Course N^0= 6: General Rules for Writing Scientific Articles

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1 What is a Science Article?

A scientific article presents research findings written by researchers and scientists. They are generally considered primary sources and are written for other researchers. The most recent articles will contain the most recent work in the field, with references to previously published works in the field of study.

2 What Are Scientific Journals?

Journal articles may include original research, re-analyses of research, reviews of literature in a specific area, proposals of new but untested theories, or opinion pieces.

2.1 What are scientific journals, and what kinds of articles do they publish?

A: Scientific journals represent the most vital means for disseminating research findings and are usually specialized for different academic disciplines or subdisciplines. Often, the research challenges common assumptions and/or the research data presented in the published scientific literature in order to gain a clearer understanding of the facts and findings. Depending upon the policies of a given journal, articles may include reports of original research, re-analyses of others' research, reviews of the literature in a specific area, proposals of new but untested theories, or opinion pieces.

2.2 How is a manuscript evaluated for publication in a scientific journal?

A: A manuscript is first submitted to a journal by the author(s) for potential publication. Authors carefully select a journal based upon the content of their article and the intended audience. The editor determines whether the manuscript is within the editorial domain of the journal and appears to be an appropriate submission. On average, over 97% of submissions to journals published by the American Psychological Association, for example, are referred to outside experts for peer review of their merits.

2.3 What is peer review?

A: Peer review is a process whereby two or more experts in the relevant topic area evaluate manuscripts for potential publication at the request of the journal editor. Reviewers are carefully selected based on their scientific expertise, research area, and lack of bias toward the authors of a given manuscript. (Manuscripts are often circulated for peer review without their title pages to mask the identity of the authors and eliminate reviewer bias.) The reviewers, who usually remain anonymous, submit their written critiques to the journal editor, including attention to the strengths and weaknesses of the manuscript, together with editorial suggestions and recommendations. The editor reads the manuscript and the reviewers' comments to make a determination as to whether the manuscript should be rejected, revised and resubmitted for further review, or accepted. Reviewers are not financially compensated for their work; they often spend between four and 12 hours (depending on the length and complexity of the manuscript) in completing a thoughtful, extensive editorial review, as one

of their service contributions to the advancement of science. Journal editors may receive a small stipend.

2.4 Why are controversial articles published?

A: Scientific progress results from the free interchange of ideas, which other scientists then support or refute through their own research, analyses, and theories. Oftentimes, controversial views are intentionally published to stimulate further debate and move the field forward to a clearer understanding of the critical issues and relevant variables.

2.5 If an article's methodology and/or conclusions turn out to be inaccurate, how is the scientific literature corrected?

A: Scientists subject published hypotheses to further scrutiny and publish their supportive or opposing conclusions. Commentaries are published about controversial findings, as well as empirical reports, that may contradict or support a hypothesis. In essence, science is a self-correcting, consensus-building enterprise, whereby any serious inaccuracies in an article are identified and the literature corrected through subsequent publications.

2.6 Do views expressed in journal articles reflect the position of the editor or association that published them?

A: No, articles published in scientific journals do not represent the positions of the association or publisher. Scientific journals typically include a disclaimer stipulating that opinions and statements contained in the journal are the personal views of the authors and do not constitute association policy or the views of the editor. Any exceptions are indicated in the article or in an editorial footnote. Furthermore, most scientific journal editors function as independent scholars, and they are neither employees nor official or legal representatives of the association or publisher.

2.7 What is the appropriate role of scientific journal articles in the development of public policy?

A: Public policy should be based on sound, peer-reviewed scientific research, whenever feasible. Such policy decisions are rightfully grounded in a large, respected body of research in a given area, not on a single study or opinion. The social policy implications of research may not be readily evident to some scientists and journal editors. If readers take issue with the social policy implications of a given article, they may submit written comments to the journal. Depending upon journal policy, such comments may be considered for publication after appropriate review.

