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# WRITING THE SCIENTIFIC PAPER

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Reduced to simple definition, a good scientific paper is a clear, concise, and accurate record of work done, or things seen, and conclusions drawn.

Item follows item in orderly array. Items logically related are grouped. Ideally, each succeeding item is a natural, logical outgrowth of the one before. The ideal is seldom attained.

Each statement stands the test of truth and clarity. Not only is it so clear that it can be readily understood by scientists; it is so crystal clear that it cannot be misunderstood or misinterpreted—by even an editor.

The good scientific paper is written with unassuming simplicity and genuine humility. Its writer is plagued with no illusions that he alone can greatly change the course of world events. He knows that at work are many skilled scientists, of whom he is only one. He feels a rewarding glow if he senses that, in the eyes of fellow scientists, he has pushed back the curtains of darkness even a few inches.

## The Approach

Scientists vary in their approach to the exertion involved in writing a paper. Some begin by making tortuous outlines that they discard after the first few hours of futile writing. Some begin by writing introductory or concluding sentences. Some begin by doodling. A few rare individuals think through the problem, make a well-organized outline of suitable simplicity, or complexity, and follow this outline to the bitter, exhausting end—or until the outline becomes the master, not the servant, of the writer.

Thoughtful planning should precede writing. Each writer-scientist should choose the approach that best fits his temperament, personality, and mood of the moment. Once he has made the momentous decision that the paper should be written, he should not wait long for the creative mood to descend upon him, or he may never begin. The creative mood can be created. Often it follows rather than precedes creation. The important thing in beginning a paper is to begin.

## Form

The form of the scientific paper has a number of possibilities. It may contain one to several of the following sections:

*Introduction.*—In this section should be recited the reasons for writing the paper.

*Acknowledgments.* — Included should be names and identifications of only those persons who have given genuine help, not the names of those the author wishes merely to flatter. It may be made painlessly brief and included with the introduction.

*Review of the Literature.*—Here the scientist finds himself presented with an opportunity to reveal what kind of man he is. He can impress the neophytes in the field by putting in all references, whether or not he has consulted them, whose titles indicate that they are even remotely related to the subject of his paper. He can omit all references, implying thereby that he is pioneering in a totally virgin field. He can include references to papers written by his friends and omit mention of those written by scientists he regards as his enemies. He can follow a more ethical procedure and, after painstaking perusal of the literature in the field, include references to all those papers he has consulted that are truly pertinent to the subject.

*Materials and Methods.*—The explanation in this section should be detailed enough to allow other scientists to check on the authenticity of the work or to duplicate the procedures upon which the paper is based. As in other sections, good judgment is needed here to determine what material should be included and what omitted.

*Main Body of the Paper.*—Great latitude is possible in this section, which should include the results of the experiments to be reported upon and may include interpretations and conclusions. Negative results, sometimes more important than positive results, should not be omitted.

*Discussion.*—This section is a possibility but not a necessity. It is more easily justified for some papers than for others. It should be not merely a convenient depository for after-thoughts. If it is to justify the space it occupies, it should be considerably more than a rehash of results. It should clarify rather than confuse issues. It may be regarded as a convenient place for: 1) bringing together facts presented in various parts of the paper and pointing out any pertinent interrelationships that exist; 2) interpreting results broadly; 3) taking a refreshing, wide-eyed look at the width and depth of problems discussed in the paper; and 4) projecting whatever thinking may be induced by the paper at least a little way into the future.

*Conclusions.*—A separate section consisting of conclusions can be used advantageously in some papers to entice hasty fellow scientists to read something more than the summary. It should deliver faithfully what its name promises.

*Summary.*—The summary should be a chronological epitomization of the preceding parts of the paper. It should include all of the most important points of the paper and should introduce no new material. Even at the risk of repetition, the abstractions should be so worded that they are in unmistakable agreement with the originals.

*Literature Cited.*—Included in this section should be data on only those papers actually cited.

*Appendix.*—Use of this section should be avoided whenever possible. Most material important enough to be included with a paper is important enough to be included in the paper.

## Blood and Sweat

The actual writing of the paper should be preceded by a complete emptying of the mind of the scien-

tist and the gradual sifting back into it of only those items pertinent to the subject. Rejected should be the pet hunches, blind spots, preconceptions, and prejudices that customarily serve as road blocks to right conclusions. Rejected at the writing of the first draft should be a too-conscious subservience to rhetorical trivia. Commas can be inserted in, or deleted from, the paper at a later date.

The thought process should precede the writing process, but, unfortunately, some writer-scientists reverse the procedure. Clear writing should, and usually does, result from clear thinking. Only by chance can clear writing derive from muddy thinking.

Common signs of muddy thinking are the following:

1.—Illogical or unrelated grouping of facts.

2.—Unjustified switch in point of view (sometimes indicated by change of subject, or of voice, as from active to passive).

3.—Use of obscure or doubtful antecedents for pronouns.

4.—Omission of vital facts or steps in procedure, interpretation, or conclusion.

5.—Needless repetition of facts.

6.—Inaccurate paraphrasing of references.

7.—Imprecise use of words, use of words in senses peculiar only to the author or a small group, or use of words for the sake of use of words.

8.—Drawing of conclusions not warranted by the facts presented —fallacious reasoning.

9.—Inclusion of only those data that are favorable to a desired conclusion, and exclusion of equally valuable data unfavorable to the conclusion.

Other common faults in scientific papers are represented by inaccuracy in making computations, in copying data, in copying quotations, and in copying items in the literature cited.

Many a writer-scientist assumes that the period at the end of the last sentence in the first draft marks completion of his paper. He is lamentably wrong. Unless he is an abnormal human being, he should at once reconcile himself to many additional hours of meticulous, arduous work. Probably he should not be satisfied with a second draft or even a third.

At this point, the writer-scientist should become the reader-scientist observing his paper critically from the lofty height of objectivity.

Many of the faults in scientific papers can be traced to reading failure—failure of the authors to read their manuscripts with thoughtfulness, thoroughness, objectivity, detachment, and patience. Patient, objective reading of early drafts will reveal fallacies and other faults that can be eliminated by the scientist of even average intelligence and ambition. Both patience and objectivity can be developed.

Some papers and some writer-scientists benefit from a resting period following one of the drafts. The resting period, which may be used for rethinking the problem and for reorienting and refreshing the writer, should not be allowed to become a rationalization for procrastination.