

## Guidelines for Writing a Scientific Paper

Writing an effective scientific paper is not easy. A good rule of thumb is to write as if your paper will be read by a person who knows about the field in general but does not already know what you did. Before you write a scientific paper read some scientific papers that have been written in the format of the paper you plan to use. In addition to the science, pay attention to the writing style and format.

**Abstract:** An abstract is a succinct (one paragraph) summary of the entire paper. The abstract should briefly describe the question posed in the paper, the methods used to answer this question the results obtained, and the conclusions. It should be possible to determine the major points of a paper by reading the abstract. Although it is located at the beginning of the paper, it is easiest to write the abstract after the paper is completed.

**Introduction:** The Introduction should (i) describe the question tested by the experiments described in the paper, (ii) explain why this is an interesting or important question, (iii) describe the approach used in sufficient detail that a reader who is not familiar with the technique will understand what was done and why, and (iv) very briefly mention the conclusion of the paper.

**Materials and Methods:** The Materials and Methods section should succinctly describe what was actually done. It should include description of the techniques used so someone could figure out what experiments were actually done. The details of a published protocol do not need to be reproduced in the text but an appropriate reference should be cited – e.g., simply indicate “were done as described by Hughes et al. (4)”. Any changes from the published protocol should be described. It is not appropriate to indicate volumes of solutions added – instead indicate the relevant information about the experiment such as final concentrations used, etc.

**Results:** Begin each paragraph with an opening sentence that tells the reader what question is being tested in the experiments described in that paragraph. Write the opening sentence in bold font for emphasis. (Sometimes a complete sentence is used and sometimes a short phrase is used – either style is OK but the style should be used consistently throughout the manuscript.) Any results that include multiple data points that are critical for the reader to evaluate the experiment should be shown in tables or figures. However, the results should be summarized in accompanying text. When referring to a particular table or figure, they should be capitalized (e.g., Table 1, Figure 6, etc.) The text of the Results section should be succinct but should provide the reader with a summary of the results of each table or figure.

Not all results deserve a separate table or figure. As a rule of thumb, if there are only a few numerical results or a simple conclusion describe the results in the text instead of in a table or figure.

Your paper should focus on what worked, not things that did not work (unless they didn't work for reasons that are interesting and provide biological insights).

**Tables and Figures:** All tables and figures should be put into a contextual framework in the corresponding text. A table of strains used should be mentioned in the Materials and Methods section, a table of results should be summarized in the Results section, a figure showing a biosynthetic pathway should be described in the Discussion section, etc. Tables and figures should present information in a format that is easily evaluated by the reader. A good rule of

thumb is that it should be possible to figure out the meaning of a Table or Figure without referring to the text. Tables and figures should typically summarize results, not present large amounts of raw data. When possible, the results should provide some way of evaluating the reproducibility or statistical significance of any numbers presented.

Tables should be sequentially numbered. Each table should have a title (shown above the table) that describes the point of the table. For example, “Table 1. Bacterial strains and plasmids used in this study.” If necessary to interpret the table, specific descriptions about what a result represents or how the results were obtained can be described in a legend below the table.

Figures should be sequentially numbered. Each figure should have a title (shown below the table) that describes the point of the table. For example, “Figure 1. Isolation of MudJ insertion mutants.” If necessary to interpret the figure, specific descriptions about what a result represents or how the results were obtained can be described immediately following the title.

Tables and figures may be printed on separate pages that follow the Reference section. Alternatively, the tables and figures may be integrated into the paper if you are using a page layout program. However, if they are integrated into the paper make sure that there is not a page break in the middle of a table or figure. Do not wrap text around the outside of tables and figures – if the results are important enough to show as a table or figure they should stand out on the page, not be buried in text.

**Discussion:** Do not simply restate the results — explain your conclusions and interpretations of the Results section. How did your results compare with the expected results? What further predictions can be gleaned from the results?

**Citations:** It is essential to credit published papers for work mentioned in your manuscript. There are a variety of ways of citing references in the text – the style used depends upon the policy of the journal. In text citations should refer to reference list. Do not rewrite title of references in text.

**Reference lists:** Like citations, a variety of reference formats are used by different journals. For an example of a commonly used example, see “Instructions to authors” on ASM web site (<http://jb.asm.org/misc/ifora.shtml>) or examples from published manuscripts.

**Genetic nomenclature:** Use correct genetic nomenclature for both genotype and phenotype. To review the rules for bacterial genetic nomenclature, see the Microbial Genetics topics link.

**Format:** Certain general rules are commonly followed in scientific writing.

*Flow.* Readers interpret prose more easily when it flows smoothly, from background to rationale to conclusion. Don’t force the reader to figure out your logic – clearly state the rationale. In addition, it is much easier on the reader if you explicitly state the logic behind any transitions from one idea to another.

*Abbreviations.* Use standard abbreviations (hr, min, sec, etc) instead of writing complete words. Some common abbreviations that do not require definition are shown on the attached table. Define all other abbreviations the first time they are used, then subsequently use the abbreviation [e.g. Ampicillin resistant (Amp<sup>R</sup>)]. As a general rule, do not use an abbreviation unless a term is used at least three times in the manuscript. With two exceptions (the degree symbol and percent symbol), a space should be left between numbers and the accompanying unit. In general, abbreviations should not be written in the plural form (e.g. 1 ml or 5 ml, not mls).

*Past, present, and future tense.* Results described in your paper should be described in past tense (you've done these experiments, but your results are not yet accepted “facts”). Results from published papers should be described in the present tense (based upon the assumption that published results are “facts”). Only experiments that you plan to do in the future should be described in the future tense.

