GUIDE TO WRITING A RESEARCH REPORT

The Scientific Manuscript

This is a basic overview of a scientific manuscript. In the sections to follow, I will break down each section in detail.

Abstract

Just about every journal out there requires an abstract. An abstract is a **single** paragraph of about 250 words or less. In the abstract, the author must summarize *why* the research was conducted, *how* it was conducted, and what the major results and conclusions were. References are typically not cited in the Abstract, since the reader expects a more full discussion in the body of the article.

Introduction

Every scientific report needs an introduction, though it is sometimes broken down into different components. The length of an introduction depends on the journal and the paper; however, the structure and content should be similar. In the introduction, the author must present the problem his or her research will address, why this problem is significant, and how it applies to the larger field of research. The author must clearly state his or her hypothesis, and quickly summarize the methods used to investigate that hypothesis. The author should address relevant studies by other researchers; however, a full history of the topic is not needed. The introduction should contain all the background information a reader needs to understand the rest of the author's paper. This means that all important concepts should be explained and all important terms defined. The author needs to know who will be reading this paper, and make sure that all the concepts in the paper are accessible to them.

Methods

In this section, several key points do need to be addressed. You should thoroughly describe the methods you used to investigate the problem, and should briefly describe why these methods were used. Any materials used should be documented, and any computer programs used should be discussed. This section should address the experiments, models, or theories devised. It should contain little to no background information, since this information should be placed in the introduction. Also, the *Methods* section should contain no results, conclusions, or interpretations.

Results

In this section, the author should thoroughly detail the results of the experiments, models, or theories developed in the body of the article. The results should be supplemented by figures and tables, and the figures and tables should be briefly explained. *No interpretations or conclusions should be drawn*. All interpretation and discussion of the results should be saved for the Discussion and Conclusions section.

Discussion and Conclusions

Most journals require a discussion and/or conclusions section. In some cases, when the author has many points to discuss, he or she may split this into two sections; however, one section is usually sufficient. In this section, the author should restate the problem he or she was attempting to address, and summarize how the results have addressed it. The author should discuss the significance of all the results, and interpret their meaning. Potential sources of error should be discussed, and anomalies analyzed. Finally, the author should tie his or her conclusions into the "big picture" by suggesting the impact and applications this research might have. This can be accomplished by discussing how the results of this paper

will affect the author's field, what future experiments could be carried out based on this research, or what affect the conclusions could have on industry.

Acknowledgments
An acknowledgements section is not usually required; however, most papers include a paragraph of acknowledgements and thanks for help received on the research or the paper. In journals where the reviewer's names are revealed, it is considered polite for the author to acknowledge the help of the reviewers.

The Abstract

What is an Abstract?

An Abstract summarizes the major aspects of a paper. It is usually one paragraph long, and should succinctly summarize the purpose of the paper, the methods used, the major results, and the author's interpretations and conclusions.

Readers use the Abstract to decide whether they want to read the rest of a paper. It must contain enough information for them to understand the work and for them to decide whether it applies to their project or not. Usually, an Abstract is 200 - 300 words, and should follow this format:

Idea 1: The problem to be investigated. This should be 1-2 sentences that sum up why this study was conducted. For example: "Several studies have suggested that rampart craters on Mars form in regions with high soil volatile contents - namely, water ice."

Idea 2: The purpose of the study. This should be 1 - 2 sentences that explicitly state what this study investigated and how it differs from similar studies. For example: "This study is the first to use data from Mars Odyssey's Gamma Ray Spectrometer to correlate the distributions of water ice and rampart impact craters on Mars. We hypothesized that if rampart craters form due to high volatile content in the soil, then regions with more sub-surface water should show a higher percentage of rampart impact craters."

Idea 3: The methods. This should be 1 - 2 sentences that summarize the important methods used to investigate the problem. For example: "We plotted the distribution of rampart impact craters on Mars and the water ice concentrations obtained by the Mars Odyssey's Gamma Ray Spectrometer, then used statistical tests to determine if there was a correlation."

Idea 4: The major results. This should be 1 - 2 sentences that summarize the major results - not *all* of the results - just the important ones. For example: "We found that regions with high sub-surface water ice concentrations had a higher percentage of rampart impact craters than regions with low sub-surface water ice concentrations. For example, 87% of impact craters in Acidalia Planitia, a very water rich area, were designated rampart craters; however, only 23% of craters in water-poor Syrtis Major were designated rampart."

