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The preparation of a scientific paper has less to do with literary skill than with organization (Lang, 1987). Authors of biomedical manuscripts want to organize each manuscript so that readers will be able to follow a sequence of events and understand the message. The editor (or the peer reviewer) of a biomedical manuscript reads it to discern (among other things) whether the author has organized the manuscript successfully and, if not, whether a specific rearrangement might make the manuscript more understandable to readers. Readers of a biomedical paper are usually physicians or scientists; they read a paper because they are interested in the message. If a paper is difficult to follow, such readers probably will not be interested in trying to understand it. In some cases, they will read the abstract, but seldom will that be enough to present the author's conclusions effectively. For the manuscript to be effective, it must be written with a specific plan in mind.

The organization of a medical or scientific paper mirrors the sequence of events detailed and discussed in the paper. The author-researcher begins by asking a question (in the Introduction), then undertakes the activities required to find an answer (described in the Materials and Methods), obtains and compiles the data (described in the Results), and answers the question (in the Discussion). Other important elements of the biomedical paper that require specific organization include the title and references. This chapter will briefly discuss each of these elements. Writing the abstract is covered in this book (see "Writing Abstracts," p. 92), and determining authorship is discussed in a chapter in *Essays for Biomedical Communicators: Volume 2 of Selected AMWA Workshops* (Witte, 1997).

Update of Iles RL. Organizing the scientific journal paper. In Minick P, ed. *Biomedical Communication: Selected AMWA Workshops*. Bethesda, Md: American Medical Writers Association; 1994:133-138.

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Do not overlook the obvious. Begin by thinking about the journal to which the paper will be submitted. Get a copy of the journal, read it, and familiarize yourself with its style and format. Make sure that your article is suitable for the intended journal. In the journal's "Instructions to Authors," the editor should describe acceptable types of manuscripts and give guidelines for submitting manuscripts, including the format for references. For example, some journals no longer accept case reports, and most journals have space limitations. Knowing the desired format before you start will make your paper easier to write and keep you from having to reformat it later. When you

in the paper chapter in

Factors Influencing HLA Sensitization in Implantable LVAD Recipients [Massad et al, 1997, 1120]



The journal will usually ask for a shorter version of the title, to be used as a “running title” or “running head” on subsequent pages of the manuscript. The running title is typed on the manuscript’s title page and is generally limited to 40 character spaces. Remember to include all of the main words from the title, specifying the independent and dependent variables whenever possible. For the running title, you can omit the species. For example, shorten

Dexamethasone Alone or in Combination with Ondansetron for the Prevention of Delayed Nausea and Vomiting Induced by Chemotherapy

to

Prevention of Delayed Nausea and Vomiting Induced by Chemotherapy [The Italian Group for Antiemetic Research, 2000, p. 1555]

Or shorten

Association Between Method of Delivery and Maternal Rehospitalization

to

Delivery Method and Postpartum Rehospitalization [Lydon-Rochelle et al, 2000, p. 1574]

AD

IMRAD stands for Introduction, Methods (and Materials), Results, and Discussion. Together, these sections constitute a scientific manuscript. The IMRAD system for writing a scientific paper originated with Pasteur, although he did not use the now-standard headings (Day, 1988). In 1972, the American Standards Institute decided to standardize all the headings used in investigative scientific papers. Thus, the IMRAD system was born. Although IMRAD is a

tense for the question and for what is known and in past tense for previous findings. And remember to use transitions.

The following brief Introduction follows the format nicely. I have italicized repeated key words and transitions, all of which make the paragraph flow well.

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Restenosis after an initially *successful percutaneous transluminal coronary angioplasty* remains an important *unsolved problem* with this *promising revas-*

Patients with angiographic evidence of clinically significant coronary artery disease necessitating PTCR were eligible for the study. Patients at high risk for ischemic events were sought in order to maximize the event rate and thus increase the opportunity to demonstrate a therapeutic effect. Patients who had received abciximab before PTCR were not eligible for enrollment [O'Neill et al, 2000, pp. 1316-1317].

complicated Methods section, like a surgical paper, always include an illustration that shows exactly how the procedure was done (Figure 2).

Explain anything that would make your reader ask "why?"—including dead-end methods and study limitations. Explain the limitations of the study methods in a matter-of-fact way. The limitations need to be addressed, but keep the statements short and simple. You do not want to overwhelm the reader with possibly negative implications.

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The last paragraph(s) of Methods should state the analytical procedures that you used to determine the significance of your Conclusions. State the procedures used to analyze each set of data and the software used for analysis. Include your rationale, detailing the main comparative analyses used. Explain whether the analyses were completed on an intention-to-treat basis. The following excerpt is a small portion of a three-paragraph description of statistical analyses for a randomized trial.

