Scientific Papers

Although scientific journals all have their own set of guidelines for contributors, the following suggestions are general enough to be of use in the preparation of your lab write-ups as well as the formulation of scientific reports and papers later in your career.

Title: This is one of the most important components of the paper. The title is the first (and sometimes only) thing a reader interacts with, and has the difficult job of convincing them to come read the whole paper. The title should be descriptive, giving an indication of what was studied (e.g. DNA replication, social relationships) and the target of the study (e.g. an organism, group, material). The wording should be chosen with care to give maximum information with least number of words.

Do	Do not
Be descriptive	Use contractions
Be accurate	Use abbreviations

Example title:
Preliminary clinical evaluation of a new antitumor agent, streptovitacin

Abstract: An abstract is a summary of the information in your paper, typically no longer than 250 words. After the title, the abstract is the most frequently read part of a scientific paper. The abstract should contain:

i) the principal objectives and scope of the investigation,
ii) ii) the methodology used,
iii) iii) a summary of the results, and
iv) iv) the principal conclusions.

Because the abstract summarizes the whole document, it should be written last.

Introduction: A good introduction has the following:

i) nature and scope of the problem,
ii) ii) a review of pertinent literature,
iii) iii) method of investigation and why the particular methods were used, and
iv) iv) the principal hypotheses of the investigation.

Writing an introduction can be quite challenging, but an effective strategy for writing the introduction is to write it after writing the methods, results, and discussion sections. Writing an introduction for sections that do not yet exist can be challenging.

Methods and Materials: Methods sections are written in past tense because they are literally documenting a past event. This section should include enough detail that a competent researcher can repeat the experiment(s). The most important aspect of this goal is to recognize

potential sources of variability, even if you do not think those factors had an effect. Variability between products and equipment can affect results; therefore, product vendor information should be supplied when products are mentioned so that a researcher can obtain the exact same chemical or equipment that was used (e.g., Gas-exchange was performed on leaves with an Li-6200 (Li-COR Inc., Lincoln NE, USA)).

Do	Do not
Include potential sources of error or variability	Include trivial details (e.g., Jon and I walked across the room.)

Example: The samples were centrifuged in a TI-32 rotor (Beckman, Brea CA, USA). The rotors and inserts were pre-cooled to 4°C for 24 hours to prevent heat damage to the samples during centrifugation).

Results: This section is where you present the data. The results section should *only* include data—discussion of what the data *means* should be reserved for the discussion section. The data is typically presented either (1) directly in the text, (2) in tables, especially when you have repetitive data with interacting factors, or (3) in figures, when data cannot be easily summarized in a table. Statistics are often best included in a table. Negative results may also be worth mentioning. This section should be written with a high degree of clarity.

Summarize data into tables and figures with the goal of communicating more effectively.

Do	Do not
Place labels above tables Place labels below figures Give tables and figures descriptive labels Refer to figures and tables in text	Interpret data

Example table title:

Table 1. Leaf mass and number of leaves for double sunlight treatment group (DSTG) between day 1 and day 14.

Discussion: The discussion section is where you recap your results and start digging into what it all means and what to do with this new knowledge. You must discuss your results in the context of the work and studies of others, discussing what others have found and how their results relate to what you observed. When you reference others' work, you should mention what the relevant finding was—in your own words—with an appropriate citation. In general, direct quotes are not used in scientific research papers.

Example use of citation:

Although there are differences in absolute magnitude, the activity profile is similar during the exponential and asymptotic phases, consistent with the observations of Armanovsky and Salander (2008).

Acknowledgements: This is a small section, which allows a researcher to acknowledge granting agencies that supported the work financially and other contributions of a non-intellectual nature.

Citations/References: Although citation and reference are used interchangeably, they refer to different parts of a paper. A citation signals to the reader that the fact in the sentence came from a source, and points them to the references section. The references section gives them detailed information so that they can find the original source and read it for themselves. Entries in the references section are almost always ordered alphabetically. Although there are differences between style guides, entries typically include the author(s), year, article title, journal, volume, issue, and pages.

