Chapter 2

Structure: Organizing Your Documents

If a man can group his ideas, then he is a writer.

—Robert Louis Stevenson

When discussing the organization of documents, Aristotle said, "A whole is that which has a beginning, middle, and ending." This approach is a good way to examine the organization of general scientific documents, such as reports and articles.

The beginning of a report or article serves a specific purpose—it prepares readers for the middle, which is the discussion of the work. In preparing readers for the middle, the beginning fulfills certain expectations of the readers. These expectations include defining the work, showing why the work was done, giving background for understanding the work, and revealing how the work will be presented. The middle, often called the discussion, simply presents the work. The middle states what happened in the work and states how it happened. The middle presents the results, shows where they came from, and explains what they mean. The ending of a scientific

document then further analyzes the work presented in the middle and gives a future perspective. While the middle presents each result separately, the ending looks at the results from an overall perspective.

Beginnings of Documents

The beginning to a scientific document has one task: to prepare readers for understanding the document's middle. The beginning to a scientific document is important because it determines whether the audience will continue reading. In a sense, the beginning is a make-or-break situation. The beginning of a scientific document includes the title, summary, and introduction.

Creating Titles. The title is the single most important phrase of a scientific document. The title tells readers what the document is. If your title is inexact or unclear, many people for whom you wrote the document will never read it. Consider a weak example:

Reducing the Hazards of Operations

What is this document about? Only a psychic could know. This document could be about anything from using catalytic igniters in a nuclear power plant to using new plastic gloves during operations on AIDS patients. Would you search the library stacks for this document? Probably not—your time is too valuable to spend on such a search.

Ideally, a strong title to a report or article orients readers in two ways: first, it identifies the field of study for the document; and second, it separates the document from all other documents in that field. A good test for a title is the way it reads in a list of titles recovered by a computer search. A strong title will meet the two criteria; a weak title will not.

A strong title identifies the field of study for the work. Consider an example that does not succeed:

Effects of Humidity on the Growth of Avalanches

Although this title is more specific than the first example, it still does not meet the first criterion. On the basis of this title, you might assume that this document is a geological study of rock or snow avalanches in a mountainous terrain. Actually, this document is about electron avalanches in electrical gas discharges. Therefore, the title should be revised to reveal the field of study:

Effects of Humidity on the Growth
of Electron Avalanches in Electrical Gas Discharges

Just because a title names the field of study does not mean the title is strong. Naming the field of study gets your audience to the right ballpark, but your audience still doesn't know who the teams are. In other words, you have to address the second criterion, which is to separate your work from everyone else's. Consider the following example:

Studies on the Electrodeposition of Lead on Copper

Although this title orients the audience to the area in which the work was done—plating of lead onto copper—this title is still unsuccessful. Somehow, the writer has to distinguish this work from other work in the area. For the work that this paper discussed, a better title would have been

Effects of Rhodamine-B on the Electrodeposition
of Lead on Copper

Now this title orients readers to the area of work and gives a specific detail ("effects of rhodamine-B") to distinguish this work from other work in the area.

In a title, an audience can absorb only three or four details. More than that—things begin to blur. For that reason, giving too many details is as weak as giving too few:

Effects of Rhodamine-B and Saccharin
on the Electric Double Layer During
Nickel Electrodeposition on Platinum
Studied by AC-Cyclic Voltammetry

There's just too much information given here. In a strong title, you must balance each detail's contribution against the space it acquires. If the principal aspect is the use of the new technique (AC-cyclic voltammetry), then a stronger title would be

Use of AC-Cyclic Voltammetry to Study Organic Agents
in the Electrodeposition of Nickel on Platinum

Without being too long, this title emphasizes the unique element of the research: AC-cyclic voltammetry. Ideally, you want your title to identify your work so that it stands apart from any other work on your mountain. Often, though, you cannot achieve this goal in a phrase that is both clear and precise. Nonetheless, you can usually find a title that indicates the most distinctive aspect of your work. What about details of secondary importance? Those you can present in the summary or introduction.

When writing titles, many scientists and engineers fall in love with big words and forget about the importance of the small words that are needed to couple those big words. Unfortunately, strings of big words are difficult to read.

10 MWe Solar Thermal Electric Central Receiver Barstow Power
Pilot Plant Transfer Fluid Conversion Study

What is this report about? Perhaps we can guess that some kind of solar energy plant is involved. But does this title orient? No, it overwhelms. Many details are included, but we have no sense of the relationship of those details. This particular document proposed a new heat transfer fluid for Solar One, the world's largest solar power plant. Given that, a stronger title would have been

Proposal to Use a New Heat Transfer Fluid
in the Solar One Power Plant

Notice how this revised title contains short words—"to," "a," "in," and "the"—interspersed among the bigger words. These smaller words serve as rest stops for the audience. Notice also that this document was a special situation, a proposal, as opposed to the typical situation of a report or article. By identifying special situations such as proposals and instructions in the titles, you orient the audience to the specific perspectives of those documents.

When writing a title, you should consider your readers. What do they know about the subject? What do they not know? In a title, avoid phrases that your audience will not recognize. If readers do not understand the title, they will often not read any further in the document.

Use of an IR FPA in Determining
the Temperature Gradient of a Face

Although most readers will realize that the engineer determined temperature gradients in this work, most readers probably will not recognize the acronym "IR FPA." Perhaps readers might realize that IR stands for infrared, but what about FPA? Another problem with this title is the ambiguous use of the word "face." What kind of face? A crystal face? A mountain face? In this engineer's case, the face was actually a human face, a detail that in the work was relatively unimportant. What was important here was that the engineer had developed a new way to measure temperature gradients. For that reason, a better title would have been

Determining Temperature Gradients
With a New Infrared Optical Device

In this revision, you give enough information to orient, but not so much information that you confuse.

Writing Summaries. Winston Churchill said, "Please be good enough to put your conclusions and recommendations on one sheet of paper at the very beginning of your report, so that I can even consider reading it." When the purpose of the writing is to inform, that is what summaries should do: give away the show right from the beginning and let the audience decide whether they want to read the document. Scientific writing is not mystery writing in which the results are hidden until the end. In most scientific documents, the strategy is to state up front what happened and then use the rest of the document to explain how it happened.

Many scientists and engineers find the principle of summarizing their work at the beginning difficult to swallow. They don't believe that audiences will read their papers and reports all the way through if the results are stated up front. Actually, these authors are right—many readers, after seeing a summary, will not read the entire document. However, the readers who are truly interested in the work will continue reading. Remember: The goal of scientific writing is not to entice all audiences to read to the end of your document, but either to inform or persuade the audience as efficiently as possible.

Besides emphasizing the most important details, summaries also make it easier for audiences to read through complex documents. Not being told what is going to happen in a complex document is akin to being blindfolded and forced to hike a difficult trail. Because you aren't sure in which direction you're headed or how far you'll be going, you're ready to quit as soon as the trail gets rough. The same is true for a document that doesn't state its results up front. For instance, in a paper filled with Monte Carlo simulation techniques, you may tire if you don't know what those simulations accomplish. If, however, you know that those simulations shed new light on nuclear fusion reactions, then you might stay with the paper.