3 General Rules for Scientific Writing

- **Organize data** so that it is easy to put in specific scientific order

- **Know your audience** so that you know what information to include, and what should be left out

• Write in **complete sentences** and be **clear** and **concise** using **specific** wording. (Flowery prose reflects flowery research)

• **Do not get too technical**, but also **avoid colloquial words**

3.1 Format

The scientific paper has the following elements: Title, Abstract, Introduction, Methods, Results, Discussion, and Literature Cited. The actual words "Introduction", "Methods," etc. are used to head the sections of your paper. Begin a new page for each section. Tables and figures are placed at the end of the text.

In the Appendix you will find an example of a short scientific paper, which contains most of the elements described below, except for an abstract. Consult that after reading each of the following sections.

3.2 Title

The title should contain three elements:

1. the name of the organism studied;
2. the particular aspect or system studied;
3. the variable(s) manipulated.

Do not be afraid to be grammatically creative. Here are some variations on a theme, all suitable as titles:

THE EFFECT OF TEMPERATURE ON GERMINATION OF CORN

DOES TEMPERATURE AFFECT GERMINATION OF CORN?

TEMPERATURE AND CORN GERMINATION: IMPLICATIONS FOR AGRICULTURE

Sometimes it is possible to include the principal result or conclusion in the title:

HIGH TEMPERATURES REDUCE GERMINATION OF CORN

3.3 Abstract

The abstract is a one or two paragraph condensation (150-200 words) of the entire work described completely in the article. The abstract should be **a self-contained unit capable of being understood without the benefit of the text**. It should contain these four elements:

1. the purpose of the study (the central question);
2. a brief statement of what was done (Methods);
3. a brief statement of what was found (Results);

4. a brief statement of what was concluded (Discussion, in part).

3.4 Introduction

The function of an introduction is to present the question being asked and place it in the context of what is already known about the topic. Background information that suggests why the topic is of interest and related findings by other scientists are usually mentioned here. In other words, this section should contain:

1. a description of the nature of the problem and current state of knowledge or understanding at the beginning of the investigation (background);
2. a statement of the purpose, scope, and general method of investigation in your study;
3. hypothesis/hypotheses and predictions.

Do not get lost in reviewing background information. Remember that the Introduction is meant to introduce the reader to your research, not summarize and evaluate all past literature on the subject (which is the purpose of a review paper). Many of the other studies you may be tempted to discuss in your Introduction are better saved for the Discussion, where they become a powerful tool for comparing and interpreting your results. Include only enough background information to allow your reader to understand why you are asking the questions you are and why your hyptheses are reasonable ones. Often, a brief explanation of the theory involved is sufficient.

The statement of purpose expresses the central question you are asking and thus presents the variable you are investigating. For example:

This study investigates the relationship between tree density and fruit size.

The purpose of this study is to determine the effect of enzyme concentration on the reaction rate of ....

The hypothesis is the explanation you are proposing for certain observations. It is a tentative answer to the question you have posed above. It should be accompanied by a prediction of results expected under certain conditions if the hypothesis is correct.

If competition lowers reproductive output, then fruit size shuld be smaller when tree density increases.

Some editors think that the principal results and conclusions should be summarized in the Introduction. This practice is advocated by Day (1983). Most biologists disagree, arguing that such a summary appears in the abstract and should not be repeated in the Introduction. You should avoid the practice except when writing for a journal that requires it.

Write this section in the past or present tense, never in the future. Avoid expressions like "This study will examine

3.5 Methods

The function of this section is to describe all experimental procedures, including controls. The description should be complete enough to enable someone else to repeat your work. If there is more than one part at the experiment, it is a good idea to describe your methods and present your results in the same order in each section. This may not be the same order in which the experiments were performed -it is up to you to decide what order of presentation will make the most sense to your reader.

1. Explain why each procedure was done, i.e., what variable were you measuring and why?

Example:

- **Difficult to understand:**
  First, I removed the frog muscle and then I poured Ringer's solution on it. Next, I atttached it to the kymograph.
- **Improved:**
  I removed the frog muscle and poured Ringer's solution on it to prevent it from drying out. I then attached the muscle to the kymograph in order to determine the minimum voltage required for contraction.