Idea 5: The interpretations. This should be 1 - 2 sentences that summarize the author's interpretations of the results.

For example: "These results lend support to the idea that the fluidized ejecta morphology that characterizes rampart craters is caused by a high water ice concentration in the sub-surface."

Idea 6: The implications. This should be 1 sentence that summarizes the meaning of these interpretations, i.e., why do we care about this.

For example: "Understanding the factors that influence crater formation and morphology will allow us to better age-date the Martian surface, and mapping the distribution of ancient rampart craters may help us estimate sub-surface volatile concentrations from the Martian past."

In this example, the resulting Abstract is about 230 words:

"Several studies have suggested that rampart craters on Mars form in regions with high soil volatile contents - namely, water ice. This study is the first to use data from Mars Odyssey's Gamma Ray Spectrometer to correlate the distributions of water ice and rampart impact craters on Mars. We hypothesized that if rampart craters form due to high volatile content in the soil, then regions with more subsurface water should show a higher percentage of rampart impact craters. We plotted the distribution of rampart impact craters on Mars and the water ice concentrations obtained by the Mars Odyssey's Gamma Ray Spectrometer, then used statistical tests to determine if there was a correlation. We found that regions with high sub-surface water ice concentrations had a higher percentage of rampart impact craters than regions with low sub-surface water ice concentrations. For example, 87% of impact craters in Acidalia Planitia, a very water rich area, were designated rampart craters; however, only 23% of craters in water-poor Syrtis Major were designated rampart. These results lend support to the idea that the fluidized ejecta morphology that characterizes rampart craters is caused by a high water ice concentration in the sub-surface. Understanding the factors that influence crater formation and morphology will allow us to better age-date the Martian surface, and mapping the distribution of ancient rampart craters may help us estimate subsurface volatile concentrations from the Martian past."

In Abstracts, bluntness is best. Phrases like "In this study, we examined...", "We hypothesized...", or "We found..." are not poetic, but they are clear and succinct. The reader should be left with no doubt about what the purpose of the study was, what methods were used, what the major results were, and why those results are important. The rest of the paper will fill in the details. The Abstract should NOT contain:

- Lengthy background information - that belongs in the Introduction
- Lengthy methods discussion - that belongs in the Methods section
- References to other literature
- Abbreviations or acronyms
- Figures, images, or references to them

Common Mistakes in an Abstract

For such a short section, the Abstract is easy to get wrong. Here are some of the major ones to watch out for in your own writing:

1. **No Abstract.** Every paper needs an abstract. Yours is no exception!
2. **Abstract Really an Introduction.** An Abstract is not an Introduction - it is a summary of the *whole* paper. Often, authors will write an Abstract that is ten sentences of background information, with no reference to the results or conclusions

of the study. Don't panic about including enough background – if a reader wants details, she goes to your introduction.

3. **Missing Information.** Authors frequently forget to include information like: What was the purpose of this study? What were the methods used? What were the major results? What do these results mean? Be sure than your Abstract answers all those questions.
4. **Too Much Information.** Some authors include way too much information on the background, the problem, the methods, or the implications of a study. Usually, 1-2 sentences for each of the major sections (Introduction - Methods - Results - Conclusions) are enough. The Abstract should be short, snappy, and succinct. When readers want details, they'll read the actual paper.

The Introduction

What is an Introduction?

An Introduction must provide the reader with all the information he/she will need to understand the rest of the paper. The author must summarize the problem to be addressed, give background on the subject, discuss previous research done on the topic, and explain in no uncertain terms exactly what this paper will address, why, and how.

An Introduction is usually 300 to 500 words, but may be more, depending on the topic. Some Introductions (especially for psychology papers) are several pages long. They usually follow this general format:

Idea 1: The broad topic: problem and background. The author should take an entire paragraph to state the problem to be investigated, and to give background on that problem. At then end of the first paragraph, the reader should know the broad topic that this paper will address. Later paragraphs will fill in the specifics. For example: "Over the past decade, there has been heightened interest in the availability of mineral resources and in how quickly the world's expanding population is depleting these reserves. As worldwide consumption and usage of materials increases (Wagner LA 2002), the question arises as to whether adequate supplies of metals such as copper, silver, and zinc exist to satisfy the rising demand. The Stocks and Flows Project (STAF) at Yale University's Center for Industrial Ecology seeks to track the current and historical reservoirs of technologically significant materials, together with the flows into and out of these reservoirs, through substance flow analysis (SFA) and life cycle assessment (LCA) as defined in Table 1. With these tools of industrial ecology, the environmental impacts and policy implications of world metal production and usage can be examined on national, regional, and global scales."

