RIGHTING WRITING

Jo Handelsman

Getting Started

Perhaps the most important aspects of writing occur before you even put pen to paper or fingertips to keyboard. First, try to answer the following questions for yourself:

Who is my audience?
Why should they care?
What are my major points?

Who is my audience?

The answer to the first question will help you define how you start your paper, the angle you take in presenting the significance of the work, and the background information you need to supply. For example, if you are presenting the discovery of a plasmid in a pathogen of trees in a forestry journal, you might emphasize the importance of the pathogen to forestry and provide background information about plasmids and their importance, but you can assume that people reading the journal understand the significance of trees. However, a paper presenting the same discovery in a journal on plasmids would not need to discuss the significance of plasmids, but the audience would not be expected to know much about trees and their pathogens.

Why should they care?

You must catch a reader's attention. Everyone has more than enough to read these days, and most people will just turn the page of a journal if the first paragraph of a paper does not capture their imagination or make a compelling case for the paper's significance. When you start writing, assume that your reader is uninterested in your topic and it is your challenge to make it interesting. You may use its significance to society or its relevance to solving practical, human problems, or you may use the pure intellectual interest of an unsolved biological problem or a paradox that needs to be explained. Whatever your angle, make it clear, concise, and honest. Usually, what interests you about the project will be interesting to your readers.

What are my major points?

Most people learn new information best when it is presented in small bits organized around an interesting concept. If you bombard your audience with too many new ideas, they are unlikely to understand them all well. If you focus your paper around one or two key ideas, it will be more cohesive and cleanly structured. Therefore, before you start writing, choose your most important points. If a reader were to learn only one thing from your paper, what would you like it to be?

The Global Issues

Good writing is typified by clear, flowing organization. In an organized piece, the reader's mind moves easily from one idea to the next through the writer's effective use of connections, transitions, and logical organization. Below are a few suggestions to help you develop the overall logic and organization of your writing.

1. The Lead

The first sentence of a piece of writing is critical. It clues the reader in to the central theme and catches attention. This is particularly important in a personal statement associated with an application to graduate school or for a job. Make your first sentence interesting, but not too long or complex—you don't want the reader to get tired on the first sentence. Be sure that your word use and grammar are absolutely correct. There is nothing as damning in an application as a glaring grammatical error in the first sentence of a personal statement. Finally, be sure that the rest of your piece lives up to the first sentence. Don't tease the reader with a neat idea and then fail to develop it.

2. Organization

Make an outline. Justify to yourself why each section should be included. What is its relationship to your topic, theme, or hypothesis? Identify the essential information and then try to streamline your material, but be thorough. It is better to review a smaller amount of information thoughtfully than to cover a great volume superficially.

Use paragraphs and subheadings to provide the reader with a sense of the organization of concepts. Lead or topic sentences can help define the content of each paragraph for the reader, but be careful not to simply repeat a subheading in the first sentence of the paragraph.

3. Transitions

Try to make explicit connections between sentences, paragraphs, and sections. Avoid lists of ideas or sentences that are not connected. Remembering this rule will make your writing more fluid, force you to make mental connections between ideas, and motivate your audience to read further. Reading a list of unconnected ideas often makes a reader say, "So what?" Logical connections will lead a reader to say, "Oh, I see!"

Compare the following paragraphs:

> Genetic diversity is a powerful tool in biotechnology. Many strains of bacteria have been used for production of vinegar, antibiotics, and enzymes in industrial microbiology. Crop varieties adapted to many different environments are used in agriculture.
>
> Throughout the history of biotechnology, genetic diversity has been a powerful tool. In microbiology, genetically diverse strains of bacteria have been used to maximize production of vinegar, antibiotics, and enzymes. In agriculture, genetic diversity has been exploited to produce crop varieties adapted to many different environments.

The first paragraph is a list of apparently unrelated pieces of information. The second paragraph connects the three sentences. The similar construction of the second and third sentences, starting with "In microbiology," and "In agriculture," provides a signal to the reader that these are examples of the point made in the topic sentence. This is reinforced by the use of the phrases "genetically diverse" and "genetic diversity" in the second and third sentences, indicating that they are examples of the overall concept of genetic diversity in biotechnology.