Although there are many names for summaries in scientific writing, there are two main types: descriptive summaries and informative summaries. The descriptive summary tells what kind of information will occur in the document; it is a table of contents in paragraph form. The informative summary tells what results occurred in the work; it is a synopsis of the work. Not all summaries are entirely descriptive or informative. Many summaries are combinations of the two. Nevertheless, it's important to understand these two types and the advantages and disadvantages of each.

A descriptive summary (sometimes called a descriptive abstract) tells readers what kind of information the document will contain. The descriptive summary is like the by-line to a baseball game:

New York (Seaver) versus Baltimore (Cuellar)

From the byline, you know what's going to happen—which teams will play and who will be the pitchers. Descriptive summaries give the same kind of information about the document, namely, what the document will cover:

A New Chemical Process for Eliminating Nitrogen Oxides From Diesel Engine Exhausts

> This paper introduces a new chemical process for eliminating nitrogen oxides from the exhausts of diesel engines. The process uses isocyanic acid, a nontoxic chemical used to clean swimming pools. In this paper, we show how well the process reduced emissions of nitrogen oxides from a laboratory diesel engine. To explain how the process works, we present a scheme of chemical reactions.

Note that the first sentence of this descriptive summary orients the audience to the identity of the work. Don't think that the repetition between the title and summary is redundant. Being redundant is a needless repetition of details. The repetition here is purposeful—you want to clarify any doubts that the audience has about the meaning of the title. Notice also that the second sentence of this descriptive summary provides a secondary detail that

could not fit into the title. When you cannot find a concise title to separate your work from everyone else's work, you can use the summary to do so. The final two sentences of this descriptive summary list chronologically what will occur in the document: a discussion of the experiment followed by discussion of the theory.

Notice also that a descriptive summary can be written ahead of time. Because the descriptive summary tells what the document will cover, instead of which results were found, you can often write the descriptive summary days, weeks, even months before the document. In fact, many people find themselves writing descriptive summaries to conference proceedings, even though the work is not yet finished. Notice also how concise a descriptive summary is, often only two or three sentences. For that reason, this kind of summary can be read quickly:

> This paper describes a new inertial navigation system for mapping oil and gas wells. In this paper the mapping accuracy and speed of this new system are compared against the mapping accuracies and speeds of conventional systems.

An informative summary, often called an executive summary when written for management, is the second kind of summary. Unlike descriptive summaries, informative summaries do present the actual results of the work. Informative summaries are analogous to box scores from baseball. In box scores, such as the ones for the famous 1969 World Series shown below, you gather the most important results of the games: how many runs (R) each team scored, how many hits (H) each team had, and how many errors (E) each team made. You also gather many secondary results such as who the winning and losing pitchers were and who hit home runs.

	First Game			R	H	E
New York Mets	0 0 0	0 0 0	1 0 0	1	6	1
Baltimore Orioles	1 0 0	3 0 0	0 0 x	4	6	0

Winning pitcher—Cuellar (1–0). Losing pitcher—Seaver (0–1).
Home runs—Baltimore: Buford (1).

Second Game

					R	H	E
New York Mets	0 0 0	1 0 0	1 0 1		2	6	0
Baltimore Orioles	0 0 0	0 0 0	1 0 0		1	2	0

Winning pitcher—Koosman (1–0). Losing pitcher—McNally (0–1).
Home runs—New York: Clendenon (1).

Third Game

					R	H	E
Baltimore Orioles	0 0 0	0 0 0	0 0 0		0	4	1
New York Mets	1 2 0	0 0 1	0 1 x		5	6	0

Winning pitcher—Gentry (1–0). Losing pitcher—Palmer (0–1).
Home runs—New York: Agee (1) and Kranepool (1).

Fourth Game

					R	H	E
Baltimore Orioles	0 0 0	0 0 0	0 0 1	0	1	6	1
New York Mets	0 1 0	0 0 0	0 0 0	1	2	10	1

Winning pitcher—Seaver (1–1). Losing pitcher—Hall (0–1).
Home runs—New York: Clendenon (2).

Fifth Game

					R	H	E
Baltimore Orioles	0 0 3	0 0 0	0 0 0		3	5	2
New York Mets	0 0 0	0 0 2	1 2 x		5	7	0

Winning pitcher—Koosman (2–0). Losing pitcher—Watt (0–1).
Home runs—Baltimore: McNally (1), F. Robinson (1); New York: Clendenon (3), Weiss (1).

From these box scores, you can infer that the Mets won the series (four games to one), that Clendenon hit three home runs, and that Koosman, Gentry, and Seaver recorded wins for the Mets. Informative summaries give you the same kind of information—namely, what happened in the project.

Like the descriptive summary, the informative summary begins by identifying the project, but then informative summaries go much further. Informative summaries also state the main results of the project. In essence, informative summaries give readers the major conclusions and recommendations at the beginning of the document. Consider an example [Kelsey, 1983]:

> This paper describes a new inertial navigation system that will increase the mapping accuracy of oil wells by a factor of ten. The new system uses three-axis navigation that protects the sensors from high spin rates. The system also processes its information by Kalman filtering (a statistical sampling technique) in an on-site computer. Test results show that the three-dimensional location accuracy is ±0.1 meters of well depth, an accuracy ten times greater than conventional systems.
>
> Besides mapping accuracy, the inertial navigation system has three other advantages over conventional systems. First, its three-axis navigator requires no cable measurements. Second, probe alignment in the borehole no longer causes an error in displacement. Third, the navigation process is five times faster because the gyroscopes and accelerometers are protected.

This informative summary is tight—there is no needless information. Informative summaries are a sum of the significant points, and only the significant points, of the project. Informative summaries are also independent of the paper itself. For instance, unusual terms, such as Kalman filtering, are defined. After reading the informative summary, the audience would read the main text of the document to find out how the work was done, not what happened.

Everything written in the informative summary—every sentence and illustration—is either a repetition or condensation of something in the main text of the document. Because informative summaries are drawn from the main text of the document, they are the last section written. Typically, informative summaries are about 5 to 10 percent of a document's length. In a formal report, that 5 to 10 percent may include illustrations.

Which type of summary should you use? Descriptive or informative? Sometimes the purpose and audience dictate which type to use. As stated in Chapter 1, if the purpose of the document is to persuade and if you have an audience antagonistic to your results, you would not state your results up front. For instance, assume that after a long study you have decided to allow a company to mine zinc in an environmentally sensitive area. In the report that announces this decision to the public, you would withhold your decision until the latter part of the report so that you can first present your arguments for that decision. In such a report, you would use a descriptive summary rather than an informative summary.

