Biology

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The Scientific Manuscript

An Overview of the Scientific Manuscript

Students in Biology courses write scientific manuscripts, just as scientists do. The manuscript's structure follows the scientific method, and the information within the manuscript responds to a hypothesis that is clearly stated near the beginning of the manuscript. The purpose of the manuscript is to communicate how you conducted the work and the results obtained so that your audience can assess the veracity of the results and the conclusion.

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Audience

Your audience consists of your professor and classmates; however, you should envision your audience as also including other scientists and academics.

Tips for Your Writing Process

- Consider the scientific manuscript a "write up" of your research more than a process of generating new information. Much of the creative and critical thinking work associated with writing a scientific manuscript comes when you, the researcher, formulate the hypothesis and conduct the research. Therefore, the first part of the manuscript–from the introduction into the results section–situates your study and describes the scientific process you followed.
- Creativity comes to the fore in the discussion as you think about the implications of your findings for future studies.
- Assess your results and reflect on them within the context of existing models in the discussion section.
- In the results section of the manuscript, critical thinking is paramount. Create a new or revised hypothesis that logically flows from your results.

Important Reminders

- Write the abstract last.
- Be sure the hypothesis is in the introduction; make sure the same hypothesis is addressed in the discussion section (later in the manuscript).
- Your hypothesis will not change as you work through the paper. Your research examines the hypothesis, and if the hypothesis needs to be revised/tweaked, you do it during the research itself–which comes well before the write-up.

Manuscript Organization

Scientific manuscripts are written in a set format, with all sections and headings the same across publications. Here are the sections of the scientific manuscript; an (H) indicates that a heading should be used to title the section.

Title

Your title must communicate what is in the paper, indicating the hypothesis and variables tested. Scientists often choose what to read based on the title; if the title does not indicate the focus of the piece, the right people will not read it. The title should be clear, informative, and straightforward. It should include key terms related to your research to alert potential readers to its content.

Abstract

An abstract is a brief overview of the manuscript and is typically the first thing scientists read; the abstract helps readers discern whether the article is of relevance to them and their research. In addition, the abstract determineshow the piece will be indexed in databases. For those reasons, the abstract is important and is written with a specific formula: write 2-4 sentences on each section of your manuscript (the introduction, results, and discussion). The abstract must include your hypothesis or objective. For more assistance, see our handout on abstracts available at http://www.gvsu.edu/wc.

Process Tip: A draft of the abstract can be written as a series of cut-and-pasted sentences from the manuscript itself. Be sure, however, to revise the abstract so that the sentences connect to one another and form a complete, polished unit.

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Introduction (H)

The introduction puts your study into context. Structurally, it is like the introduction of most academic essays: it begins with a broad hook to orient your readers to the general topic of your research and then narrows down into your hypothesis. It includes quite a bit of background information, and your instructor may ask you to complete a literature review section as part of the introduction. A literature review is an overview of primary research articles pertinent to the research you conduct.

To write a literature review, ask yourself these questions:

- What are the common assumptions or findings among the articles you read?
- How do the articles build on one another, showing a trajectory of knowledge about this particular scientific issue?
- What is the connection between this primary research and your own work? That is, how can your work be interpreted within the context of the field?
- What is your hypothesis? Does it flow easily from the literature review you just wrote?

For more help writing a literature review, see our handout at http://www.gvsu.edu/wc.

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The introduction, in addition to presenting and justifying the general problem addressed and your hypothesis, should introduce the general methodological approach used to test your hypothesis and a justification of that approach. This should include a description of your study species.

Tips for Your Introduction

If you do not include a literature review in the manuscript, your introduction might include answers to these questions:

- What is the phenomenon you are studying?
- What is the significance of this phenomenon to your area of research?
- What is already known about the phenomenon, and how does your hypothesis flow from those understandings?
- What is your hypothesis?

Materials/Methods (H)

This section describes what you used to test your hypothesis and your methodology in carrying out the research. It must be exact and precise so the procedures can be replicated by other scientists. The information must be written out in paragraph form and worded in the past tense. Materials can be listed with semicolons between the items, but should not include bullets.

It can be helpful to break this section down into sub-sections, both to keep you organized as a writer, and to aid the reader in keeping track of your procedures. It can be helpful for scientists to follow specific sections for specific instruments or materials they need in their labs. If creating sub-sections, label each with a header indicating the specific procedure you used.

Results (H)

Results must be written in two formats (Data Display and Written Text) and must compliment one another.

