formula. However, my homemade formula was slightly better than using no leavening at all.

3. Combining the results of the first 3 trials, after 15 minutes, there were 75 mealworm beetles (*Tenebrio molitor*) in the darkened area and 5 in the lighted area. Combining results of the second 3 trials, there were 89 mealworm beetles in the darkened area and 11 in the lighted area.

Examples of Conclusions/Discussion Section:

1. My hypothesis that the beetles would be more likely to move to the darkened area was strongly supported by the results. It would be interesting to repeat this experiment with mini darkling beetles (*Tenebrio obscurus)* to see if they act in a similar way.

2. Before doing the experiment, I thought iron would be a better conductor of electricity than silver. My results indicate the opposite. The results do not support my hypothesis. Next time, I would like to see if copper is also a better conductor than iron.

3. After reviewing my results, I could find no consistent pattern in my data. There was no clear advantage or disadvantage to doing homework while listening to Justin Bieber songs. My hypothesis that it would be helpful was not supported by the results. It might be useful to try again, substituting another kind of music, such as rap or jazz.

EXAMPLES OF FULL ABSTRACTS

Example 1: In the Category of Behavioral and Social Sciences

THE STROOP EFFECT

The objective of this project was to analyze the Stroop Effect on 13-15 year old females and 13-15 year old males. The main purpose of this experimentation was to determine if the females could perform the Stroop Effect dominantly than the males or vice versa. This test is used to measure an individual's selective attention, cognitive flexibility, and processing speed. The participants would be able to learn that the Stroop Effect could be used to improve the abilities of individuals and increase the changes of good judgment and decisions in actual life situations.

In order to test the Stroop Effect on genders, 10 females and 10 males from Palos Verdes Peninsula High School were needed. The individuals were given the test and were timed. Precautions were taken into account and made sure that no participant was color blind. The results were anonymous and recorded in seconds. After, the average of the time was taken for each gender to read the Stroop Effect and compared.

The data collected showed that the males had an average of 12.39 seconds to read the Stroop Effect and the females had an average of 13.67. Therefore, the 13-15 year old males performed the Stroop Effect faster than the 13-15 year old females with only a 1.28 second difference.

The results show that 13-15 year old males have sharper selective attention and speed than their female counterparts. These teenagers of both genders can still be analyzed together and can generally conclude that teenager's minds can deal with interference if an effort is made.

Example 2: In the category of Chemistry

Increasing the Efficiency of DMFCs Using Different Supply Conditions, Temperatures, and Catalysts

This project was designed to improve the efficiency of Direct Methanol Fuel Cells by testing different factors including oxygen flow rate, methanol solution concentration, temperature, and catalyst used.

I constructed two different fuel cells by pressing two pieces of Teflon-coated carbon paper around a Nafion film. In both cells, the cathode was painted with a platinum black catalyst and the anode was painted with a carbon-supported platinum and ruthenium black catalyst. A commercial anode catalyst was purchased and compared to one synthesized in the lab with a novel 90% carbon, 10% tantalum carbide support. This membrane-electrode assembly (MEA) was then placed within a fuel cell housing, and the entire fuel cell, using tubing, was fed with a methanol solution at the anode and oxygen at the cathode. After conditioning the cells, data collection began by evaluating current and voltage output at various oxygen flow rates, temperatures, and methanol solution concentrations. All of the data was collected on the computer using a fuel cell test system.

The maximum power density attained was about 55 mW/cm^2. The cell did perform better at higher temperatures, as expected. The cell with the lab-synthesized catalyst was able to produce higher power density at lower currents. The stronger methanol solution also enabled the fuel cells to perform better. Overall, the second fuel cell with the synthesized catalyst performed better.

Ultimately, my hypothesis was supported and the synthesized catalyst allowed the cell to perform better than the commercial catalyst; more research could lead to its use in commercial cells.

Example 3: In the category of ENGINEERING

A MAXIMUM POWER POINT TRACKING HARDWARE WITH AN IMPROVED HILL CLIMBING ALGORITHM

The objective of this project was to develop maximum power point tracking (MPPT) hardware to optimize the efficiency of the solar photovoltaic (PV) panel. The PV panel converts solar energy into electricity and the MPPT hardware enables the PV panel to operate at its maximum power point. Popular MPPT algorithms such as the perturb-and-observe (P&O) and hill climbing (HC) algorithms suffer from various deficiencies which were addressed in this project.