The Specific Issues

The construction of each sentence is critical to enhance the clarity and impact of writing. While and the specifics may seem picky or unimportant, the most minor mistakes can make your writing ambiguous, boring, or hard to read. Below are some pointers that will help your writing be comprehensible and interesting.

1. Stacked modifiers

In writing about science, we have a tendency to use strings of adjectives, or stacked modifiers, to avoid lots of prepositional phrases. Use of extra words is usually discouraged, but they can be very welcome to readers if they help you avoid dense sentences filled with many stacked modifiers. This is especially important for readers who are not familiar with the jargon of your field. It is often hard for a reader who is unfamiliar with the material to figure out how the words in a series of stacked modifiers fit together. An example is "cryptic plasmid subclones." Is the plasmid cryptic, or are the subclones cryptic? This would be clearer if it was written: "subclones of the cryptic plasmid." Two short words have been added, but the ambiguity is gone.

2. Hyphens

Another way to handle stacked modifiers is to hyphenate the modifiers to distinguish them from the noun. An example is "weak root pathogen." If the pathogen affects weak roots, it should read "weak-root pathogen." (The alternative meaning is a root pathogen that is weak; in this case, do not hyphenate). Do not hyphenate two-word descriptors when one of the words is an adverb. (These can usually be spotted by their "-ly" endings.) For example, "genetically engineered microorganisms" and "randomly generated mutants" should not be hyphenated.

3. Verbs

Follow the usual rules. What is published or generally known is presented in the present tense, your results are presented in the past tense, and predicted results should be in the conditional tense. A common mistake is to describe predicted results in the past tense, and this can make it very hard for the reader to distinguish between what *happened* and what *might happen*.

Avoid the passive voice. Never use the wordy passive.

Active voice:	The plants grew rapidly.
Passive:	Rapid growth of the plants was observed.
Wordy passive:	It was observed that plant growth was rapid.

Verbs provide the spice in scientific writing. Search for interesting, active verbs to stimulate your reader's imagination. Examine the phrases from writing by Paul Ehrlich, one of the most persuasive writers on the topic of biodiversity conservation.

"The food resource...in all major ecosystems is the energy that green plants bind into organic molecules...."

"...our species can safely commandeer upwards of 80 percent of...."

"Arresting the loss of diversity will be extremely difficult."

"...the spewing of toxins into the environment..."

from *Biodiversity*, ed. E.O. Wilson

6. Word use

Variety. Try not to use different nouns for the same subject. Many students purposely interchange "bacterium," "cell," and "organism" for variety. This can be very confusing to the reader. Science writing is precise, and no two words mean the same thing, so consistently use the one that is appropriate for your meaning.

Pretentious and empty words. Try to avoid pretentious words that can be replaced by simple, direct words. Some examples:

there exists (there is)
by means of (with, by)
utilize (use)
due to the fact that (since, because)
in order to (to)

Try to cut all words that do not advance your ideas. "Empty" words are those that slow down the reader and obscure meaning. An example is: "experiments proposed in this investigation will..." In this phrase, "in this investigation" adds nothing. They are empty words. Weeding out empty words makes your writing more vigorous and direct.

To find empty words, focus on the main point of the sentence. Identify the subject and the verb. Where is the action in the sentence? Identify the words that contribute to that idea and delete phrases that add nothing.

Waffle words. Use sparingly and avoid more than one in a sentence.

Excessive waffling:	The data may suggest that the bacteria could swim.
Really excessive waffling:	The data may potentially suggest that the bacteria might be able to swim.
Just the right amount of waffling:	The data suggest that the bacteria swim.

Excessive waffling: It appears that the plasmid may potentially transfer to other bacteria.
Just the right amount of waffling: The plasmid may transfer to other bacteria.

Latin names. Match your verbs properly to Latin word endings.

Singular: The bacterium is fast.
Plural: The bacteria are fast.

When the genus name is turned into a colloquial name, don't capitalize it: "rhizobia," "pseudomonads," "enterococci," "bacilli."

7. Writing in parallel

To save words and achieve maximum clarity, use the same grammatical structure in two parts of a compound sentence. If you change verb tense in the middle of the sentence, the second part tends to dangle.

Nonparallel: Plants require water for root growth and producing seed.
Parallel: Plants require water for root growth and seed production.
Parallel: Plants require water to produce roots and seed.