1) **Data Display:** This section presents visuals that show the reader your findings, such as graphs, tables, and photographs. Graphics need to be clear and communicate well—they should look professional. Good data displays are readable and clear, meaning that:

- The font size is readable.
- Pattern contrasts are sharp so that visual elements showing different data are in strong contrast to one another and therefore easy to read.
- If photographs are included, they are sharp and in focus.
- If graphs are included, the correct type is chosen (bar, line, etc), with each line/bar in contrasting patterns.
- Labels are clear, easy to understand, and correctly positioned so that readers are not confused about what they describe.
- A legend, consisting of a table or figure number, a title, and an explanation, must be provided. The legend allows graphs and data display to stand alone. All figures and tables are numbered separately but consecutively from the beginning of the paper, regardless of section (introduction, materials and methods, etc.). The title of the figure or table is usually in bold and like all titles need not be a complete sentence (e.g., "The effect of calcium on toe length"). Sometimes, the title can encapsulate the results illustrated by the figure (e.g., "Calcium causes an increase in toe length"). The explanation includes all abbreviations and symbols (including a key to multiple lines or symbols on your graph, or multiple lanes in your gel) used in tables and figures. It also includes what the values represent (means, an indication of variability, the number of replicates). In addition, an explanation of the statistical tests performed as well as their results should be included (P values, significant differences, etc.). Legends indicate magnifications, units, etc, as that information helps other scientists to replicate methods correctly.

2) **Written Text:** This section should describe with sufficient detail what your experiment yielded. Do not describe your results in great detail; instead, pull out the results that are most important. Even though all your results should be described in the data display you must annotate them by pointing the reader to specific results that affect your conclusions. Stay descriptive; don't editorialize in your results section, as the significance of these findings and implications for future research comes in the discussion section.

Discussion (H)

This section builds on the results and is the point in the manuscript where you, the writer, get to editorialize about the results. It is the place where you get to talk with other scientists about what you think your research means within the context of other research. A few strategies for writing a good discussion section include:

- Discuss every result you described in the results section, being careful to discuss each data display/figure. (If you don't end up

Take Notice of Voice/ Tone

A formal tone is necessary. Scientific manuscript writing is academic and professional.

Objectivity is paramount. Some professors interpret this to mean that there should be very few–if any–references to the writer(s) in the first person ("I", "we"). Avoiding first person pronouns can be difficult, and often requires the use of passive voice:

Active Voice: "We tested this prediction by …"
Passive Voice: "This prediction was tested by …"

The reality is that scientific writing is changing. It has become more common for scientists to write in the first person, particularly when passive voice would get wordy or awkward. Check with your professor on his or her preferences when it comes to using first person and/or passive voice. To learn more about how to identify active and passive voice, see our handout at http://www.gvsu.edu/wc.

The writing–as well as the research itself–is driven by a hypothesis.

- A hypothesis is an underlying statement of explanation about how the world works. From it flow predictions.
- A scientist tests a hypothesis by testing these predictions–and "test" is the key word here. One should not write about "proving" or "showing" a hypothesis, as those are biased words that indicate an argument rather than objective scientific discovery.
- A typical hypothesis is written in "If....then...." language–it is a statement about how the world works and a prediction about it based on an underlying logic. This underlying logic is the hypothesis.

discussing a particular result, it may not be significant enough to have included in the Results section.)

- Ask yourself... “How does each result connect to what others have found?” and “How does each result connect to the original hypothesis/model?”
- Include in the final paragraph a summary statement that indicates whether the hypothesis is supported, and indicate a vision for what might happen next, in further research conducted by yourself or others.

Prompts for Writing Consultations

- Is there a clear purpose to the research?
- Are previous/related findings addressed in the introduction?
- Is the hypothesis written clearly in the introduction?
- Is the hypothesis addressed fully in the results/findings section?
- Is the experiment replicable? (Are the methods easily understandable to the point of completing the steps?)
- Does the discussion section develop each finding in the order that they were mentioned in the results section?
- Does the writer clearly state whether or not the hypothesis was supported by the results?
- Are limitations clearly addressed?
- Are visuals clearly labeled, appropriate to the content, and formatted in such a way that they are easy to understand?
- Does the writer adequately discuss findings within the text of the manuscript, not just in the visuals?
- Does the abstract match the overall manuscript? Should it be more concise, or is anything missing that should be included?
- Remember that brevity and concisness are most important.