This paragraph gives the reader:

1. The broad topic: World-wide depletion of mineral resources
2. The problem: Do we have enough copper, silver, and zinc?
3. The background: STAF is tracking this problem using SFA and LCA

Idea 2: Narrower topic: background and problem. Next, the author shouldzero in on the specific problem his/her paper will address. This should be done as bluntly as possible, i.e.: "This study examines . . ." or "This paper focuses on . . ." For example: "This paper characterizes the anthropogenic life cycle of silver for 1998 in the Commonwealth of Independent States (CIS) of Central Asia, one of nine world regions designated by the STAF group." In the next several paragraphs, the author should discuss this narrowed topic and must include the following:

- **Clear Statement of Hypothesis**. This is the "If-Then" statement that underlies the author's whole study. **If** rampart craters on Mars form because of groundwater **then** we should see a correlation between groundwater and rampart crater distributions. Most authors forget this. The author need not write "We hypothesized that…" The hypothesis can be something as simple as an If-Then statement of what they were looking for. For example: "Previous studies have suggested that the lobate ejecta blankets that characterize rampart craters form because of groundwater or ice in the subsurface. If this is true, then areas with more groundwater or ice should have more rampart impact craters and areas with no groundwater or ice should have no ramparts."
- **Previous Research**. The author should summarize the results and findings of other studies in this area. What research has been done on this topic? How will this study differ? What other studies on similar topics might influence this study? The author should provide enough discussion on previous research for the reader to understand the bigger picture, but not too much. This is not a review paper - the author should only discuss those papers that truly are relevant to his/her study. Depending on the topic, the discussion of previous research might run for two paragraphs or two pages.
- **Explanation of Concepts**. In different journals, this means different things. For example, in a journal that specializes in gene therapy research, an author need not explain basic theories. Authors are expected to explain all concepts that an average undergraduate science major would not be familiar with. For example, the author need not explain how impact craters form, but should explain how multi-ringed impact basins form.

Idea 3: Motivation for Research. The final paragraph of the Introduction should be a summary of "Why should we care?" Why is the research important? Why is this problem important? How will answering this problem advance research in this area, in industry, in policy, or in people's lives?

Common Mistakes in an Introduction

1. **Too Much Information.** Authors sometimes include far too much information in their Introductions. Only information related to the subject should be included. For example, this is far too much information: "Benjamin P. Danielson (1954) first described the morphology of multi-ring impact basins on the Moon. He characterized them as large impact basins with multiple terraced levels, central rings, central peaks, and abundant secondary craters. Since then, multi-ring impact basins have been identified on Earth, Mercury, Venus, Mars, and many of the outer satellites." This whole section could be reduced to: "Danielson (1954) defined multi-ring impact basins as having multiple terraced levels, central rings, central peaks, and abundant secondary craters."
2. **Not Enough Information.** Another common mistake authors make is to assume that their audience knows more than they do. Authors often do not explain concepts, do not provide enough background information, or do not discuss enough previous studies. Reading a paper where the author assumes you know thing you don't is incredibly frustrating and pointless. Don't make your readers struggle to understand your paper – make yourself clear. *This is a difficult balance to strike, between superfluous explanations and not enough information.* Think carefully about your audience and discuss with your advisor what should be included and what left out. The reviewers will help with this too, providing an outsider perspective.

3. **Unclear What Study Is.** Often, authors will build a thorough Introduction, but it is unclear what the rest of their paper will cover. The author needs to **bluntly** state what this paper will cover, how, and why. Phrases like "This study examines…" or "In this study…" are valuable.
4. **Lists.** A common temptation in Introductions is to list material, either in paragraph or bullet format. Sometimes this is unavoidable. Usually it is not. Try to avoid lists and describe your study in prose instead.
5. **Confusing Structure.** Authors often throw all sorts of information into an Introduction without thinking thru the organization. The result is a confusing read. Remember to follow the structure outlined above: Big problem – my portion of that big problem – hypothesis (logic underlying my study) – description of my study – why the reader should care about this study.
6. **First-Person Anecdotes.** Undergraduates sometimes confuse a scientific manuscript with *My Wild Adventures in the Lab*. They might try to open an Introduction with an amusing story to "draw the reader in", thinking that this is an essay for an English class. First-person reporting does not belong in a research manuscript. The author shouldn't even say "I found…" but "It was found…" It's a passive voice, but a standard one for reporting research.

