CHAPTER 5

Reviewing Prior Research

5.1 The Role of Prior Research in Scientific Argument

Scientific work is often conducted under solitary and isolated circumstances: late nights in the lab, long hours in the field collecting samples, visits to remote research sites. This work is neither planned nor interpreted in isolation, however. New studies are conducted because they promise to shed light on issues considered important by the research community; research questions are valid in that they reflect gaps or inconsistencies in the field's understanding; methodological decisions are made with an awareness of what has been done by others and how it has worked; and the outcomes of research are interpreted in light of the theories, questions, methods, and findings that have come before. Research becomes meaningful only when viewed in the context of the field's developing knowledge.

In his Nobel Prize lecture, Barry Marshall pointedly highlighted the situated nature of his and Robin Warren's research on *H. pylori*:

> The [lecture] title, "*Helicobacter* Connections" refers to the two components of our discovery. Firstly, we were able to associate a new bacterium with peptic ulcer disease. Secondly, we could see that the new bacteria could explain many phenomena observed by other gastric researchers over the previous 100 years. By connecting this literature with our own observations, we were able to confirm our hypothesis rather quickly. As a result, other researchers were often dismayed at our supreme confidence that these new bacteria were serious pathogens and that antibiotics would provide a cure for peptic ulcer. (Marshall 2005c)

Marshall's observation underscores the critical role of prior research in interpreting new discoveries. In the day-to-day work of scientific texts, such connections are concretely revealed through research citations. The practice of citing prior research is integral to arguments written for research audiences, including

the arguments contained in grant proposals, research reports, and many types of brief research notes and letters. The National Academy of Sciences describes this practice as follows:

> Citations serve many purposes in a scientific paper. They acknowledge the work of other scientists, direct the reader toward additional sources of information, acknowledge conflicts with other results, and provide support for the views expressed in the paper. More broadly, citations place a paper within its scientific context, relating it to the present state of scientific knowledge. (NAS 1995, p 12)

Berkenkotter and Huckin (1995) argue that this process of contextualizing one's work is essential, for "it is only when scientists place their laboratory findings within a framework of accepted knowledge that a claim to have made a scientific discovery, and thereby to have contributed to the field's body of knowledge, can be made" (p 47). The importance of situating one's work is dramatically illustrated in their case study of a biologist, June Davis, whose initial submissions of a manuscript were twice rejected by journal reviewers who were not convinced that the study's findings were significant enough to warrant publication. The manuscript was accepted only after Davis bolstered her argument by responding to reviewers' calls for more explicit connections to previous research in the introduction and discussion sections of her report (Berkenkotter and Huckin 1995). See Dong (1996) for a similar account of a doctoral student's struggle to situate his work in the context of related literature in order to complete his dissertation in genetics.

As described in Chapters 4 and 7, reports and proposals always begin by reviewing the current state of the field's knowledge of the phenomenon under study. Many proposal formats require a separate background section devoted to reviewing prior research, sometimes referred to as a "review of the literature." Research reports tend to include a more abbreviated review of research in the introduction section, but as the Davis case illustrates, this brief review serves a critical role in establishing the context for the study. Citations of prior research also appear in the discussion sections of research reports, where authors make reference to previous studies in order to help readers interpret the scope, scale, and significance of the reported findings and to help them understand how the new research extends, refines, or challenges the state of knowledge in the field. Previous studies are frequently cited in methods and results sections as well, often as precedents for specific methodological decisions or data analysis procedures. As we discussed in Chapter 4, decisions about what statements need support or justification, and how much support or justification is appropriate, depend on the writer's awareness of what the audience knows and expects. Knowing when and to what degree to qualify, explain, justify, and cite is one of the ways scientists create a professional *ethos* (Herrington 1985).