Format often dictates which type(s) of summary you use. Journals, for example, have such tight length restrictions that you seldom have room to write an informative summary. In some journals, you have room for only a descriptive summary. Formal reports, on the other hand, do not have such tight restrictions. For that reason, you often have room in formal reports to include both types of summaries.

In still other situations, you have room for something in the middle—a summary that blends informative and descriptive elements. Consider an example [Perry and Siebers, 1986]:

A New Chemical Process for Eliminating Nitrogen Oxides From Engine and Furnace Exhausts

> This paper introduces a new chemical process for eliminating nitrogen oxides from engine and furnace exhausts. Nitrogen oxides are a major ingredient of smog and contribute heavily to acid rain. In this process, isocyanic acid—a nontoxic chemical used to clean swimming pools—converts the nitrogen oxides into steam, nitrogen, and other harmless gases. While other processes to reduce nitrogen oxides are expensive and, at best, only 70 percent effective, our new process is inexpensive and almost 100 percent effective.
>
> In laboratory tests, our process eliminated 99 percent of nitrogen oxides from the exhaust of a small diesel engine. If incorporated into diesel engines and industrial furnaces, this new process could greatly reduce the 21 million tons of nitrogen oxides released each year into the atmosphere of the United States. Besides presenting experimental results, this paper also presents a scheme of chemical reactions to explain how the process works.

Most of the sentences in this summary are informative. These sentences present the most important results: the description of the new process and its effectiveness at reducing nitrogen oxides from the exhaust of a test engine. The last sentence of the summary, though, is descriptive.

Instead of actually presenting the chemical reactions that explain the process, the summary just states that the scheme will be given. Such a descriptive treatment was necessary because the format didn't allow room for all six chemical equations.

Writing Introductions. When audiences read an introduction to a scientific document, they have expectations that have arisen from reading the introductions of other scientific documents. In general, by the end of the introduction, audiences expect answers to the following questions:

> What exactly is the work?
> Why is the work important?
> What is needed to understand the work?
> How will the work be presented?

Don't assume that your introduction must explicitly address all four questions. Depending on the work and the audience, your introduction may address only two or three of the questions. Also, don't assume that for every document the most efficient order for answering the questions is the one listed above. Again, the way you write your introduction depends on your work and your audience. In one document, you may begin your introduction by explaining what the work is. On another document, though, you may feel that your audience needs some background before learning the identity of the work. Although introductions vary in the type and order of information, introductions should be designed so that readers do not reach the middle of your document with any of these four questions still burning.

Your introduction is your first chance to define the full boundaries of your work. In the introduction, you're not cramped by space as you are in your title and summary. Therefore, you should take advantage of the opportunity:

> This paper presents a model to describe the electrical breakdown of a gas. We call this model the two-group model because of the similarity between the problem of gas breakdown and the problem of neutron transport in nuclear reactor physics. The two-group model is based on electron kinetics and applies to a broad range of conditions (breakdown in pure gases, for example). The model also provides a continuous picture of the initial phase of breakdown above the Townsend regime, both in structure of the breakdown and in the physics of the processes. [Kunhardt and Byszewski, 1980]

This introduction gives details about the work that couldn't fit into the title or summary, details such as where the theory got its name and the theory's relation to other theories.

When you identify your work in your introduction, you should specify the scope and limitations of the work. The scope includes those aspects that the project includes. The limitations are the assumptions that restrict the scope's boundaries. Scope and limitations usually go hand in hand. Often, when you identify a project's scope, you implicitly state what the limitations are. Sometimes, though, you must clarify your limitations:

> In this paper, we have compared the life expectancies of three different groups of people: heavy alcohol drinkers, moderate alcohol drinkers, and people who do not drink alcohol. We have not, however, studied the social, medical, or economic makeup of these groups—three elements that could affect life expectancies much more than alcohol intake.

The first sentence of this example specifies the scope, and the second sentence specifies the limitations. In this example, you have to specify your limitations because your limitations raise important questions that your readers might not have inferred from the scope.

Besides being an opportunity to define your work, the introduction is an opportunity to show why your work is important. Unfortunately, many scientists and engineers launch into the project's nuts and bolts without showing the importance of the work. The result is that many readers don't finish the document because they have no reason to work through the details. Reading scientific documents is taxing work, and readers need incentives to keep going. Showing the importance of the work provides an incentive.

Another reason to show the importance of the work is money. Most scientific projects depend on outside funding, and before someone will give away money, they have to be convinced that the work is important. More often than not, that particular someone will be someone outside science and engineering. Justifying your work to someone outside science can be difficult. You cannot get away with just saying the project is important, as this physicist tried to do:

> This paper presents the effects of laser field statistics on coherent anti-Stokes Raman spectroscopy intensities. The importance of coherent anti-Stokes Raman spectroscopy in studying combustion flames is widely known.

This introduction convinces readers of nothing. Instead of just telling readers that the project is important, you should show readers that the project is important, as this chemist did [Thorne and others, 1985]:

> This paper presents a design for a platinum catalytic igniter in lean hydrogen-air mixtures. This igniter has application in light-water nuclear reactors. For example, one danger at such a reactor is a loss-of-coolant accident, in which large quantities of hydrogen gas can be produced when hot water and steam react with zirconium fuel-rod cladding and steel. In a serious accident, the evolution of hydrogen may be so rapid that it produces an explosive hydrogen-air mixture in the reactor containment building. This mixture could breach the containment walls, allowing radiation to escape. To eliminate this danger, one proposed method is to ignite intentionally the hydrogen-air mixture at concentrations below those for which any serious damage might result.

Although most work has a practical application, don't assume that you have to show a practical application for all work. Many strong projects exist for the sole purpose of satisfying curiosity. In such cases, you cannot assume that your readers already share your curiosity. You must instill that curiosity. You should raise the same questions that made you curious when you began the work:

> In size, density, and composition, Ganymede and Callisto (Jupiter's two largest moons) are near twins: rock-loaded snowballs. These moons are about 5000 kilometers in diameter and contain 75 percent water by volume. The one observable difference between them is their albedo: Callisto is dark all over, while Ganymede has dark patches separated by broad light streaks. This paper discusses how these two similar moons evolved so differently. [LLNL, 1985]

How much space should you devote to justifying your work? That answer depends on your audience. If your readers are experts in your field, you may not have to justify your work explicitly—your readers might implicitly understand the importance. However, not justifying your work limits your audience. Your audience, in essence, becomes only those experts.

The third question that readers expect an introduction to answer (what is needed to understand the document?) is really a question of what background information the introduction provides. That answer depends on your readers and how much they know about your work. For instance, if you were writing about the effects of a long-duration space mission on the human immune system and if your audience was a general scientific and engineering audience, then much of the background would be on the human immune system itself. However, if your audience consisted of immunologists, then much of the background would be on something else, perhaps a review of the immunology findings from previous space missions.