An improved HC algorithm was developed and implemented in the MPPT hardware. For each perturbation cycle, the algorithm sampled the PV panel output power for multiple duty cycles of the switched DC-DC converter then dwelled at the duty cycle which resulted in the highest power. This duty cycle was also used as the midpoint of the next set of perturbations. Hardware including a PV panel, a boost DC-DC converter, an LED load circuit, and a TMS320F28335 microcontroller was assembled to validate the algorithm.

Step-up voltage conversion of the DC-DC converter was demonstrated, and the sensitivity of output power over the perturbation of switch duty cycle was characterized. Efficient and robust maximum power point tracking was achieved at all irradiance conditions. At constant irradiation levels, the output power achieved by the MPPT algorithm was >98% of that achieved by manually setting the PWM duty cycle to the optimal values.

The improved algorithm of this project was significant because it addressed the deficiencies of popular algorithms with simple modifications. The sample-select-dwell process minimized oscillations, improved tracking speed, and reduced sensitivity to voltage noises.

Example 4: In the category of ZOOLOGY

Effects of Different Light Wavelengths on Food Consumption in *Hippolytidae*

This project was designed in order to determine the effects of exposing Hippolytidae (broke back shrimp) under red and blue lights on the food consumption of brine shrimp. The project stemmed from an earlier experimental idea to see the varying pigmentation patterns on spot prawns under differing lights. However, maturation of the larval prawns had setbacks, and a more viable test organism was found in the broke back shrimps. Taking the basis idea of lightings effect on organisms, this modified project seeks to extend the lighting environment to stimulate differing depths in the ocean. Therefore, experimentation provided a broader understanding to these species environmental surroundings.

In order to obtain quantifiable data from experimentation food density was calculated prior to and after each twenty-minute feeding period. Brine shrimp proved to be readily counted, by sampling portions of the food mixture and counting brine shrimp per portion under a TEC microscope. From this known concentration of food mixture a counting after feeding was used to see the change in food density, which would thus indicate how much food was consumed in each tank under specific lighting conditions. Brine shrimp are known to be phototactic, moving to the area of light, so light was placed equally distributive over the tanks.

The initial experimental data of shrimp was taken from gravid females, however they soon became gravid and further experimentation continued with solely non-gravid shrimp. However, comparison between gravid and non-gravid shrimps was noted. For the gravid shrimp the greatest food consumed was seen in the tank exposed to blue light, the difference in food density was 13.00 brine/ 10mL as opposed to the shrimp in red light whose food density only equated to 5.50 brine/10mL. Data indicates gravid females prefer deeper ocean depth, an environment chosen for larval dispatching. As expected, the non-gravid shrimp had a greater difference in food density when under the red light. The difference between all trials of non-gravid shrimp averaging to 12.00 brine/10mL in red light tanks compared to 6.60 brine/10mL in blue light tanks. This data supports the hypothesis that shrimps use phototaxic cues during feeding, and thus being at a shallower ocean depth is ideal.

The knowledge gained from this project not only helps distinguish effects between gravid and non-gravid shrimp, but also better related oceanic feeding. The gravid shrimp, preferring deeper depth to hatch larvae were consumed more under blue light simulating the deeper depth. Non-gravid shrimp not inclined to deeper oceanic depth consumed most in their preferred shallow habitat. Analysis of experimental data was used to further accommodate these species in aquarium environments, assimilating the shrimps to man-made conditions.

INTRODUCTION

Definition The **Introduction** sets the scene for your report. Is a literature and concept review and discusses the results and conclusions of previously published studies to help explain why the current study is of scientific interest. The introduction is organized to move from general information to specific information. The background must be summarized but should not be itemized. Take care not to go too far in providing too much background information. Limit the introduction to studies that relate directly to the present study. Emphasize your specific contribution to the topic.