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In the Methods section, subheadings should be used whenever possible, especially when the section is long and complicated, and always for clinical trials. Sample subheadings include "Study Design," "Enrollment of Patients," "Study Protocol," "Study End Points," and "Statistical Analyses."

Because the Methods section describes work already completed, write it in past tense, in either passive or active voice. Although the active voice is more interesting to read, frequent use of "I" may seem

egotistical, so passive is often used in this section. Remember, however, that you can mix the voice and tense in scientific manuscripts, so you can change from active to passive, using active when you want more emphasis.

What were the findings? The answer is in the Results section.

The Results section, which logically answers the research question, should correlate directly with the Methods section. For every method, there should be a result. When possible, use the same order and subheadings that you used in Methods so that the correlations will be easy for the reader to follow. For example, in a manuscript called “Administration of Wine and Grape Juice Inhibits In Vivo Platelet Activity and Thrombosis in Stenosed Canine Coronary Arteries” (Demrow et al, 1995), the subheadings used by the authors in the Methods section are

- Group 1: Red Wine
- Group 2: White Wine
- Group 3: Grape Juice
- High-Performance Liquid Chromatography Analysis

Likewise, the Results section has the same headers.

Although not all headers from the two sections must mirror each other, try to keep them as closely related as possible. Another example comes from “Hemodynamic Effects of Sildenafil in Men with Severe Coronary Artery Disease” (Herrmann et al, 2000). Headers used in Methods are

- Study Subjects
- Study Protocol
- Calculations
- Statistical Analysis

whereas headers in Results are

- Clinical Characteristics
- Systemic and Pulmonary Hemodynamic Effects
- Coronary Hemodynamic Effects
- Adverse Effects

Begin each paragraph by stating a result. Do not begin by restating your methods. Cite data that establish the similarities between the treatment groups first, and then present the results of the treatment. State the effect of the intervention on the primary and secondary outcome measures in the trial and include the confidence level. Remember to use data from only

Figure 2. A s - -s s s s ↗

the study being reported. If necessary, describe a previous study in the Introduction and discuss its relevance in the Discussion, but do not include any previous work in Results. Only in certain scientific fields (eg, biochemistry) would the methods and results be reported together. In some scientific studies, in which multiple experiments lead to a final result, each experiment may be reported with its result, the paper being organized chronologically by experiment.

Also remember that the Results section is another appropriate place for tables and figures, which are perfect for presenting detailed data (Table 2 [Moynihan et al, 2000, p. 1648], Figure 3). No one wants to read strings of data written into sentences. By using illustrations, you can keep written data to a minimum. Charts make protocol results easier to understand (Figures 4 and 5). A response to treatment can be shown graphically with a line drawing (Figure 6). Bar graphs show changes better than tables (Figure 7) and can be used for more complex data to show comparisons (Figures 8 and 9). Diagrammatic illustrations can also be used to enhance figures that show the results of diagnostic tests and surgical procedures (Figure 10) and to simplify complex scientific concepts (Figure 11). Never repeat textual information in the tables or graphs. The text should supplement or highlight,

In addition to reporting percentages, include absolute numbers in parentheses when feasible:

There was no significant difference in the incidence of hospitalization for congestive heart failure between the two groups; the annual rates were 3.5 percent among the patients with a ventricular pacemaker and 3.1 percent among those with a physiologic pacemaker (reduction in relative risk, 7.9 percent; 95 percent confidence interval, -18.5 to 28.3 percent; $P = 0.52$) [Connolly et al, 2000, p. 1389].

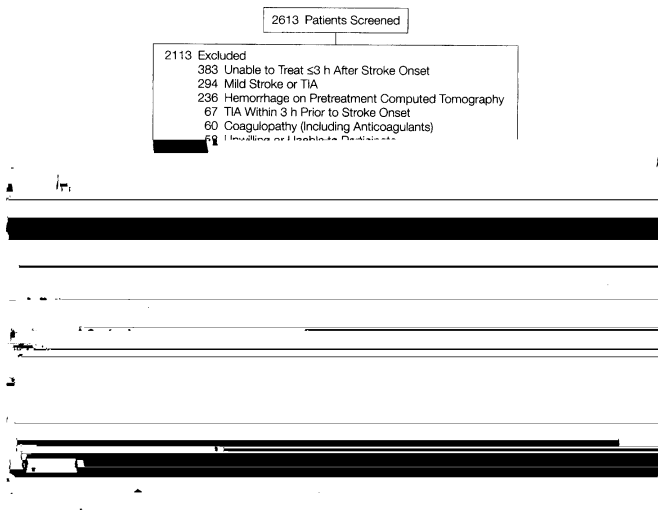


Figure 4. (Connolly et al, 2000, p. 2398)