In general, the less your audience knows about your subject, the more difficult it is to write the background section. Unless you plan to spend the rest of your career

on one document, you can't begin at the lowest stratum of science with Euclid or Archimedes and cover everything in between. You have to be selective. For instance, if it were 1913 and you were Niels Bohr writing the theory of the hydrogen atom, you might assume your readers were familiar with Balmer's equation for wavelength and Coulomb's law of force, but not with Rutherford's nuclear model for the atom, which was proposed in 1911. You might then start your paper at an "elevation of knowledge" somewhere just below Rutherford's work.

No matter how much your readers know about your work, you should be selective with background material, particularly in journal articles. Because most formats for journals have tight space constraints, you should provide background on those things that your audience really needs. Many scientists and engineers mistakenly assume that they have to provide a historical discussion with each document. If a historical discussion serves your readers in the document, then provide it. However, in many documents, other kinds of information such as definitions of key terms are more important.

Also, don't assume that all background information must go into the introduction. Sometimes, if you have a lot of background information, your document will read more efficiently if in the introduction, you restrict yourself to background that applies to the entire document. In other words, if the background is pertinent to only one section of the middle, then place that background within that particular section. If you have a lot of overall background information, you might place that background information in a separate section following the introduction so that the background information does not overwhelm the other aspects of the introduction.

The last expectation that an audience has for an introduction is the mapping. In general, the longer a document is, the more important the mapping of the work becomes. This principle is not only true in scientific writing, but in all kinds of communication. Anyone who has ever attended a Southern Baptist revival understands this point. In a Southern Baptist revival, the preacher has no time limit. One saving grace, though, is that most Southern Baptist revival preachers use three-point sermons. In a three-point sermon, the preacher states in the beginning the three points to be covered—say Sin A, Sin B, and Sin C—and then the preacher covers those three sins, one at a time, and in the order stated. Once the preacher has covered all three sins, the sermon is over and you sing the invitational hymn. This mapping of the sermon's structure allows the congregation to know at any given moment in the sermon about how much longer the preacher will be speaking. For a congregation in the South during a muggy summer evening, that information is important. If the preacher's only on Sin A, you know you've got a while to go. You sit still and breathe slowly. However, if the preacher is on Sin C, you relax a little, wipe the sweat from your forehead, and slide your thumb to the hymn of invitation.

Although the subject matter for your documents will be different than the subject matter of a revival sermon, the principle of mapping remains the same. Consider the mapping in this journal article about a "nuclear winter" [Garberson, 1985]:

> This report discusses the effects of smoke on the earth's climate following a large-scale nuclear war. In the first section of the report, we present a war scenario in which 10,000 megatons of high-yield weapons detonate. The second section of the report then introduces assumptions for the amount of smoke produced from resulting fires, the chemical characteristics of the smoke, and the altitudes at which the smoke initially enters the atmosphere. In the third section, we present computer models that show how the smoke distributes itself in the weeks and months following the war. Finally, in the fourth section, we discuss how the earth's climate changes as a result of that smoke distribution.

Once you have given a map of your strategy, you are obligated to stick with it. Nothing makes a congregation more restless than a preacher who promises to talk about three sins and then covers four.

You might ask what is the point of mapping the document in the introduction, when the summary has already done that. Two reasons exist. First, by mapping the document at the end of the introduction, you make a nice transition from the beginning to the middle of the document. Second, in some documents, the reader desires a justification for why you organized the document as you did. For instance, in an evaluation article, why do you discuss Option A before Option B? A summary does not have space to provide this kind of information; an introduction does.

Middles of Documents

The middle, or discussion, of a scientific document simply presents the work. In the middle, you state what happened as well as how it happened. You state the results, show where they come from, and explain what they mean. What organization problems must you surmount in the middle? In writing the middle, you select a strategy and then convey that strategy to the audience in your choice of headings and subheadings. There are many logical strategies in scientific writing: chronological strategies, spatial strategies, flow strategies, as well as the traditional strategies, such as cause-effect, that you studied in high school. The names of these strategies aren't so important. What's important is that you choose a logical strategy that is appropriate for your audience. Also important is that you reveal that strategy through your headings and subheadings.

Choosing an Appropriate Strategy. To describe your work, you can draw from a number of strategies. Which strategy is the most appropriate? This answer depends, as you might imagine, on the subject and audience.

One of the most common strategies is the chronological strategy, which follows the variable of time. Chronological strategies are appropriate in discussions of time-line processes and cyclic processes. In a time-line process such as the evolution of Hawaiian volcanoes, you would follow the development of the volcano through its eight life stages. In a cyclic process, such as the orbit of a comet, you would designate a beginning to the orbit and follow the process until it completes the cycle.

Note that in both situations, you assign markers that divide the process into stages or steps. When dividing a process into steps, you should try to group the steps into clusters of twos, threes, or fours so that your audience can remember them. Although readers occasionally remember longer lists, such as the months of the year, lists longer than four tax the memory. How then would you handle a situation, such as the Hawaiian volcano, in which you have eight steps [Bullard, 1976]? One way is to break the list of eight into two lists of four: the building stages and the declining stages. In the building stages, the volcano develops from the sea floor to a volcano above sea level (Kilauea is a good example of a volcano in the building stages). In the declining stages, the volcano deteriorates due to erosional effects (Oahu exemplifies a volcano in the declining stages).

- Building Stages
    - Explosive Submarine Stage
    - Lava-Producing Stage
    - Collapse Stage
    - Cinder-Cone Stage
- Declining Stages
    - Marine and Steam-Erosion Stage
    - Submergence and Fringing-Reef Stage
    - Secondary Eruptions and Barrier-Reef Stage
    - Atoll and Resubmergence Stage

Another common strategy is the spatial strategy. Here, the strategy follows the physical shape of a form or object: the curvature of a fossil, the dispersion of a volcano's ash plume, or the shape of a comet. As with chronological strategies, you would want to divide the form into two, three, or four distinct parts. For instance, in describing a comet, you might divide the comet into its head, coma, and tail.

A third common strategy in science and engineering is to follow the flow of some variable, such as energy or mass, through a system. Consider, for example, the nuclear fusion experiment in Figure 2-1. For this system, you could choose a spatial strategy in which you begin with the circumference of the experiment and then work your way radially inward. Given the complexity of this experiment, though, this strategy proves cumbersome. A better strategy would be to follow the flow of energy through the system. This strategy reduces the experiment from three dimensions to one dimension. In this strategy,

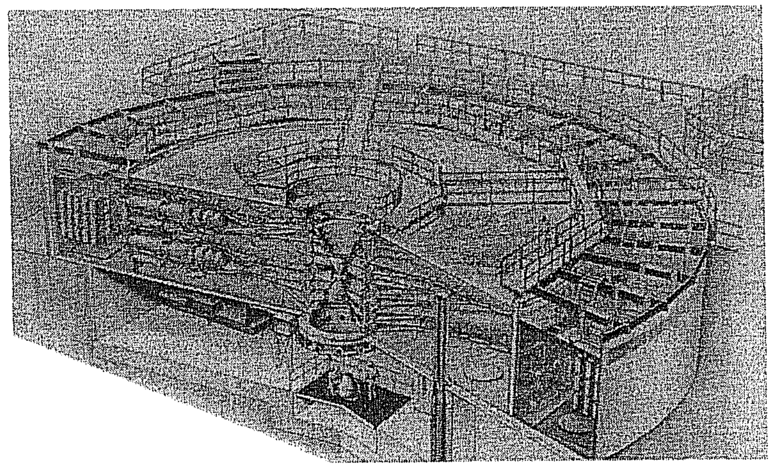

Figure 2-1. Cutaway of nuclear fusion experiment at Sandia National Laboratories. Here, an accelerator focuses lithium ions onto deuterium-tritium pellets in an attempt to produce nuclear fusion [VanDevender, 1985].

you follow the energy as it changes from electrical energy to particle beam energy and then to fusion energy. As with the first strategy, you end up moving radially inward, but unlike the first strategy, you have your audience thinking in one dimension rather than three.