The Methods & Materials Section

What is a Methods & Materials Section?

Though papers may vary in the structure in the middle, the standard body of a research manuscript is a Methods & Materials section.

The purpose of the section is to make it possible for interested readers to **repeat** the author's experiment and reproduce his/her results. The author must describe, in painful detail, exactly what he/she did: what experiments were run and how they were run, what equipment and materials were used and how they were used, how much, how often, what, where, when, and why. Some of the information the section must include is:

- Subjects used (animals, plants, humans) and their pre-experiment handling and care (anything that might affect the results must be included)
- Sample preparation techniques
- Origins of samples and materials (e.g., "Twenty-one 18-year-old students from the Psychology 101 class at the University of San Diego in California")
- Description of the field site (if applicable) including physical and biological features, and exact location (include a map, if applicable)
- Protocol for collecting data - how were the procedures carried out?
- Statistical analysis techniques used. If used (for example, in ANOVA tests), the author must report the threshold used to determine statistical significance.
- Information on computer programs used or written (for some computer science or physics articles, the author should include the relevant codes in the appendix)
- Descriptions of equipment set-up and function. If parts of the experiment have been described elsewhere, then the author may reference it. For example: "Samples were prepared using the same process as described by Newton et al. (2000)." Otherwise, the author must describe each piece of the experiment. The author should use the third person, passive construction throughout, and always use the past tense. For example: "The sample was heated to 90 degrees C for 30 seconds." - NOT: "I heat the sample to 90 degrees C for 30 seconds."

A Note on Details

Hitting just the right level of detail is difficult in these sections. An author must provide enough detail for a reader to be able to reconstruct his/her study, but not so much that the relevant points get buried. When reading your M&M section, ask yourself at each place: "Would I need to know this to reproduce this experiment?" If the detail is not needed, remove it. For example, this is too much detail: "We poured the Pepsi into a graduated cylinder until the bottom of the meniscus was at the 45 ml line. We poured the Pepsi onto the top of the agar sample, and then repeated the procedure 55 times." You're not writing for middle schoolers – another scientist will know how to add 45 ml of Pepsi to a sample. So, you can reduce this to: "45 ml of the Pepsi was added to each of the 55 samples."

Common Mistakes in a Methods & Materials Section

1. **Not Enough Information.** Oddly, few people include *too much* information -nearly every author includes *too little*.

   For example, this is too little information to reproduce a study: "We created mosaic images from the THEMIS instrument."

   This should be expanded to: "Using USGS Integrated Software for Imagers and Spectrometers (ISIS), we mosaicked day-time thermal inertia images from the Thermal Emission Imaging Spectrometer (THEMIS) on board Mars Odyssey. The images covered the region 7°N to 34°N and 209°E to 236°E around the Olympus Mons volcano on Mars, and had a resolution of 100 meters-per-pixel. THEMIS images from October 2002 to July 2004 data releases were used. The max/min light/dark ratios were stretched manually to match individual images."

2. **Background / Introduction Material Included.** Sometimes an author will include background material or explanations of concepts in the Methods & Materials section. That material belongs in the Introduction. In this section, the author should make no references to outside work, unless referencing a method or material. For example, this is OK: "Samples were prepared using the method described by Newton et al. (2000)" - but this is not: "This theory was first proposed by Newton et al. (2000)."

3. **Verbose Descriptions.** In the case of experimental setups, a diagram is worth a thousand words. Some authors - especially in chemistry or physics papers - describe elaborate lab setups with run-on sentences like: "Main blue-cord A was then connected via 0.25-inch screws to the third quarter-inch mark of lead pipe B, which was taped to wooden crate C with 0.5-inch-wide gray duct tape and . . ." The mind goes blank. Spare your readers. Include a diagram.