Contents The **Introduction** should contain:

- Sufficient background information to allow the reader to understand and evaluate the results of your study.
- A brief literature review. Cite and discuss previous research from relevant literature, and state how your research relates to or differs from others' work;
- The rationale for your study. Why did you choose that subject and why is it important? (What prompted your research?)
- A simple statement of the most important point(s) that you will address in your paper.

Rules The **Introduction** should:

- Proceed from the general to the specific. It should introduce the problem, present necessary background information, show the continuity between previous work and the work you did, and indicate what you hope to achieve (lead into why the present study was done).
- Include only background information and studies that are relevant to the present study. ***Do not*** try to include everything that you know about the topic.
- Cite the relevant literature sources in the text.
- Assume that the reader is scientifically literate but not familiar with the specifics of the study.

Checklist When finished, check the following:

- Is there a critical mass of published articles?
- Is the literature correctly cited?
- Is the previously cited literature developed into a paragraph(s) organized in a logical progression (i.e. general to specific) leading to the present research effort?

HOW TO CITE SOURCES IN THE INTRODUCTION SECTION (Refer to and use the MLA format.)

Introduction The Introduction sets the scene for your report. It is background information that shows that you investigated your topic. It explains something about your topic subject and what has been done in the past.
It is important to cite sources in the introduction section of your paper as evidence of the claims you are making. There are ways of citing sources in the text so that the reader can find the full reference in the literature cited section at the end of the paper, yet the flow of the reading is not badly interrupted. All scientific papers rely to some degree on previously published work. When a fact or an idea is borrowed (whether directly or paraphrased) from another source, it must be acknowledged, or cited, in the text and the origin of the information must be revealed.

Definition A **citation** is the formal acknowledgement within the text. The citation serves as a link between the text in which it appears and the formal, alphabetical list at the end of the paper called ***REFERENCES*** (Ebel, 1987).
All citations in the text must appear in the ***REFERENCES***; and all references in the list must be cited in the text. A references list differs from a Bibliography, in which you list everything you have read, whether it is cited or not.

Citing in Text There are several systems for formatting citation in text and References, including the American Psychological Association (APA) and **Modern Language Association (MLA)**. The **MLA** format is the one you most commonly use in your English and Language classes. You should know how to cite references in text and how to list references.
Shown below is an example of citations in a written project report and also the **References** page (using the MLA format).

Consistency Use the **MLA** style and make sure you remain consistent with the selected style guide.

SHOWN BELOW IS *A PORTION* OF AN INTRODUCTION FROM A STUDENT RESEARCH PAPER. BELOW THAT IS THE REFERENCE OR CITATION PAGE AT THE END OF THE PAPER. NOTE HOW THE REFERENCES ARE CITED IN THE TEXT BY THE USE OF PARENTHESIS AND HOW THE PAGE NUMBER IS NOTED.

Example – Part of an Introduction with citations:

Currently, there is great concern about flooding the wild gene pool with a more restricted selection from hatchery stock. However, for this to occur, cultured individuals must escape, survive in an unfamiliar environment, and breed successfully with indigenous species (Skaala 77). The impact of cultured fish escapees is dependent on several factors, especially at what life stage they escape. Individuals released at an earlier point in life have a better chance at survival, as they have more time to adapt before reproducing (Skaala 83). If inputs of cultured fish are frequent, as is often the case in the real world, the gene pool of native species will be reduced, even with the lowered reproductive success of farmed fish. (Gumpie's Guide to Fish 34)……**etc,, etc., etc.**

NOTE: THIS IS JUST A PORTION OF THE INTRODUCTION.

EXAMPLE OF REFERENCES **The references go at the end of the research paper.**

References

Bugg, R. L, C. S. Brown, and J. H. Anderson. "Restoring Native Perennial Grasses to Rural Roadsides in the Sacramento Valley of California: Establishment and Evaluation." *Restoration Ecology* 5. 1997: 214-228.

"Cover Crop Fundamentals." Ohio State University Department of Horticulture and Crop Science. http://ohioline.osu.edu/afg-fact/0142.html

"Gumpie's Guide to Fish." The Fava Project. http://members.efn.org/~rossr/cont/html

Ghoshal, Kalpana., Samson T. Jacob. "Ara-ATP Impairs 3'-end Processing of Pre-mRNAs by Inhibiting both Cleavage and Polyadenylation." Oxford University Press 19: 21 (1991) 5971-5875.