2. Experimental procedures and results are narrated in the past tense (what you did, what you found, etc.) whereas conclusions from your results are given in the present tense.
3. Mathematical equations and statistical tests are considered mathematical methods and should be described in this section along with the actual experimental work.
4. Use active rather than passive voice when possible. Always use the singular "I" rather than the plural "we" when you are the only author of the paper. Throughout the paper, avoid contractions, e.g. did not vs. didn't.
5. If any of your methods is fully described in a previous publication (yours or someone else's), you can cite that instead of describing the procedure again.

Example:

The chromosomes were counted at meiosis in the anthers with the standard acetocarmine technique **of Snow (1955).**

3.6 Results

The function of this section is to summarize general trends in the data without comment, bias, or interpretation. Statistical tests applied to your data are reported in this section although conclusions about your original hypotheses are saved for the Discussion section.

Data may be presented in figures and tables, but this may not substitute for a verbal summary of the findings. The text should be understandable by someone who has not seen your figures and tables.

Example:

- Incorrect:
  The results are given in Figure 1.

- Correct:
  Temperature was directly proportional to metabolic rate (Fig. 1).

1. All results should be presented, including those that do not support the hypothesis.

2. Statements made in the text must be supported by the results contained in figures and tables.
3. The results of statistical tests can be presented in parentheses following a verbal description. Example:
   - Fruit size was significantly greater in trees growing alone **(t = 3.65, df = 2, p < 0.05).**

3.7 Discussion

The function of this section is to analyze the data and relate them to other studies. To "analyze" means to evaluate the meaning of your results in terms of the original question or hypothesis and point out their biological significance.

1. The Discussion should contain at least:
   - The relationship between the results and the original hypothesis, i.e., whether they support the hypothesis, or cause it to be rejected or modified.
   - An integration of your results with those of previous studies in order to arrive at explanations for the observed phenomena.
   - posssible explanations for unexpected results and observations, phrased as hypotheses that can be tested be realistic experimental procedures, which you should describe.
2. Trends that are not statistically significant can still be discussed if they are suggestive or interesting, but cannot be made the basis for conclusions as if they were significant.
3. Avoid redundancy between the Results and the Discussion section. Do not repeat detailed descriptions of the data and results in the Discussion. In some journals, Results and Discussions are joined in a single section, in order to permit a single integrated treatment with minimal repetition. This is more appropriate for short, simple articles than for longer, more complicated ones.
4. End the Discussion with a summary of the principal points you want the reader to remember. This is also the appropriate place to propose specific further study if that will serve some purpose, but do not end with the tired cliche' that "this problem needs more study." All problems in biology need more study. Do not close on what you wish you had done; rather finish stating your conclusions and contributions.

3.8 Tables and Figures

Tables and figures should be used when they are a more efficient way to convey information than verbal description. They must be independent units, accompanied by explanatory captions that allow them to be understood by someone who has not read the text.

Do not repeat in the text the information in tables and figures, but do cite them, with a summary statement when that is appropriate.

Whenever possible, use a figure instead of a table. Relationships between numbers are more readily grasped when they are presented graphically rather than as columns in a table.

1. Tables
   - Do not repeat information in a table that you are depicting in a graph or histogram; include a table only if it presents new information.
   - It is easier to compare numbers by reading down a column rather than across a row. Therefore, list sets of data you want your reader to compare in vertical form.
   - Provide each table with a number (Table 1, Table 2, etc.) and a title. The numbered title is placed above the table.
2. Figures
   - These comprise graphs, histograms, and illustrations, both drawings and photographs. Provide each figure with a number (Fig. 1, Fig. 2, etc.) and a caption that explains what the figure shows. The numbered caption is placed below the figure.
   - Figures submitted for publication must be "photo ready," i.e., they will appear just as you submit them, or photgraphically reduced. Therefore, when you graduate from student papers to publishable manuscripts, you must learn to prepare figures that will not embarrass you. Lines should be drawn with black ink (not ballpoint or marker). Symbols, letters, and numerals must be produced by stencil or mechanically, and should be large enough to withstand reduction. Proportions must be the same as those of the page in the journal to which the paper will be submitted.
   - Graphs and Histograms
     Both can be used to compare two variables. However, graphs show continuous change, whereas histograms show discrete variables only. Compare Figures 1 and 2 in the Appendix. You can compare groups of data by plotting two or even three lines on one graph, but avoid cluttered graphs that are hard to read, and do not plot unrelated trends on the same graph.
     For both graphs, and histograms, plot the independent variable on the horizontal (x) axis and the dependent variable on the vertical (y) axis. Label both axes, including units of measurement.
   - Drawings and Photographs
     These are used to illustrate organisms, experimental apparatus, models of structures, cellular and subcellular structure, and results of procedures like electrophoresis. Preparing such figures well is a lot of work and can be very expensive, so each figure must add enough to justify its preparation and publication, but good figures can greatly enhance a professional article, as your reading in biological journals has already shown.