4. **Results Reported.** Sometimes, authors get so carried away describing their experiments that they report results in this section. For example: "The samples were soaked in linseed oil for 4 hours, turning purple and developing a distinct smell of cabbage." The information about color and smell here should not be included in the Methods & Materials section, but in the Results section.

5. **Sources of Error Discussed.** Discussion materials do not belong in the Methods & Materials section. The author should not discuss sources of error or possible causes for results - in fact, the author should not discuss results at all.

For example, this kind of sentence does not belong in the Methods & Materials section: "During image stretching, some resolution was lost, possibly interfering with counts of craters less than 5 km in diameter." This should be rephrased to:

"During image stretching, some resolution was lost."

The interpretation of how this might affect results should be saved for the Discussion section.

The Results Section

What is a Results Section?

With very few exceptions, every journal requires a Results section. **It *cannot* be combined with the Discussion section.**

The purpose of a Results section is to present the *key* results of the experiment without interpreting their meaning. The trick is knowing what to include. The author should **not** include the raw data, but should **summarize** it with text and tables. The author should avoid writing out long lists of numbers - numbers and measurements should all be tabulated.

For example: "Regional age-dating with crater counts from ejecta blanket degradation approximated ages from regular crater counts (Table 1)." The ages for each region from both methods would then appear in Table 1. The author should state the results of statistical analyses in this section, but should not describe every detail of the analysis. We assume our readers know what a null hypothesis is, a rejection rule, chi-square test, etc.

Important negative results should be reported too - though not interpreted.

It is highly recommended that authors separate each significant result into a subsection (with bolded subheading summarizing the result). It is important to have one result flow after another to form a story.

Common Mistakes in a Results Section

1. **Raw Data.** Occasionally an author will for some reason include all his/her raw data. This is not just unnecessary - it's mind-numbing. The author should present only the key results, meaning those results that bear on the question or problem being addressed. Generally this means presenting means, percentages, standard deviations, etc. All graphs and quantitative data should be reported in μ (mean) ± σ (sd or SEM). For comparison studies, statistical significance MUST be included. NO exceptions.
2. **Redundancy.** Authors will often present their results in a table, then re-state everything in the text. This is redundant. Text should be used to clarify figures and tables - not rehash them.
3. **Discussion and Interpretation.** Author cannot include interpretation or discussion in the results section. This includes discussion of possible sources or causes of error.
4. **No Figures or Tables.** Every Results section should have at least one table. No matter what discipline the author is writing in, he/she should have data to present. A notable exception is some mathematics or computer science papers.
5. **Methods/Materials Reported.** Often, an author will write something like this is the Results section: "We found that sample A contained pyroxene, so we ground sample

B to a powder and ran the experiment again. With sample B, we found pyroxene again." The information "so we ground sample B to a powder and ran the experiment again" is M&M material and does not belong in the Results section. The author must report only results in the Results section – no new methods or materials at all.

The Discussion Section

What is a Discussion Section?
The purpose of a Discussion section is to interpret the results, relating them to previous studies that the author and other authors have done. The author should begin the Discussion section by re-stating the hypothesis he/she was testing. Then he/she may begin interpreting the results in light of this hypothesis. To interpret the results, the author should address the following questions:

1. Did the results provide answers to the (testable) hypotheses?

2. If so, what does this mean for the hypothesis?

3. If not, do the results suggest an alternative hypothesis? What is it? Why do the results suggest it? What further results might solidify this hypothesis?

4. Have others proposed it before?

5. Do these results agree with what others have shown? If so, do other authors suggest an alternative explanation to explain the results? If not, how does this experiment differ from others? Is there a design flaw in this experiment? In others?

6. How do these results fit in with results from other studies? Do results from related studies affect the way these results are being interpreted?

   In addition to simply interpreting the results, the author should discuss the following questions (though the order may vary):

   - What factors or sources of error might have influenced these results?
   - What anomalous data turned up and how can it be explained? Is it explained by the author's theory? Someone else's theory? Error?
   - Was this experiment the most effective way to test this hypothesis? (Obviously the author thought so at the beginning, but does he/she still think so?) How could the experiment be improved to gain further insight?
   - How have the results and conclusions of this study influenced our knowledge or understanding of the problem being examined?

7. What would be the next step in this study?

8. What experiments could be run (or data found) that would lend further support to the author's hypothesis? (Either the original hypothesis, or the new one designed to explain the results). What experiments could be run (or data found) that would disprove the author's hypothesis?