"Legume Seed Inoculants." Colorado State University. http://ext.colostate.edu/pubs/crops/00305.html

Martin, Georges., Andreas Moglich, Walter Keller, Sylvie Doublie. "Biochemical and Structural Insights into Substrate Binding and Catalytic Mechanism of Mammalian Poly A) Polymerase." J. Mol. Biol. 341 (2004) 911-925.

Proudfoot, Nick., Justin O'Sullivan. "Polyadenylation: A Tail of Two Complexes." *Current Biology* 12 2002: 855-857.

Skaala, Oynstein. "Ecological Effects of Escaped Salmonids in Aquaculture." *OECD Documents: Environmental Impacts of Aquatic Biotechnology*. Paris: Organization for Economic Co-Operation and Development, 1995. 71-86.

HYPOTHESIS (OR PROBLEM STATEMENT)

Definition This section should include a statement of objectives and a statement of hypotheses. This will be a good transition to the next section which is **Methods and Materials**.

Example Here is an example:
"**My objective was to determine if the relationship between legumes and nitrogen-fixing bacteria is species specific. My hypothesis is that legumes would grow best when infected by the same *Rhizobium* species that occurs within the field."**

Checklist When finished, check the following:

- Is the hypothesis/problem statement constructed in clear unambiguous language?
- Does the hypothesis/problem statement reflect the introductory paragraph (i.e. same terminology, same vocabulary)?
- Does the hypothesis/problem statement reflect the most recently reported research – from the Introduction?
- Does the hypothesis/problem statement identify the new area of research (i.e. the next logical step) which begs clarification/study?

MATERIALS AND METHODS

Introduction The cornerstone of the scientific method is reproducibility (ability to be reproduced). This section should describe the experimental design with sufficient detail for a trained researcher to replicate your experiments and obtain similar results. This section should also enable the reader to evaluate the appropriateness of your methods and the reliability and validity of your results.

NOTE: THE METHODS MUST BE PRECISELY DETAILED. ANOTHER PERSON MUST BE ABLE TO RECREATE YOUR PROCEDURE WITHOUT YOU BEING THERE. EVERY DETAIL MUST BE INCLUDED.

Definition The **Materials and Methods** section describes:

- how you conducted your study.
- what materials and equipment you used, and
- what methods or procedures you followed.

It ***is not*** a numbered list of experimental steps or a cookbook recipe

Text The text should be written **in the third person, past tense. DO NOT** say: "I grew the plants in a box and I gave them plant food once a week." You **SHOULD SAY**: "The plants were grown in a box and plant food was given once a week."

Rules The **Materials and Methods** section should be written:

- in narrative, paragraph format.
- precisely – be specific. Don't leave the reader with unanswered questions.
- Describe in detail the methodology you used to collect data, make observations, design apparatus, etc. Your report should be detailed enough so that someone would be able to repeat the experiment from the information in your paper. Include detailed photographs or drawings of self-designed equipment.

The Materials and Methods section ***should not*** include any of the Results.

Materials Materials are not listed separately, but rather included in the description of Methods. Include exact technical specifications for:

- chemicals: Use generic or chemical names, not trade names unless the known difference is critical.
- apparatus: Describe your apparatus only if it is not standard ad was constructed for your study. Use figures, if appropriate, to help the reader picture the equipment.
- techniques: standardization methods, solvent concentrations, times, temperature.
- experimental animals, plants, and microorganisms: genus, species, special characteristics such as age and sex.

√ Use metric units for all quantities and temperatures.
√ Include method of preparation.
√ Include criteria for selection and an "informed consent" statement when human subjects are used.

Methods include precise description of the sample;
include methods of data collection;

Sequence It is a good practice to write the Materials and Methods section as you conduct your experiments so technical details are fresh in your mind.

RESULTS

Introduction The **Results** present the data, the most important part of the paper. The whole paper must stand or fall on the basis of the Results (Day, 1994). This section presents the results of the experiment but does not attempt to interpret their meaning. As with the Methods section, the trick to writing a good Results section is knowing what information to include or exclude. You will not present the raw data that you collected, but rather you will summarize the data with text, tables and /or figures. Use the text of the paper to state the results of your study then refer the reader to a table or figure where they can see the data for themselves.