*Third vs first person.* It is OK to use first person in scientific writing, but it should be used sparingly – reserve the use of first person for things that you want to emphasize that “you” uniquely did (i.e. not things that many others have done as well). Most text should be written in the third person to avoid sounding like an autobiographical account penned by a narcissistic author. However, it is better to say “It is possible to ..” than to say “One could ...”. Writing that uses the impersonal pronoun “one” often seems noncommittal and dry.

In addition, inanimate objects (like genes, proteins, etc) should be described in third person, not with anthropomorphic or possessive terms (e.g., instead of saying “its *att* site”, say “the chromosomal *att* site”).

*Empty phrases.* Avoid using phrases that do not contribute to understanding. For example, the following phrases could be shortened (or completely deleted) without altering the meaning of a sentence: “the fact that ...” (delete); “In order to ...” (shorten to simply “To ...”). Likewise, the title of a table of results does not benefit from the preface “Results of ...”. In short, don't use more words than you need to make your point.

*Specify.* If several expressions modify the same word, they should be arranged so that it is explicit which word they modify. It is common to use a pronoun such as “it” or “they” to refer to a concept from the previous sentence. This is OK as long as there is only one concept that “it” or “they” means. However, if there are more than one concepts it is easy for the reader to get confused about what the pronoun is meant to specify (even if you know which one you mean). It is better to error on the side of redundancy by repeating the concept in subsequent sentences, than to take the chance of confusing the reader. Don't make the reader guess what you mean.

*Parentheses.* Avoid double parentheses. For example, “Three gene products catalyze reactions in the pathway for proline biosynthesis (Figure 1) (3)” could be reworded to say “Figure 1 shows the three reactions of the pathway for proline biosynthesis (3).”

**Proofreading:** Always spellcheck your paper and carefully proofread your paper before submission. In addition to checking for errors and typos, read your paper to yourself as if you were reading it out loud to ensure that the wording and sentence construction is not clumsy.

## **SOME USEFUL RESOURCES:**

Instructions to Authors, J. Bacteriol. [<http://jb.asm.org/misc/ifora.shtml>]

Word usage in scientific writing [<http://www.ag.iastate.edu/aginfo/checklist.html>]

Dangling modifiers [[http://owl.english.purdue.edu/handouts/grammar/g\\_dangmod.html](http://owl.english.purdue.edu/handouts/grammar/g_dangmod.html)]

- Alley, M. 1996. The craft of scientific writing, 3<sup>rd</sup> edition. Prentice Hall, NJ. [and accompanying web site: <http://filebox.vt.edu/eng/mech/writing/>]
- Day, R. 1998. How to write and publish a scientific paper, 5<sup>th</sup> edition. Orynx Press.
- Day, R. 1995. Scientific English: A guide for scientists and other professionals, 2<sup>nd</sup> edition. Orynx Press.
- Goben, G., and J. Swan. 1990. The science of scientific writing. Am. Scientist 78: 550-558. [Available online at <http://www.research.att.com/~andreas/sci.html>]
- McMillan, V. 1988. Writing papers in the biological sciences. Bedford Books, NY.
- Strunk, W., and E. B. White. 1979. The elements of style, 3<sup>rd</sup> edition. MacMillian Publishing Co.

**Some standard abbreviations:**

<b>Unit</b>	<b>Abbreviation</b>	<b>Defination</b>	
Time	sec	Seconds	
	min	Minutes	
	hr	Hours	
Weight	g	Grams	
	mg	Milligrams ( $10^{-3}$ g)	
	$\mu$ g	Micrograms ( $10^{-6}$ g)	
Volume	l	Liter	
	ml	Milliliter ( $10^{-3}$ l)	
	$\mu$ l	Microliter ( $10^{-6}$ l)	
Nucleotide length	bp	Base pairs	
	Kb	Kilobase pairs ( $10^3$ bp)	
	Mb	Megabase pairs ( $10^6$ bp)	
Common molecular biology terms	A, T, G, C, U	Adenine, Thymidine, Guanine, Cytosine, Uracil	
	DNA	Deoxyribonucleic acid	
	RNA	Ribonucleic acid	
	NTP	Nucleotide triphosphate	
	dNTP	Deoxyribonucleotide triphosphate	
	NAD	Nicotinamine adenine dinucleotide	
	EDTA	Ethylenediamine tetraacetic acid	
	EGTA	Ethylene glycol-bis(b-aminoether) N,N,N',N'-tetra acetic acid	
	TRIS	Tris(hydroxyamino)methane	
	UV	Ultraviolet light	
	PFU	Plaque forming units	
	Symbols for chemical elements	C, N, P, etc	Carbon, nitrogen, phosphorus, etc
	One- or three-letter abbreviations for amino acids	e.g. Ala (A)	Alanine
Arg (R)		Arginine	

	Asn (N)	Asparagine
	Asp (D)	Aspartic acid
	Cys (C)	Cysteine
	Gln (Q)	Glutamine
	Glu (E)	Glutamic acid
	Gly (G)	Glycine
	His (H)	Histidine
	Ile (I)	Isoleucine
	Leu (L)	Leucine
	Lys (K)	Lysine
	Met (M)	Methionine
	Phe (F)	Phenylalanine
	Pro (P)	Proline
	Ser (S)	Serine
	Thr (T)	Threonine
	Trp (W)	Tryptophan
	Tyr (Y)	Tyrosine
	Val (V)	Valine