3.9 Litature Cited:

This is the last section of a scientific paper. References are listed by author, as indicated by the following sample list.

Papers are not referred to by footnotes as in literature papers but are cited within the body of the text (see Section I below).

1. We will follow the format of the journal, Ecology. Other journals use variations on this theme. Ask your instructors for the specific format they want you to adopt for your work.
   - (Journal): Strong, D. R., Jr. 1980. Null hypothesis in ecology. Synthese 43: 271-285.
   - (Book): Eadie, W. R. 1954. Animal control in field farm and forest. MacMillan Co., New York, New York, USA.
   - (Article in a book): Werner, P.A. 1979. Competition and coexistence of similar species. Pages 287-310. In O.T. Sol-brig, S. Jain, G. B. Johnson and P. Raven, editors. Topics in plant population biology. Columbia University Press, New York, New York, USA.
   - (Multiple authors): Gross, K. L. and P. A. Werner. 1978. The biology of Canadian weeds. Canadian Journal of Plant Science 58:401-413.
   - (Thesis): Calvo, R. N. 1990. Pollinator limitation, cost of reproduction, and fitness in plants: a demographic approach. Dissertation. University of Miami, Coral Gables, Florida, USA.
   - (Technical report): Heinselman, M. L. 1981. Fire intensity and frequency as factors in the distribution and structure of northern ecosystems. Pages 7-57 in H. Mooney, I. M. Bonnicksen, N. L. Christensen, J. E. Loten, and W. A. Reiners, editors. Fire regimes and ecosystem properties. USDA Forest Service General Technical Report WO-26.
2. All authors must be named in the Literature Cited; use "et al." only with the text.
3. No reference is listed in this section unless it was cited somewhere in the text.

3.10 Format for Citing References in the Text

You must cite another researcher whenever you refer to his or her results, conclusions, or methods in your paper. The reference in the text is made only to the author's name and date of publication. There are three ways of doing this:

1. Both the name and date can go inside parentheses is the name is not actually part of your sentence. Not all journals include the comma between author and year. For example:

   Enzymes are inhibited by cyanide **(Grubb 1977).**

   Because enzymes are inhibited by cyanide **(Grubb 1977),** I expect to find....

Notice that the parenthesis is placed at the end of the sentence of clause containing the reference and that punctuation FOLLOWS the citation.

2. Another way to cite a study is to make the last name of the researcher the subject or object of the sentence or clause and follow it immediately with the date of the study in parentheses:

   Grubb (1977) found that cyanide inhibits enzymes.
   Because Grubb (1977) found that cyanide inhibits enzymes....
   These data support the conclusions of Grubb (1977).

3. If you wish to emphasize the date of the cited study, you can omit the parentheses:

   As early as 1977, Grubb observed the inhibitory effect of cyanide on enzyme action.

   This strategy is often effective for presenting an historical perspective of the problem (i.e., useful in Introduction).
4. It is INCORRECT to separate the date of publication from the author's name:

   Incorrect:
   Grubb found that cyanide inhibits enzyme action **(1977).**

   Correct:
   Grubb (1977) found that cyanide inhibits enzyme action**.**

5. If you wish to cite more than one study per reference, i.e., if more than one author has reached the same conclusion or worked on the same problem independently, you may list them together in the same parentheses and separate their names by semicolons:

   Cyanide has been found to inhibit enzyme action **(Grubb 1977, Smith 1980, Taylor 1983).**

   By convention, these citations are listed in chronological order.

6. In the case of more than three authors, you may use et al. (from "et alii," Latin for "and others") after the first author's name:

   Cyanide has been found to inhibt enzyme action (Jones **et al.,** 1985)