Definition The **Results** section contains all the major experimental findings of the study and their statistical analyses, presented in a logical order with text and visuals that complement and supplement the other.

Contents The **Results** section contains:

- visuals (tables, figures, and/or illustrations)where necessary for clarity and conciseness,
- text that summarizes the data collected and points out highlights of visuals, and
- any appropriate statistical analyses of the data.

Visuals The visuals should:

- highlight an important point and be referred to somewhere in the text.
- be well designed so they are clearly understood without reference to the text.
- ***not be*** redundant. ***Do not include the same data in both a table and a figure (or graph).*** Figures or graphs are good because they show trends. Choose the best format for presentation. Are shapes and trends more important to the readers, or exact values?

Text The text should:

- **be written in the past tense**; for ex.: "Nitrogen fertilizer significantly increased soy bean total biomass regardless of the presence or absence of *Rhizobium* (Table1)."
- summarize the data collected, point out the important features, and connect the results with one another.
- not interpret the results and discuss the conclusions of the results (a trend can be mentioned, but no interpretation or extended discussion occurs in this section).
- not include raw data. This data should be in a table or in an appendix.

Sequence Prepare your tables or figures before writing the text. The visual representations will help you clarify your own thinking and make it easier for you to write the Results. This will also help reveal whether there are gaps in the data and whether more experimental work should be done.

Tables Use tales to show large amounts of data (usually numbers) in a small space.

Rules Use the following guidelines for tables:

- Place columns to be compared next to each other, if possible.
- Label each column with a column heading. Make the headings clear but concise; Abbreviations may be used, but do not use periods. Capitalize first words in column headings.
- Label each column with a column heading. Make the headings clear but concise. Abbreviations may be used, but do not use periods. Capitalize first words in column headings.
- Include units of measure in the headings if appropriate, ex.: *Nitrates (mg/L).*
- Use horizontal lines if needed. Vertical lines are normally not used; columns are defined by spacing.
- Use single spacing for data and headings. In some instances, you may want to use wide space (extra line) to separate groups of data.
- Align numbers in each column on the right. However, if decimal points are used, the numbers should be aligned on the decimal point.
- Use an initial zero before the decimal (0.25).

- Use notes for more extensive explanation of data or headings. Notes are place below the table and referenced by superscript letters.
- Order the notes to a table in the following sequence:
  - General notes provide information relating to the table as a whole; place the letter reference at the end of the title
  - Column (row) notes refer to a particular column (row); place the letter reference at the end of column (row) heading
  - Probability level notes indicate the results of tests of significance
- Tables should be placed as near as possible to the discussion in the text.

Figures Figures include graphs, photographs, and diagrams. Figures are used to convey the overall pattern of the results at a quick glance.

Rules Guidelines for graphs, pictures, and diagrams

- Place the figure caption and legend below the figure. A caption is a brief but descriptive title. For example, *FIGURE 2. Average Nitrate Content of Wells*. A legend consists of one or more sentences that describe what is shown in the figure and point out important features. Sometimes a caption and legend are combined. For example, *FIGURE 2. Average Nitrate Content of Wells. The average of all seven readings of the nitrate level for each well is given. The dotted line represents the maximum contaminant level (MCL) which the EPA has established for public drinking water.*
- Figures should be placed as near as possible to the discussion in the text.
- *All pictures should be referenced. If you use a picture or diagram from a reference source, you must cite the reference below the picture just like you did in the introduction.*
- *Pictures taken by the author of the paper should contain the caption: "Picture taken by author."*
- *Do not have picture of any persons faces.*

GRAPHS Label both axes on graphs with the variable being measured, the units of measurement, and the scale.

Line Graphs Line graphs are the best because they show a trend or pattern. They allow plotting values of a quantity as a function of another variable.

Bar Graphs Bar graphs are appropriate for showing discrete values and comparisons. They emphasize individual amounts rather than trends or direction. They have the most impact when used to display relatively few values of one or more series.

Pie Graphs Pie graphs are 100-percent graphs and are used to show percentage distribution of parts of the whole. They are intended to provide an overview rather than exact values.