In thus acknowledging the work of others, researchers demonstrate not only that their knowledge is up to date but also that they have taken advantage of the best of the field's expertise in designing, carrying out, and interpreting their own work. Researchers who fail to acknowledge the relevant prior research will appear either naïve (if readers are charitable) or arrogant (if they have no reason to be charitable). Pons and Fleischmann again represent a case in point. In their

first paper in the *Journal of Electroanalytical Chemistry* (Fleischmann and Pons 1989), they claimed that the energy in their cold fusion experiment was produced by "an hitherto unknown nuclear process or processes" (p 301). In a critique of this paper, Huizenga (1992) criticized the researchers not only for neglecting to qualify their "risky assumption" but also for failing to "acknowledge the extensive literature on nuclear reactions acquired and the basic principles established over the last half century" (p 25). As described in Chapter 1, the general disapproval with which this research was met was due as much to the way in which Pons and Fleischmann presented and situated their work as it was to the quality of the research itself.

EXERCISE 5.1

Choose one or more full-length research reports or grant proposals, either from this text or from your own field. In each major section of the paper, find two or three sentences that include citations of previous research. How are citations used in different sections of the paper? Look for citations that support qualifications, explanations, or justifications made in the text. What other functions do citations serve in the texts you've examined?

5.2 Reviewing as a Genre: The Review Article

Before we discuss general strategies for reviewing research in scientific reports or proposals, we will briefly examine the *review article*, a distinct genre in which these strategies are paramount. Many journals publish full-length review articles, often solicited from experts in the field on topics of particular interest to the journal's readers (Noguchi 2006). Journals such as *Reviews of Modern Physics* and *Annual Review of Analytical Chemistry* are devoted entirely to this purpose. Review articles tend to be written for a journal's broadest readership, sometimes including researchers in related fields (Day and Gastel 2006; Noguchi 2006), and thus are pitched at a somewhat more general level than research reports. As described in *Nature*, review articles "survey recent developments in a topical area of scientific research or, on occasion, can be more wide-ranging" (Nature 2008d). Such surveys serve an important function in their respective fields in that they offer a comprehensive synthesis of the results of a wide and complex set of studies. In so doing, the review may have a substantial influence on how readers perceive the nature and implications of recent developments in a field and thus may influence the direction of subsequent research (Myers 1991). In their historical review of research genres, Gross et al. (2002) report that the review journal emerged in the late 19th and 20th centuries, presumably in response to the increasing volume of published literature, and coinciding with the emerging conception of research reports as developing arguments rather than simply displaying facts. Because review authors describe and evaluate the studies of others, highlighting important findings and also noting gaps or shortcomings in the literature, Gross et al. consider the review article a "second tier of peer review" (p 190). Indeed,

Noguchi (2006) points out that inclusion in a review article indicates a certain level of acceptance or recognition of a finding, functioning in effect as "'a coming of age ceremony' to make official the recognition of a fact as a portion of 'truth' and as such, allow it to be used to construct other truths" (p 244). Thus, though research reviews do not report new results, they nevertheless play an important role in the development of disciplinary knowledge.

The review article we've included in Chapter 9 (page 234) illustrates two primary traits implied above: comprehensiveness (it reviews 123 studies!) and recency or timeliness. Martin Blaser's review, published in *Gastroenterology* in 1987, was occasioned by the renewed interest in "gastric bacteria" sparked by Marshall and Warren's work in the mid-1980s. Like other important reviews, this piece helped the field take stock of a rapidly developing research area. As Blaser notes in his introduction, "The field has moved quickly, and a review of its current status is appropriate."

The goal of such status reports is to describe what the field has learned so far: what, if any, consensus is developing, and what questions remain to be answered? Review articles may be especially useful to those who distribute resources, both financial and human, including, for example, program officers at funding agencies and administrators in research agencies such as the EPA. Similarly, reviews are useful to practitioners, including medical professionals, agricultural producers, and resource managers, who must make daily decisions about courses of treatment, feed composition, management practices, and so forth, and who want to base those decisions on the most current information available. Comparable to the discussion and implications sections contained in reports of individual studies, review articles discuss the implications of the complex set of findings under review. Blaser, for example, helped researchers and clinicians make sense of the many reported observations of gastric bacteria by pointing out trends and patterns across studies. His concluding paragraph emphasized directions for future research and implications for clinical practice. As noted in Chapter 1, as early as 1993 over a thousand *Campylobacter pylori* studies had appeared in the new era heralded by Blaser's review. The issues Blaser raised have not been fully resolved, but the field's understanding of the relationship between *C. pylori* and gastric illness has advanced to the point where much current research focuses on clinical techniques for detection and treatment.