Format for citations varies considerably from one journal/book to another. If you have not been given a specific style to work with, you should identify the appropriate formatting standards for the situation. Always be consistent in applying one formatting style to your document, without mixing elements.

The Discussion Section

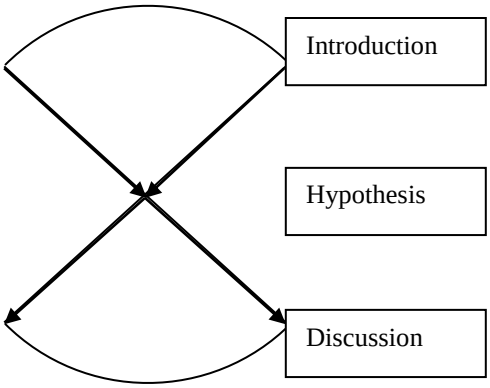
Writing the Discussion section can be challenging, but it is also the most exciting component of a scientific report. In the Discussion, the writer has the opportunity to be creative and to show the logic and reasoning behind their conclusions.

General Comments for Writing the Discussion

At its core, the Discussion section is devoted to intellectual exploration of the research topic. The original hypothesis and the results are explored and evaluated, and the conclusions from this exploration are then applied to the topic in general.

Form

There is a certain symmetry between the Introduction and the Discussion. The Introduction section starts from a general perspective then focuses down to a specific question. In contrast, the Discussion starts at the specific question and works outwards, applying the new knowledge to the big picture.



Intellectual Exploration

The intellectual exploration aspect of the discussion section is composed of reasoning and inclusion of pertinent information. Previous experiments, past conclusions, and current theories must be re-interpreted using the new data. This task is accomplished by including references to others' works (e.g., "The mean relationship between tail length and offspring survival is consistent with Jacobson and Larb's (2004) observation that greater tail allows individuals to access normally inaccessible resources")

Acknowledging Limitations

In exploring the new results, the limitations of the experiment must be explored as well. All experiments have limitations, and these limitations must be defined (e.g,. Although we have developed a new method for co-purifying protein x and protein y thereby establishing a link between these proteins' functions, the sequence and nature of their functional relationship cannot be determined from samples prepared using this method."). Pertinent limitations in others' results can also be identified as part of the discussion (e.g., "Jacobson and Larb's (2004) observations were limited to daylight observations, so they were unable to determine if individuals were succumbing to starvation or predation.").

Persuasion
The Discussion section can be thought of as a collection of "arguments" based on the author's and other people's results. Each paragraph should include a topic sentence and a concluding sentence. Each assertion or topic sentence must be supported by what is already known about the subject, as well as by your results.

Contribution
The Discussion is where you show what you have contributed. For experiments that are part of a class, your contribution is to confirm and support existing theories or "facts."

Language/Word Choice
A scientist's language must reflect the scientific method; therefore, words, phrases, and sentences should reflect a rigorous and objective search for information. Differences in meaning can be subtle but are important:

Inappropriate	Suitable
proves, proof (absolute language)	supports, evidence, consistent, contradictory
almost, sort of, kind of (ambiguous language)	similar, dissimilar, possible correlation

Prove, proof—these words have a type of closure that scientists dislike. One cannot necessarily prove a theory without any chance of it being disproven in the future (when we will likely have more accurate or specific measurement tools available), but one can certainly provide evidence *in support of* a theory.

Sort of, almost—Ambiguous language should be avoided. Things can be similar or dissimilar, but they cannot be sort of similar.

Strategy for writing the Discussion
List all of the points or arguments you want to make in the Discussion, and rank them. This list should include:

1. A definite statement accepting or rejecting the hypothesis, a strong answer to the research question, or an equivocal statement if more study is required.
2. Relevant information for interpreting the new data.
3. Limitations of the new data.
4. How the new information relates to previous experiments (i.e., is it consistent with similar experiments?).
5. A statement of contribution to the body of knowledge

Try to end with some suggestions for the future. You don't necessarily have to have a solution to all problems—suggesting future areas to focus on for more research is still a suggestion.