   This section should synthesize the whole paper. The author should re-address the major issues he/she discussed in the Introduction, and re-interpret them in light of the results.

A Note on Good Writing

Rules of good writing apply to every section in a scientific paper, but are particularly important for the Discussion section. This is the section where the author draws together the entire paper and dishes out the take-home message. This is the most important part of the paper.

The author should carefully construct it, using topic sentences and watching out for wordiness.

Common Mistakes in a Discussion Section

1. **Combined with Results.** It's amazing how often authors combine the Results and Discussion sections, even though we specifically tell them not to. The Results and Discussion sections cannot be combined. They have two very different purposes. The Results section is for fact. The Discussion section is for interpretation.
2. **New Results.** Sometimes an author will include a new result in the Discussion section – one he/she did not report in the Results section. **All** results **must** be reported in the Results section. They can be restated in the Discussion section, but they must appear in the Results.
3. **Broad Statements.** Sometimes an author will draw sweeping conclusions based on his/her one tiny study. These are only appropriate even for major, groundbreaking papers – the kinds of papers that undergraduates rarely write. For example, it's unlikely that a paper examining valley networks in one small region of Mars is going to shed light on the evolution of the Martian climate through time or the fate of the liquid water that once ran on its surface. The study might provide new clues, but no sweeping, broad statements can be made.
4. **The "Inconclusive" Cop-Out.** Months of research and pages of words, all leading up to a: "The results are inconclusive." What a waste! Don't waste your reader's time with a statement of "it's inconclusive". The author needs to draw what conclusions he/she can, then suggest how the experiment should be changed to properly test the hypothesis.
5. **Ambiguous Data Sources.** Often, an author will get so wound up in his/her Discussion, that it's hard to tell when he/she is talking about the results of *this* study and when he/she is talking about the results of *other* studies. Don't let authors get away with that kind of ambiguity – *whose* study is being discussed is vital information.
6. **Missing Information.** Authors often leave out critical information from the Discussion section. For example, they might forget to re-state their hypothesis and motivation, might not tie their work into the larger field of research, might not compare their work to other's, might not discuss sources of error . . . in short, they might not answer all the questions outlined in the "What is a Discussion Section" above. Be sure to discuss everything.

Figures, Tables, Equations, and References

Figures & Tables

Terminology
A table presents lists of numbers or text in columns, and should be used to illustrate differences, but not to represent relationships.

A figure is any visual presentation of results or illustration of concepts/methods, including: graphs, images, diagrams of set-ups, drawings, maps, etc.

Referencing Figures & Tables
You should reference figures and tables like this:

"The results clearly indicate a positive trend (Figure 1)."

Authors should avoid sentences that only direct the reader to a figure or table. For example: "Figure 1 illustrates the positive trend." All Figures and Tables are numbered sequentially: Figure 1, Figure 2, Figure 3, Table 1, Table 2, Table 3. The author should number them in the order they are called, so, for example, Figure 9 should never be referenced before Figure 1.

Good Figures and Tables
A Figure or Table should be able to stand alone, separate from the text of the article, and be understood. That means they **MUST**:

- **Be High Resolution.** Pixilated images, fuzzy graphs, and illegible tables are the bane of a good paper.
- **Have Neat, Legible Labels.** On graphs, each curve should be clearly and legibly labeled. On images, the relevant parts should be clearly and legibly labeled. On tables, the columns should be clearly and legibly labeled. There should be zero ambiguity about what the figure or table is illustrating.
- **Be Simple.** Figures and tables that cram too much information into a small space obscure their meanings and defeat their own purpose.
- **Be Clearly Formatted.** Tables should have lines clearly separating it from other pieces of the manuscript. Graphs should have appropriate axes, and images should have appropriate boxes.
- **Indicate Error.** All tables should have Standard Deviation information; all graphs should have error bars.
- **Have Detailed Captions.** This is the most important point, which brings us to our next section . . .

Captions

Captions are one of the most important elements of a good manuscript.
Often, a reader will flip through a paper, read the captions, and decide if it is worth the read.

A caption should be clear and succinct, yet detailed. It should convey all the information needed for a reader to understand the figure, without reading the whole manuscript. For example, a good caption of a graph would tell the reader what the graph illustrates, what samples were used, if any (not just "Sample B-12", but "Sample B-12, the potassium-rich feldspar"), and the relationship displayed.