In contrast to the trends toward multiple authorship in research reports and proposals, review articles are often single-authored. (In a sample of 25 review articles published in *PNAS* (*Proceedings of the National Academy of Sciences of the United States of America*), Noguchi (2006) found 72 percent to be single-authored [p 102].) The review thus represents one expert reader's interpretation of the state of knowledge in the field. Given the important role that review articles play in shaping a field's understanding of the research base, journal editors are particularly careful to ensure the integrity of this interpretive process. To guard against potential bias, some journals have established stricter conflict-of-interest policies for authors of review articles. The *New England Journal of Medicine*, for example, will accept research reports from authors with significant financial ties to companies whose products are affected by their research, provided those relationships are disclosed. But such relationships are not allowed for authors of review articles and editorials (*NEJM* 2008).

Review authors must convince not only the journal's editors but also its readers that the selection and interpretation of prior studies are free of bias. In his review, Blaser based his advice to clinicians on his interpretation of the field's current understanding of the relationship between these bacteria and specific gastric conditions. For this interpretation to be accepted by readers in the field, it needed to be carefully and clearly supported, not only with citations of relevant studies but also with enough information about those studies to enable readers to see the trends the author had seen. We'll return to this issue later in this chapter.

Notice that research reviews typically present a synthesis of *findings* rather than a synthesis of *views*. Direct quotations are rarely found in research reviews because the primary focus is not on what previous authors have believed or said but on what their studies have demonstrated. Reviewers are interested in researchers' claims only insofar as they are supported by the empirical evidence they present. Even in reviews of theory, common in fields like geology, meteorology, and astrophysics, theories tend to be discussed in the context of the physical observations they seek to explain. In short, the goal of the research review is to help readers make sense of all the available evidence. The reviewer offers a description of what the field does and doesn't know on a given topic at a given point in time.

In keeping with this descriptive goal, scientists tend to adopt an objective and respectful tone when synthesizing the work of other researchers. In comparing and contrasting research findings, review authors often point out limitations in the scope or methods of individual studies, but by now it should be clear that *review* in this context means to synthesize or characterize a body of information, not simply to point out flaws (as is often the case, for example, in film reviews in the popular press). Though pointed and personal criticisms are somewhat more acceptable in the humanities literature, where authorial presence is generally more prominent (Madigan et al. 1995; Hyland 1999), such tactics are inconsistent with the *ethos* of the objective scientist and the high value placed on consensus in the scientific community. In the sciences (Gilbert and Mulkay 1984) and social sciences (Madigan et al. 1995), public discussion tends to stay focused on the strengths and limitations of the work itself. Though there is clearly an evaluative dimension to the review, the overall goal is descriptive.

EXERCISE 5.2

It will be useful to have some potential topics in mind as you continue to read this chapter about reviewing prior research. Researchers frequently discover topics for research while reading the work of others. Review articles are excellent sources of research topics. As you saw in Chapter 4, research reports also tend to outline directions for further research in discussion or conclusion sections. Review the discussion sections of two or more research reports, either those contained in this textbook or, ideally, papers from your field. What kinds of further studies are suggested? List the potential research questions proposed or implied by these authors.

5.3 Locating the Literature

Whether writing stand-alone review articles or reviews embedded in other kinds of scientific texts, experienced researchers rarely begin their reviews of research from scratch. By the time they are ready to write the introduction to a research report or the background section of a grant proposal, they have become very familiar with previous work in the area, some of which may be their own. Thus, the scientist-author already knows which previous studies are pertinent to the argument at hand. But new scientists, or researchers working in new areas, may need to do a more extensive search of the available literature in order to develop this sort of familiarity with the research base. Therefore, some search strategies are in order.