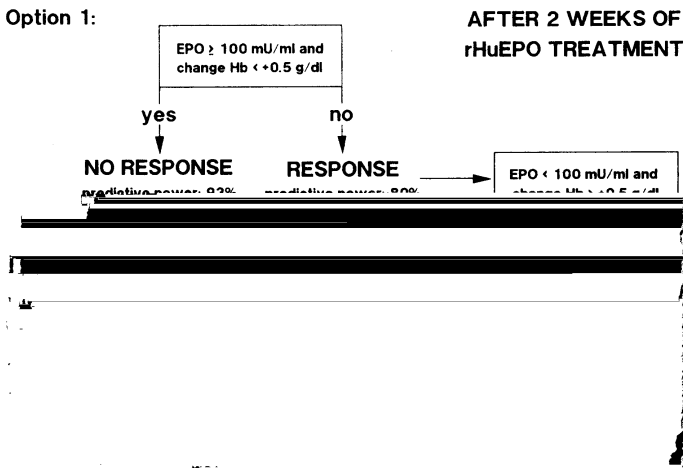
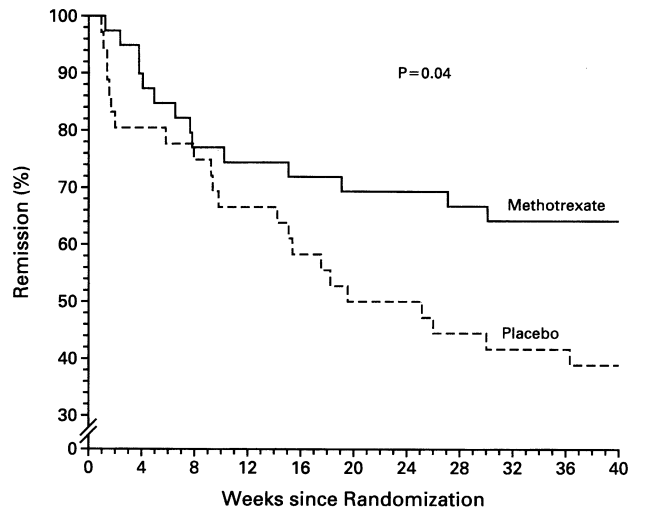


Figure 5. A (E, 1994, p. 1059)



No. At Risk	0	4	8	12	16	20	24	28	32	36	40
Methotrexate	40	36	32	28	24	20	17	14	11	8	5
Placebo	40	36	32	28	24	20	17	14	11	8	5

Figure 6. (F, 2000, p. 1630)

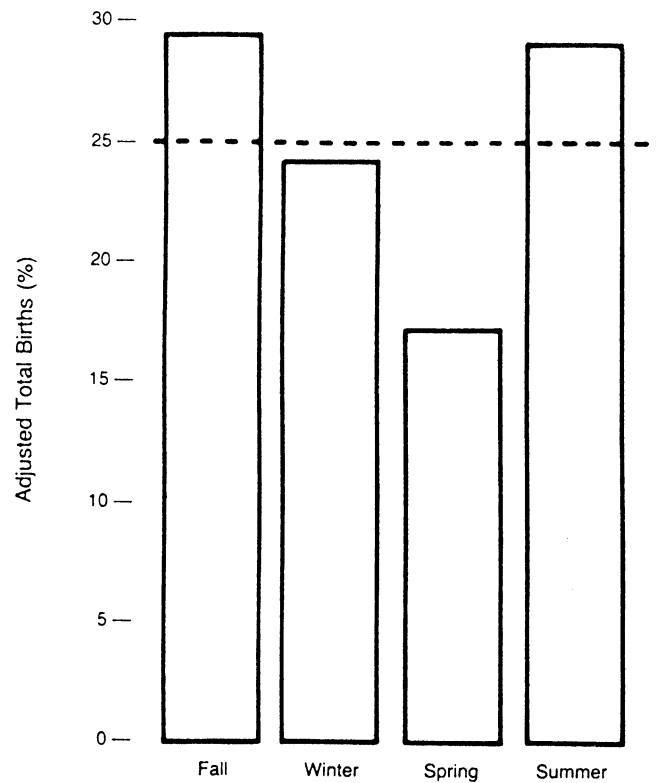


Figure 7. A (1990, p. 15)

Remember that good writing keeps the reader from having to guess the author's meaning. Whenever you use the word *significant*, report confidence intervals, standard deviations, and *P* values. Many journals now require exact *P* values, even for studied data sets for which the results are not significant.