This last one is very important – a caption should tell the reader the meaning of the figure or table. Does the table illustrate a trend that the reader should be noting? Does this figure illustrate the sample site, and, if so, what are the features of note at this site?

Captions have a lot of information to relay, so they **must** be longer than one or two sentences. They shouldn't be longer than about 10 sentences.

Equations

Equations are some of the most thoroughly abused elements of a scientific manuscript. Some authors for some reason derive everything – they rarely need to. Also, equations are often simply *typed* in to the manuscript, ensuring that the symbols and formatting will be utterly distorted upon publishing.

Equations must be written in Word's Equation Editor Function and saved as **".tif"** (using Adobe Photoshop) and imported into the document. They should be numbered sequentially, and referred to in the text as "Eq. 1", "Eq. 2", etc. Derivations should only be done if they are relevant to the work. Many mathematics papers do require lengthy derivations. If the derivation has been presented in some other work, it is usually best to just write: "As derived in Jones et al. (1999)."

References

Types of References
Scientific manuscripts may reference peer-reviewed journal articles, abstracts, books, and personal communications. They should not reference textbooks, and they should reference as few non-peer-reviewed works (e.g., abstracts and personal communications) as possible. The majority of a manuscript's references should be from peer-reviewed sources.

Also, authors should not reference themselves too often. For undergraduates, this means not referencing the advisor too often. A reference section that is 50% the authors does not carry much weight.

Formatting
Before submitting your manuscript to a journal, check what their referencing style is. It is thoroughly unprofessional to submit an unformatted article to a journal. Be professional. Do your homework.

Use the following in-text formatting style:

- "Recent evidence suggests that the most recent volcanism at Olympus Mons may have been 30 million years ago (Head 2003; Albertson et al., 2004; Albertson et al, 2005; Xu and Charleston 2005)."
- "Xu and Charleston (2005) found evidence of recent volcanism on Olympus Mons dating to around 30 million years ago."

The end-of-text referencing style is:

- "Jones, H.P. (2001) Behavior of fruit flies. Fruit Fly Journal 81: 982- 988."
- "Jones, H.P. and Smith, T.J. (2001) Behavior of fruit flies. Fruit Fly Journal 81: 982-988."
- "Jones et al. (2001) Behavior of fruit flies. Fruit Fly Journal 81: 982- 988."

Common Mistakes in Figures & Tables

1. **Inappropriate Format.** How does your journal want figures and tables submitted? Within the text? As separate files? Jpeg? Bitmap? Make sure you submit them that way.

2. **Redundant Information.** Authors will often include the same information in many places: the text, figures, and tables. If an author includes information in figures, he/she should not include the same information in tables – and vice versa. Also, if a table or figure gives specific results, the author should not re-list those results in the text of the paper.
3. **Ugly.** The most common problems with figures and tables is that they are blurry, unclear, unlabeled, pixilated, and, in a word: ugly. Figures and tables are some of the most important pieces of a paper. The author should invest time and effort into making clear, succinct, visually pleasing figures and tables. This doesn't mean they need to be *pretty* – just clear, concise, and professionally laid-out.

Common Mistakes in Captions

1. **No Caption.** No more need be said. Don't do it.
2. **One-Liner.** One sentence is never, ever, enough for a caption. Give the reader more information.
3. **Regurgitates Figure/Table.** A caption that re-states exactly what the table/figure says is no good – the caption must explain *what it means* and *why it is important.*

Common Mistakes in Equations

1. **Superfluous Derivations.** Most papers don't need derivations of every equations used. Use your best judgment and, with every equations, ask: "Does this really need to be here?"
2. **Format.** All Figures and Tables should be included as separate ".tif" files– *not* inserted into the text. When they are inserted into the text, the quality degrades.

Common Mistakes in References

1. **Formatting.** The most common mistake in references is their formatting. No matter how many times we tell people how to format their references, they still use brackets, numbers, footnotes, or any number of other methods. Be professional. Do your homework before submitting.
2. **Type of Reference.** Some papers will cite 5 references, all of them textbooks. This is unacceptable. A scientific manuscript should cite several – meaning at least a dozen – papers from peer-reviewed journals or books. If a paper cites less, then the author probably has not included enough background information and discussion of relevant research.