As stated earlier, the organizational problems in scientific writing usually don't arise because the chosen strategies are illogical. Rather, the problems arise because the logical strategies chosen are inappropriate for the audience. In describing the nuclear fusion experiment, the flow of energy from electrical energy to fusion energy works well for a technical audience. However, for a non-technical audience, such as the United States Congress, which is deciding whether to fund this project, you might reconsider this strategy. Because Congress thinks of the project as a nuclear fusion project, you might begin with the fusion energy rather than with the electrical energy:

> In our scheme of producing nuclear fusion, we compress tiny deuterium-tritium pellets, which are about the size of BBs. To compress these pellets, we require the energy of a focused beam—in our scheme, a beam of lithium ions. Producing this particle beam requires a huge pulse of electrical energy, which is supplied here by a Marx bank generator.

For this non-technical audience, we've moved backwards from the recognized goal of producing nuclear fusion to the unfamiliar steps of generating a particle beam and charging a Marx bank generator. We've chosen not only a logical strategy, but an appropriate strategy.

The traditional strategies that you learned in high school are also common in scientific writing. For instance, you use a division-classification organization to group items into parallel parts. Take the example of the global climatic effects following a nuclear blast. These effects include radiation fallout, nitrogen oxides, and smoke. Now you could choose a chronological strategy and discuss each of these three effects during the first week after the blast, then the second week, and then the third. This strat-

egy proves cumbersome though because the time scales for the effects are so different—the global climatic effects of radiation fallout take place over a matter of hours, while the effects of smoke continue for weeks. A better strategy involves treating each effect separately:

> Effects of Radiation
> Effects of Nitrogen Oxides
> Effects of Smoke

Granted, within each of the three sections, you would probably use a chronological strategy, but your overall strategy would be a classification into parallel parts. Cause-effect organizations and comparison-contrast organizations also occur in scientific writing. Cause-effect organizations serve documents in which you investigate why things occur (for instance, why the *Titanic* sank so quickly). Likewise, comparison-contrast organizations serve documents in which you evaluate a number of options (for instance, an evaluation of lifeboat designs for a cruise ship).

Choosing an appropriate strategy is not a paint-by-numbers decision. You can't pull out a chronological strategy for instructions or a spatial strategy for equipment specifications and expect the strategy to work every time. For each document, you should tailor a strategy that is appropriate for the subject matter and the audience. Tailoring a strategy is often a trial-and-error process. You envision a path, you try it, and then you look back to see whether it works for your subject matter and audience.

Creating Sections and Subsections. For scientific documents that are longer than a couple of pages, having sections and subsections becomes important. Why? One reason is that sections and subsections show readers the strategy of the document. The headings and subheadings act as a roadmap for readers. When the headings and subheadings are well-written, the readers can quickly see the document's organization. Sections and subsections also provide readers with white space. Readers of scientific papers and reports need white space so that they have time to rest and reflect on what they have read. Besides showing strategy and providing white space, sections and subsections allow readers to jump to information that interests them. Along the same lines, sections and subsections allow readers to skip information that does not interest them. Remember: The primary purpose of your writing is not to entice readers into reading every word you've written, but to inform or persuade your audience as efficiently as possible.

How long should your sections and subsections be? As with most questions about style, there is no absolute answer. If your sections are too long to read in one sitting, your readers will tire in the same way that a driver tires from a long stretch of highway. On the other hand, if your sections are too short, your paper or report will appear as a collage of titles and subtitles. The unnecessary white space will cause your readers to make too many starts and stops. The overall effect is that your readers will tire much in the same way that a driver tires from the starts and stops of congested city traffic.

How should you title a section? When creating titles for sections, you should strive for the same clarity and precision that you have attained in the title of a document. Don't resign yourself as many scientists and engineers do to cryptic one-word titles that clue the readers to nothing:

Slurry
    Combustion
    Pollution
Dry
    Combustion
    Pollution

These titles are vague. Because readers often skim through documents to look for particular results, you want your

heading titles to indicate the sections where those results can be found.

Coal-Water Slurry
    Combustion Efficiency
    Combustion Emissions
Dry Pulverized Coal
    Combustion Efficiency
    Combustion Emissions

When creating titles for sections, you should also consider the parallelism of the titles. In other words, don't write

Mining the Coal
Transportation Stage
Burning the Coal

The second heading is not parallel to the other two. Think of your sections as pieces of a pie. It makes no sense to slice a pie and have one piece be apple and another be pecan. If your first subsection title is a noun phrase, then all the subsection titles of that section should be noun phrases. Likewise, if your first subsection title is a participial phrase, then all the subsection titles of that section should be participial phrases.

Noun Phrase	**Participial Phrase**
Mining Stage	Mining the Coal
Transportation Stage	Transporting the Coal
Combustion Stage	Burning the Coal

Finally, if you break your information into one subsection, you must have a second. Having a single subsection is similar to slicing a pie and ending up with only one piece:

Precombustion Processes
    Coal Cleaning
Combustion Processes
Postcombustion Processes

Because "Coal Cleaning" has nothing to be parallel to, this breakdown is inherently non-parallel. You should either include another subsection beneath "Precombustion Processes," such as "Coal Switching," or drop the "Coal Cleaning" subsection:

Precombustion Processes	Precombustion Processes
Coal Cleaning	Combustion Processes
Coal Switching	Postcombustion Processes
Combustion Processes	
Postcombustion Processes	

A good test for headings is how well they reveal the organization of the document when they stand alone as a table of contents. If they do not reveal the organization, then you should reconsider them. In the following example from a progress report on the forensic investigation of Pan Am Flight 103, the weak headings on the left suffer from a number of problems: vague descriptions, non-parallelisms, and single-item subheadings.

Weak Headings	**Strong Headings**
Debris Recovered	Completed Work
Cataloguing	Recovering Debris
Interpretation	Cataloguing Debris
Results	Interpreting the Debris
Placement	Preliminary Results of Work
Bomb Makeup	Placement of Bomb
Work to Be Done	Construction of Bomb
Interpretation	Future Work

In the revision on the right, notice the parallelism on the heading level and in each subheading grouping. Also notice that the revision reveals the overall strategy for the document.