Nonparallel: Seed exudate may inhibit growth of beneficial bacteria and suppressing infection of seeds by pathogens.
Parallel: Seed exudate may inhibit growth of beneficial bacteria and suppress infection of seeds by pathogens.

If you include a list of items, try to start each member of the list with the same form of speech. For example, study the following list of objectives:

Nonparallel:
To clone the gene.
Sequencing the gene.
The function of the gene will be determined.

Parallel:
To clone the gene.
To sequence the gene.
To determine the function of the gene.

8. The dreaded "that" vs. "which"

The words "that" and "which" have different uses in English, although they are often used interchangeably. The following rule used to be followed strictly in all good writing, but many people ignore it now. It is still useful, and adhering to it makes writing less ambiguous.

"That" is used in restrictive clauses, and "which" is used in nonrestrictive clauses, which are usually preceded by a comma. This may sound trivial, but the differences in meaning can be significant. Look at the following:

The pestagon that generates research about insects is in Davis, CA.
The Pestagon, which generates research about insects, is in Davis, CA.

In the first sentence, the dependent clause is "that generates research about insects" and it is absolutely essential to the sentence. It defines which pestagon, in a group of pestagons, the sentence is about. From this sentence, we infer that there must be other pestagons, but the one the writer is telling us about is the one that generates research about insects.

In the second sentence, the independent clause, "which generates research about insects," is incidental. It is an aside that tells a reader something about the Pestagon, but does not distinguish this pestagon from other pestagons. The implication of this sentence is that there is only one Pestagon.

If you can't remember the rule about clauses, look for the comma. A comma always precedes the appropriate use of "which" in the middle of a sentence.

DRAFTING A SCIENTIFIC PAPER

Readers usually expect a scientific paper to adhere to the following organization:

Title. Use a concise phrase that captures the most important point of the paper.

Abstract. Provide your reader with a synopsis of your work that will stand alone and stimulate the reader's curiosity.

Introduction. The introduction identifies the topic in broad terms to capture the widest diversity of readers, offers a specific illustration of that topic, then explains why the topic is important and articulates a research question or claim that your paper will answer.

Methods. Provide a clear description of what you did and how you did it, complete enough that someone could repeat your experiments successfully. Reference published methods appropriately. The balance between how much you say and how much you reference depends on the journal.

Results. Introduce the results with a brief rationale (no more than a phrase or a sentence) for what you have done. Then launch into what you have found. Don't simply repeat what is obvious in the tables and figures. Restate only the most important results, and then use this section to indicate patterns and trends in the data.

Figures and Tables. Make sure the legends are clear and complete, enabling a reader to make sense of your findings without reading the text. Make sure that headings of columns in tables refer to the data and units in the columns. Make sure that axes on graphs are labeled clearly and units are defined.

Discussion. Start with a summary of the important findings in your paper, drawing them together in a new way that doesn't simply repeat the Results section. Then launch into interpretation. Why are your data significant, and what new insight do they give us into your research question? Into your topic in general? Do they point us in new directions or promote a new understanding of an old concept? How do your results articulate with previous findings in your field? What cautions must we use in interpreting or extrapolating these results and what limitations are intrinsic to your methods? Finally, what are the next key steps, how does your work lay the foundation for them, and how will they contribute to the larger picture of the field?

Remember that the less you say, the greater the impact of what you do say. Be absolutely ruthless with the Discussion—make a list of the points you want your reader to understand and then write a paragraph about each. If you go on and on, your readers will lose your key points and you are probably restating results or delving into obscure detail. If you must elaborate, make it absolutely clear to your reader why all of these points must be considered. The Discussion of a paper is often the most difficult and fun to write. This is where you craft your science, giving it emphasis, texture, and context.

All the paragraphs in the Introduction, Results, and Discussion should be connected with transitions that explain how the concept you've just finished writing about relates to what you're about to start discussing. Use outlines, topic sentences, and key concepts to structure your text. If it's not clear to you what you want to say before you write it, you can be sure your readers won't get it.

Jo Handelsman
Department of Molecular, Cellular and Developmental Biology
Yale University

With contributions from Christina Matta and Brad Hughes, University of Wisconsin-Madison