DISCUSSION AND CONCLUSIONS

Introduction The Discussion and conclusions can be the hardest section to write because you interpret your results in this section and draw conclusions.

Definition A **Discussion and Conclusions** section is an analysis of your results. It is a concise discussion of your most important results in the context of other peoples' work (as reported in the Introduction) and the conclusions drawn based upon your research findings (as reported in the Results).

Contents It should:

- briefly restate your hypotheses; explain how your data either supported or rejected your initial research question(s);
- show how your results agree (or contrast) with previously published work (include appropriate literature citations):
- state your conclusions as clearly as possible; (remember: not all papers have earth-shattering conclusions.)
- summarize your evidence for each conclusion;
- acknowledge any limitations which affect the results; discuss any other factors over which you had no control; explain their possible effect on study outcomes;

Rules The Discussions and Conclusions should:

- proceed from most specific (your results), through the more general (others' results), to the most general (implications drawn from your study). You are free to explain what the results mean or why they differ from what other workers have found.
- ***not*** simply *restate* the results. This section should *analyze the results*.
- discuss any theoretical implications or practical applications of your work

FUTURE RESEARCH

Contents Include suggestions for procedural improvements, if applicable.
Make recommendations for future research.
Wh at will you do next?

ACKNOWLEDGEMENTS

Introduction As a matter of scholarly courtesy, you should acknowledge those who helped you technically, intellectually, and financially.

Definition the Acknowledgements is a short paragraph where the researcher acknowledges the contributions of others to the research study.

Contents Mention everyone who helped you. Foremost and firstly you probably should thank your parents.

REFERENCES

Introduction Virtually all scientific papers rely to some degree on previously published work. When a fact or an idea is borrowed (whether directly or paraphrased) from another source, it must be acknowledged, or cited, in the text and the origin of the information must be revealed.

Definition A citation is the formal acknowledgement within the text. The citation serves as a link between the text in which it appears and the formal, alphabetical list at the end of the paper called *References*. All citations in text must appear in the *References*; and all references in the list must be cited in the text. A *References* list differs from a Bibliography, in which you list everything you have read, whether it is cited or not.

Citing in Text You will use the Modern Language Association (MLA) system for formatting citations. An example of a Reference page at the end of a Research paper is shown below.

References

Bugg, R. L, C. S. Brown, and J. H. Anderson. "Restoring Native Perennial Grasses to Rural Roadsides in the Sacramento Valley of California: Establishment and Evaluation." *Restoration Ecology* 5. 1997: 214-228.

"Cover Crop Fundamentals." Ohio State University Department of Horticulture and Crop Science. http://ohioline.osu.edu/afg-fact/0142.html

"Gumpie's Guide to Fish." The Fava Project. http://members.efn.org/~rossr/cont/html

Ghoshal, Kalpana., Samson T. Jacob. "Ara-ATP Impairs 3'-end Processing of Pre-mRNAs by Inhibiting both Cleavage and Polyadenylation." Oxford University Press 19: 21 (1991) 5971-5875.

"Legume Seed Inoculants." Colorado State University. http://ext.colostate.edu/pubs/crops/00305.html

Martin, Georges., Andreas Moglich, Walter Keller, Sylvie Doublie. "Biochemical and Structural Insights into Substrate Binding and Catalytic Mechanism of Mammalian Poly A) Polymerase." J. Mol. Biol. 341 (2004) 911-925.

Proudfoot, Nick., Justin O'Sullivan. "Polyadenylation: A Tail of Two Complexes." *Current Biology* 12 2002: 855-857.

Skaala, Oynstein. "Ecological Effects of Escaped Salmonids in Aquaculture." *OECD Documents: Environmental Impacts of Aquatic Biotechnology*. Paris: Organization for Economic Co-Operation and Development, 1995. 71-86.

APPENDICES

Definition Appendices contain supplemental information such as lists of terms, definitions, and questionnaires that are useful but not essential to the body of the research paper. Most readers will not bother to check appendices.

Rules Appendices should be included only if they help readers to understand, evaluate, or replicate the study. For example, you have a large table of raw data, but most of it is not essential to the discussion in the paper. You could include the complete table as an appendix and a smaller table with a subset of data in the text.