Endings of Documents

The ending of a scientific document provides closure. The ending contains the conclusion sections (of the main text) as well as the back matter. Just as readers have

certain expectations for an introduction, readers have certain expectations for the conclusion sections. First, in the conclusion sections, readers expect an analysis of the most important results from the document's discussion. Second, readers expect a future perspective on the work. While readers have certain expectations for the conclusion sections, they generally do not for the back matter. Because of that, back matter sections vary considerably. In a document such as a journal article, the back matter is usually nothing more than a list of references. In a formal report, though, the back matter might contain several appendices, a glossary, an index, as well as a bibliography.

Writing Conclusion Sections. Readers have two expectations for the conclusion sections of a scientific document: an analysis of the key results from the document's middle and a future perspective on the work. What's the difference between the analysis in the conclusion sections and the analysis in the discussion? In the conclusion's analysis, you treat the results as a whole, rather than individually as you did in the discussion. Note that in this analysis you should not act like Perry Mason and bring in new evidence that unravels the mystery of your project. In other words, the conclusion's analysis should arise from the findings presented in the discussion.

Besides presenting an analysis of the key results in the conclusion sections, you also give a future perspective on the work. In some documents that future perspective might be recommendations. In other documents that future perspective might be a nod to the direction in which your research will head. A third kind of future perspective is to mirror the scope and limitations that you presented in the beginning of the document. In the document's beginning, you started with a "big picture" and focused until you reached the scope and limitations of the work. In the conclusion, you now take the work's results that you discussed in the document's middle and show the ramifications of those results on the big picture. In a sense, you complete a circle because in the document's beginning, you started with the big picture, and here you end with the big picture.

How long should a conclusion be? For a short paper, a conclusion may be only one paragraph or even one sentence:

> These tests showed that a nonpowered igniter for lean hydrogen-air mixtures is feasible, and that such an igniter could contribute to the safety of light water nuclear reactors by igniting safe concentrations of hydrogen during a loss-of-coolant accident [Thorne and others, 1985].

Typically, a conclusion section runs the length of an informative summary—about 5 to 10 percent of the length of the main text. What's the difference between a conclusion and an informative summary? Sometimes, very little. However, a conclusion addresses an audience that has read the document, while an informative summary does not. Because of this difference in audience, a conclusion gives you the chance to go into more depth on the results and recommendations.

Another way to look at a conclusion is to see it as bringing together the loose ends of your work. Although you typically cannot tie everything into a neat package, you can convey some sense of closure to your audience. In other words, you don't have to reach a summit in your conclusion, but you should arrive at a plateau.

Consider a conclusion section to a report [Jansen, 1991] about the forensic investigation into the downing of Pan Am Flight 103. Notice that the future perspective in this paper is a series of recommendations.

> **Conclusions**
>
> The bombing of Pan Am Flight 103 on December 21, 1988, was the worst aviation accident in British history. All 259 passengers on board the aircraft as well as 11 residents of Lockerbie, Scotland, where the plane fell, were killed. The mid-air explosion spread wreckage from the plane over a 1000 square mile area, and more than one thousand workers were needed to collect the debris of the plane [Brown, 1989].
>
> ***Summary of Investigation.*** The forensic investigation into this disaster combined scientifically advanced techniques to reach certain conclusions about the responsible terrorists and their methods. When the bomb aboard Flight 103 exploded, it sent thousands of pieces of debris to the ground. The main way that authorities recovered this debris was by a ground search. The search party consisted of over one thousand volunteers, police, and soldiers, and the search area was about 1000 square miles. This area the authorities divided into twelve sections—each section being about 80 square miles. In addition to the ground search, authorities used infrared photography from satellites and low-flying airplanes. As the wreckage was collected from the ground around Lockerbie, it was brought to an empty airplane hangar several miles from the crash site, where technicians slowly reconstructed the Boeing 747.
>
> In the investigation, one of the first questions that officials asked was, "Where was the bomb on the plane?" During the explosion, the temperatures and pressures inside the cargo hold of the plane reached enormous levels. Temperature and pressures of this magnitude cause certain changes in metals. By studying these changes, forensic analysts estimated the bomb's location. After inspecting many pieces of the plane, analysts concluded that the bomb had exploded just under the "P" in the Pan Am logo. Analysts also concluded which cargo bay (14L) had stored the bomb.
>
> A gas chromatograph analyzed the chemical composition of each piece of debris that was brought in from the crash site. The chromatograph told researchers how much residue from the bomb was on the piece of debris. From the chromatograph findings, researchers decided that the bomb had been located in a copper-colored Samsonite suitcase [Emerson and Duffy, 1990].
>
> Researchers also determined that the bomb placed aboard Flight 103 was technologically advanced. By comparing the chemical composition of the bomb residue to compositions of known explosives, researchers concluded that the explosive was Semtex, a Czech-made plastic explosive. From the tiny fragments of the bomb imbedded in the items around it, bomb experts learned that the bomb used a two-step detonator, which exploded the bomb only after both

detonators were activated. The first detonator was a barometric detonator that went off when the plane's altitude caused the pressure inside the cargo bay to dip below a certain level. The second detonator was a simple timer.

One of the parts of the bomb that authorities recovered was a microchip from the detonator circuit. This microchip had the same structure as a microchip found on two Libyan agents who in 1986 were caught carrying twenty pounds of Semtex into Senegal [Wright and Ostrow, 1991].

Something that confused investigators in the early part of the investigation was that the pilot had not sent any distress signal. Although the plane began to break up soon after the bomb detonated, authorities felt that the pilot would have had time to send a "Mayday" call. However, once it was concluded that the bomb had detonated in cargo bay 14L, airplane experts realized that the bomb had damaged the plane's electronics center. This center receives electrical energy from the plane's engines and distributes it to every electronic device on the plane. When the bomb damaged this electrical station, the radios used to send distress signals became useless [Emerson and Duffy, 1990].

From the collected pieces of plane wreckage, experts were able to tell how the plane disintegrated. The explosion produced one large hole in the fuselage and another in the main cabin floor of the forward cargo hold. The pressure blast of the bomb caused large cracks to develop along the fuselage and floor, even though the aircraft had been specially strengthened to carry military freight during national emergencies. The cockpit, nose, and forward cabin then separated from the rear section of the plane [Shifrin, 1990].

Perhaps the most important result of the investigation was that authorities collected enough evidence to bring the case to trial. The microchip recovered from the bomb's detonator linked the regime of Libya's Moammar Gadhafi to the bombing. Authorities believe that the bombing was in retaliation for the 1986 bombing of Tripoli by the United States [Wright and Ostrow, 1991]. Also, the cargo bay containing the bomb held many bags from Malta, a country closely allied with Libya. Although two Libyans have been identified as being responsible for planting the bomb, authorities still have not been able to extradite them.