Always state your data clearly and simply, and write in the past tense because you are describing what you have already done. If there were any deviations from the study as stated in the protocol, describe them, along with the reasons for the deviations.

D

What do your findings mean? The answer is provided by the Discussion.

The purpose of the Discussion is to explain the principles, relationships, and generalizations implied by the Results. You should discuss—not recapitulate—the results, and you need to be persuasive. Write in the present tense, except when describing results; then write in the past tense.

Every Discussion should have a beginning, middle, and end. The first sentence of the Discussion should clearly answer the research question by using the same key terms that were used in the statement of the question at the end of the Introduction. Readers should not have to guess at your answer. In the following example, note the repetition of key words and phrases.

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... to test whether abnormal *coronary* vasoconstriction detected by hyperventilation testing before angioplasty increases the likelihood of restenosis.

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... The presence of abnormal *coronary* vasoconstriction detected by hyperventilation testing before angioplasty increases the likelihood of restenosis.

Never begin the Discussion with background information, and never repeat information stated in the Introduction. Background material should be found only in the Introduction.

In the middle of the Discussion, interpret your results and show how they support your answer. Topics should be discussed in descending order of their importance to the answer. Use comparisons to other studies to explain how the results fit in with existing knowledge. You can do this in several ways:

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Our data show that oral sildenafil does not adversely affect coronary blood flow, coronary vascular resistance, or coronary flow reserve. On the basis of the decrease in the heart rate–systolic blood pressure double product (a surrogate measure of myocardial oxygen demand), we might have expected a parallel decrease in coronary blood flow due to autoregulation. The absence of such a finding in our study may reflect the inaccuracy of the double product as a true measure of myocardial demand, variations in the calculated values for coronary blood flow and resistance, or a vasodilatory effect of sildenafil that blunts the expected reduction in coronary blood flow [Herrmann et al, 2000, p. 1625].

Our study did not address the mechanism for the previously reported adverse cardiovascular events after the use of sildenafil, but our results do suggest that this mechanism is not the result of an adverse effect on coronary hemodynamics. Others have speculated that cardiac events may be due to interactions with other drugs . . . [Herrmann et al, 2000, p. 1625].

C E ()
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The fact that our study was prospective lends support to the evidence of a causal role of sleep-disordered breathing in hypertension. We found that the presence of sleep-disordered breathing was predictive of hypertension four years later [Peppard et al, 2000, p. 1382].

It is noteworthy that high percentages of the patients at low risk who were given placebo did not have delayed vomiting (87.2 percent) or moderate-to-severe

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E

Make the ending of your Conclusion section strong. The concluding paragraph should restate the answer to the research question. Begin with a signal, such as “In conclusion” or “In summary,” so your readers will know that this is the answer. After stating the Conclusion, you can briefly mention possible applications, implications, or speculations.

A

Our findings support the statement of the American College of Cardiology and the American Heart Associa-

markedly reduces hospitalizations. *J Am Coll Cardiol.* 2000;35:1737-1744.

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Marianne Mallia has worked as a medical editor and writer for 25 years. She is currently senior medical writer and manager in the Section of Scientific Publications at the Texas Heart Institute in Houston, Texas. Mallia has edited and written more than 1600 scientific articles, speeches, and books, including *Surgical Treatment of Aortic Aneurysms*, by Denton A. Cooley, MD; *Reflections and Observations: Essays of Denton A. Cooley*; *A History of the Texas Heart Institute*; and the *Heart Owner's Handbook*. For many years she served as a consultant to the *Texas Heart Institute Journal*. Mallia has served on various committees of the American Medical Writers Association (AMWA), both in the Southwest Chapter and at the national level. For more than 15 years, she has led workshops throughout the Texas Medical Center and Houston, at other institutions around the country, and at chapter and Annual Conferences for AMWA. Mallia's AMWA workshops include *Organizing the Biomedical Paper*, *Medical Manuscripts Other Than the Biomedical Paper*, *How to Organize and Run Medical Writing Internships*, and *Advanced Writing*. In 1996 she was named an AMWA Fellow, and in 1998 she received the Golden Apple Award for outstanding workshop leadership. Mallia was workshop coordinator for the 1997 and 1998 Annual Conferences, was Annual Conference Chair in 1999, and currently serves as Administrator of Education.