Recommendations of Investigation. The investigation into the bombing of Pan Am Flight 103 led to several recommendations to help prevent another explosion of this kind. Some of these recommendations were for changes to airplane construction; other recommendations were for changes in airport safety.

Recommendations for changes in airplane construction fell into two categories: changes in the cargo-bay design and changes in the flight-recorder apparatus. After reviewing the investigation, the Air Accidents Investigation Branch of the British Transport Department recommended that all luggage be contained in stronger cargo bays. Although authorities admit that such measures could not have prevented the Flight 103 disaster, they feel that stronger cargo bays could allow planes to survive explosions of smaller bombs [Shifrin, 1990].

Other suggestions for changes to airplanes concerned the flight recorders. Because the bomb of Flight 103 cut power to the flight recorders, the recorders were of no help to the investigation. Part of the problem was that the voice recorders had no power backup. Furthermore, several minutes of recordings were stored in volatile memory (which is erased in a power failure) before being transferred to magnetic tape. Therefore, not only were investigators unable to hear what happened in the plane after the power went out, but they were also unable to hear what happened just before that time. The Air Accidents Investigation Branch recommended that flight recorders have back-up batteries, and that their volatile memory be replaced with non-volatile memory [Shifrin, 1990].

Although the proposed changes to airplanes would certainly help reduce the effects of bombs and make the subsequent investigations easier to carry out, keeping bombs off planes was made a higher priority. To do so, authorities imposed several new security restrictions on airports, particularly those in Europe and the Middle East. First, authorities insisted that each bag correspond to a passenger, and that if a passenger gets off the plane, the corresponding bags get off as well. Second, authorities began randomly searching passengers and their bags. Last, authorities stepped up plans to install sophisticated devices capable of detecting plastic explosives such as Semtex [Watson and others, 1989].

Writing the Back Matter. Rarely will you write a report for only one type of audience. Most scientific reports have several types of readers, each type with a different technical background and reason for reading the report. How then do you write the main text of your report for all these audiences? The answer is that you don't. You write the text of your report for your main audience, and you supply back matter in the form of appendices and glossaries for your secondary audiences.

Often, you write appendices to give additional information to secondary audiences. This information can take many forms. For instance, a common type of appendix presents background information to a less technical audience. For example, if you had written a report on improving a chemical test for the forensic analysis of blood, you might include for less technical readers an appendix [Mickey, 1993] explaining the analysis of bloodstains. As with any appendix, this appendix should stand on its own as a separate document with a beginning, middle, and ending.

Appendix
Analysis of Bloodstains

Forensic serology is an important field in forensic science because bloodstains are frequently obtained at crime scenes involving homicides, rapes, and assaults. During an examination of a suspected stain, the forensic serologist must answer three questions:

(1) Is it blood?
(2) If it is blood, is it human?
(3) If it is human blood, how closely can it be associated to a particular individual?

To answer these questions, the forensic serologist performs several tests on the stains [Saferstein, 1981].

Two blood identification tests are the phenolphthalein test and the luminol test. The phenolphthalein test is a catalytic color test that produces a deep pink color when blood, phenolphthalein, and hydrogen peroxide are mixed. The luminol test, unlike the phenolphthalein test, results in the production of light rather than color. The luminol test is used exclusively by investigators to detect small traces of blood and unusual bloodstain patterns [Lee, 1982].

After identifying a stain as blood, the serologist determines whether the bloodstain is of human origin. The precipitin test is the standard test used in forensics to determine the species of a bloodstain. By injecting an animal (usually a rabbit) with human blood, antibodies will form in the animal that react specifically with the human blood. The animal is then bled, and the blood serum is isolated. The blood evidence is layered on top of the serum in a test tube. If the blood evidence is human, a white band or cloudy ring will form at the interface of the two liquids.

The last and most important step in analyzing a bloodstain is to associate the blood to a particular individual. The traditional methods (all blood analysis methods prior to DNA fingerprinting) of tagging a bloodstain to a person require the serologist to determine the combination of blood factors in the blood sample. If a sufficient number of the blood factors can be determined, the probability of an individual having that combination of blood factors is determined by taking the product of each blood factor's frequency in the population. The traditional methods are accurate for a fresh blood sample, but most blood evidence is received in the form of dried blood stains. Few of the blood factors survive the drying and aging of a bloodstain.

DNA fingerprinting is the most accurate test used in forensics to tag a bloodstain to an individual. An advantage of DNA fingerprinting is that DNA molecules can be detected in dried blood. The most common DNA fingerprinting technique is called "restriction fragment length polymorphism" analysis, or RFLP analysis. In this analysis, RFLP patterns are visible after transferring the DNA fragments to an x-ray film. The RFLP pattern, which is similar to a bar code on groceries, is the final product of a DNA fingerprint. When the bars of two samples match, scientists conclude that the samples came from the same person. False identification of a suspect is avoided with DNA fingerprinting because degraded DNA will not produce a different RFLP pattern. As the DNA degrades, the overall RFLP pattern becomes weaker, but individual RFLP patterns are neither created nor destroyed [McNally, 1989].

Forensic scientists have studied the environmental effects of the integrity of DNA samples. These environmental effects include heat, humidity, soil, and ultraviolet light. The results of these experiments have shown that only soil contamination affects the integrity of DNA isolated from bloodstains. However, the integrity of the DNA is not altered such that false patterns are obtained. This finding substantiates the claim that DNA will not identify the wrong suspect [Shaler, 1989].

Forensic experts envision a national computer file of the DNA types of convicted felons. The California legislature already requires that sex offenders and murderers submit a sample of their DNA upon release from prison. A DNA database, similar to the FBI's fingerprint database, could revolutionize law enforcement.

Another type of appendix is one having detailed information for a more technical audience. For instance, in a report on the forensic use of gas chromatography and mass spectrometry, you might include an appendix for more technical readers on the types of mass spectrometers. This appendix could explain the workings of four common types of mass spectrometers: time-of-flight, magnetic sector, quadrupole, and ion trap. In this appendix, you could provide diagrams to explain how each spectrometer works.

Still a third kind of appendix is one that presents branch information. Sometimes you want to include secondary information that is interesting, but not directly pertinent to the results you're emphasizing. For a report on forensic techniques, that secondary type of information could be a case study, such as the case of the Birmingham Six. In this case, six men were wrongly convicted of bombing two pubs in Birmingham, England. The men were convicted on the basis of a single test, called the Greiss Test, which detected amounts of nitroglycerine. The men tested positive. Years later, while researching the Greiss test, scientists discovered that contact with many substances such as playing cards, adhesive tape, and plastic wrappers from cigarette packages produced false positives [Hamer, 1991]. Although information about this case of the Birmingham Six is not necessary for understanding your work, you still could include the information for the sake of completeness or audience interest. In such a situation, an appendix would be an appropriate place for the information.

For smooth transitions in the document, there should be at least one mention of each appendix somewhere in the main text of the report. In other words, when the occasion arises in the text, refer readers to the appendix. For example,

> The mass spectrometer must also be in a high vacuum to minimize the number of gas molecules that collide with the ions. For more information on the different types of mass spectrometers, see Appendix B.

A glossary is a special appendix that gives background definitions to secondary audiences. Let's say the primary audience for a report on the effects of spaceflight on the human immune system were immunologists and the secondary audience included NASA management. In the back of the report you might include the glossary [Bodden, 1993] given below. This glossary allows you to inform the secondary readers about the vocabulary of the report without breaking the continuity of the writing for the primary readers. Notice that if the primary readers had been NASA management, it would have been appropriate to define these terms in the text.

Glossary

antibody: a protein molecule that is released by a daughter cell of an activated B cell. Antibodies bind with antigens and serve as markers that give signals to immune cells capable of destroying the antigens.

antigen: a substance or part of a substance that is recognized as foreign by the immune system, activates the immune system, and reacts with immune cells and their products.

cytoxic: a type of activity related to destructive capabilities. Cytoxic can be used interchangeably with the word "killing."

humoral: of or pertaining to body fluids.

immune response: a defensive response by the immune system as a reaction to detection of an antigen. T cells and B cells detect antigens after the macrophage has signaled that an antigen is present. This detection by the T cells and B cells provokes the cells to respond; thus, they become activated.

immunocompetent: ability of the body's immune cells to recognize specific antigens. When T cells and B cells become immunocompetent, they are able to attack antigens.

immunodeficiency: a disease resulting from the deficient production or function of immune cells required for normal immunity.

killer T cell: a type of T cell that directly kills foreign cells, cancer cells, or virus-infected body cells.

white blood cell: a type of body cell that is involved in body protection and takes part in the immune response. For instance, lymphocytes are a specific type of white blood cell.

In creating a glossary, arrange terms in alphabetical order. Use italics or boldface in the text to key readers to the terms that the glossary will define. As with appendices, the glossary should have a direct connection to the text of the document.

Note that some documents have box stories, also called "sidebars," that fill the same role as appendices and glossaries in a report. Instead of falling at the end of the document, these box stories are formatted alongside the text so that a secondary audience can stop and read them. In practice, though, some documents have so many box stories that primary audiences need a map to find out which paragraphs in the main text to read next. In such cases, the writer has sacrificed the primary audience's continuity in reading for the chance to give background or detour information to the secondary audience—not a good trade.

Hypertext, which is a form of writing for computer documents such as those to be found on the World Wide

Web, overcomes this problem by placing box stories in hidden computer windows. The readers then have a choice: continue reading the text or access the window by clicking on a color-coded word. In essence, what hypertext provides is an efficient way for secondary readers to reach the back matter without interrupting the main text for the primary readers.

References

Bodden, C., "Effects of a Long-Duration Space Mission on the Human Immune System," *Undergraduate Engineering Review* (1993), p. 39.

Brown, David A., "Investigators Expand Search for Debris From Bombed 747," *Aviation Week and Space Technology*, vol. 130, no. 25 (January 9, 1989), pp. 26–27.

Bullard, Fred M., *Volcanoes of the Earth*, 2nd ed. (Austin: University of Texas Press, 1976).

Emerson, Steven, and Brian Duffy, *The Fall of Pan Am Flight 103* (New York: G. P. Putnam's Sons, 1990).

Garberson, Jeff, "Climate Change: From the 'Greenhouse Effect' to 'Nuclear Winter,'" *The Quarterly* (Livermore, CA: Lawrence Livermore National Laboratory, July 1985), p. 98.

Hamer, M., "Forensic Science Goes on Trial," *New Scientist* (November 9, 1991), pp. 30-33.

Janzen, P., "The Investigation Into the Fall of Pan Am Flight 103," *Undergraduate Engineering Review* (1991), pp. 53–58.

Kelsey, James, "Inertial Navigation Techniques Improve Well-Bore Survey Accuracy Ten-Fold," *Sandia Technology*, vol. 7, no. 1 (1983), p. 22.

Kunhardt, Erich, and W. Byszewski, "Development of Overvoltage Breakdown at High Pressure," *Physical Review A*, vol. 21, no. 6 (1980), p. 2069.

Lawrence Livermore National Laboratory (LLNL), "Exotic Forms of Ice in the Moons of Jupiter," *Energy and Technology Review* (Livermore, CA: Lawrence Livermore National Laboratory, July 1985), p. 98.

Lee, H. C., "Identification and Grouping of Bloodstains," *Forensic Science Handbook*, 2nd ed., ed. by R. Saferstein (Englewood Cliffs, NJ: Prentice-Hall, 1982), pp. 267–327.

McNally, L., "The Effects of Environment and Substrata on Deoxyribonucleic Acid (DNA): the Use of Casework Samples From New York City," *Journal of Forensic Sciences*, vol. 34, no. 5 (September 1989), pp. 1070–1077.

Mickey, C., "Analysis of Bloodstains," *Undergraduate Engineering Review* (1993), p. 12.

Perry, R. A., and D. L. Siebers, "A New Method to Reduce Sulfur Dioxide Emissions From Diesel Engines," *Sandia Combustion Research Program Annual Report* (Livermore, CA: Sandia National Laboratories, 1985), chap. 3, p. 3.

Saferstein, R., *Forensic Science Handbook* (Englewood Cliffs, NJ: Prentice-Hall, 1982).

Shaler, Robert, "Evaluation of Deoxyribonucleic Acid (DNA) Isolated From Human Bloodstains Exposed to Ultraviolet Light, Heat, Humidity, and Soil Contamination," *Journal of Forensic Sciences*, vol. 34, no. 5 (September 1989), pp. 1059–1069.

Shifrin, Carole A., "British Issue Report on Flight 103, Urge Study on Reducing Effects of Explosions," *Aviation Week and Space Technology*, vol. 133, no. 12 (September 7, 1990), pp. 128–129.

VanDevender, P., "Ion-Beam Focusing: A Step Toward Fusion," *Sandia Technology*, vol. 9, no. 4 (December 1985), pp. 2–13.

Wright, Robin, and Ronald J. Ostrow, "Libya Regime Suspected in Pan Am Blast," *Austin American Statesman* (June 24, 1991), section A, pp. 1, 4.

Chapter 3

Structure: Providing Transition, Depth, and Emphasis

Science is built up with facts, as a house is with stones. But a collection of facts is no more science than a heap of stones is a house.

—J. H. Poincaré

Structure is not just the organization of details. Although organizing details in a document is certainly important, many well-organized documents fail to inform because the writer has not made strong transitions between the details or has not presented the details at the proper depth or has not placed the proper emphasis on the details.

Transitions Between Details

In a scientific document, you make transitions not only between sentences and paragraphs, but between sections. You may organize your paper into logical sections, but if you don't make transitions between those sections, you can lose your readers.

In the previous chapter, several reasons were given