Research reviews focus on primary sources—original reports of individual studies published in professional research journals—as opposed to secondary sources such as textbooks or magazine articles written for nonexpert audiences. But secondary sources are excellent places to start in your search for the primary literature. Biddle and Bean (1987) recommend beginning a search with the sources you find at home, for example, your textbooks and lab manuals, both of which may include lists of works cited or suggestions for further reading. To this we would add as easily accessible starting points other course readings, class discussions, and conferences with your professors. If you have chosen a topic that was raised in class, your professor or lab instructor should be able to refer you to a recent paper on the subject. If your topic was suggested in the discussion section of another researcher's report, then you've already identified the first study to include in your review.

The easiest way to search for prior research on a topic you are investigating is to begin with such a reference in hand. This advice is more helpful than it sounds. First, the paper will contain at least a brief review of relevant research and a discussion of implications, providing you with a quick introduction to the topic. Second, if you have even one study in hand, you'll be able to locate the network of previous work by searching "backwards" through its reference list or "forwards" via author or citation searches (more on this below). This process will take some trial and error; you will undoubtedly come across studies that are not directly relevant to your specific topic. Streamline your search by using the descriptions of the cited studies in your article-in-hand to help you decide which are likely to be most pertinent to your particular research interest.

For example, turn to the first paragraph of the Burkholder et al. (2005) article on *Pfiesteria* toxicity (page 307). This text is dense with citations, each selected to illustrate or provide support for the statement in which it appears. If you want to learn more about linkages between fish kills and human health, the first sentence tells you that references 1–3 will be useful sources. If you want to find out just how toxic different strains of *Pfiesteria* are, the second sentence will lead you to examine sources 5–7. Even the brief reviews embedded in article introductions such as this can point you to promising sources for your own research. Electronic indexes and abstract services are powerful tools in the digital information age and can be especially useful if you are starting

from scratch—that is, if you don't have a source in hand. But be prepared to spend some time exploring multiple databases and experimenting with different keywords and combinations. A wide variety of digital search tools are available in the sciences, ranging from general multidisciplinary services such as *Web of Science* and *Academic Search Premier* to domain-specific sources such as *Agricola* (agriculture and related fields), *Medline* (biomedical sciences), and *GeoRef* (earth sciences), to sources focusing on specific research areas within domains, for example, *Fish and Fisheries Worldwide*, *Textile Technology Index*, and *Bacteriology Abstracts*. The reference staff in your campus library are familiar with the databases accessible to students on your campus. (Just as libraries subscribe to journals for use by library patrons, they also subscribe to databases for access by library patrons.) This staff can help you choose appropriate databases for topic searches in your field and will also be able to help you get started on keyword searches once you've identified the index tool you want to use.

In addition to the library staff, consult with your professors to identify the most useful indexes and abstract databases for your research topic, and/or check the websites or masthead pages of the primary journals in your field. Journal websites typically include a list of databases in which the journal is indexed, often under a heading such as "Abstracting/Indexing" on an "About this Journal" or "Information for Authors" page. In print journals, indexing information is generally included on the masthead page, which provides information about the publisher, copyright notices, subscription procedures, and so forth, and usually appears inside the front cover or somewhere near the table of contents. Two sample index lists are reprinted in Figure 5.1.

If you do have an article in hand, it can help you both test and navigate the indexes you've identified as potentially useful. First, see if you can find your initial article in the database, e.g., by searching on the first author's name and the date of the publication. If your original source is not contained in the database you've chosen, it may not be an appropriate search tool for your topic. Try

Behavioral Ecology

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Behavioral Ecology is covered by the following major indexing/abstracting services: Animal Behavior Abstracts; Current Contents/Agriculture; Biology & Environmental Sciences; BIOSIS; Ecology Abstracts; Elsevier BIOBASE/Current Awareness in Biological Sciences; E-Psyche; Geo Abstracts; GEOBASE; Research Alert; SCISEARCH; Wildlife Review; Zoological Record; PsychINFO.

Nature

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The Nature and Nature Publishing Group journals are indexed by the following abstracting and indexing services: British Library, CABS (Current Awareness in Biological Sciences), Chemical Abstracts Service, Crossref, EBSCO Publishing, EMBASE, Google Scholar, Infotrieve, IngentaConnect, ISI Web of Knowledge, OCLC (Online Computer Library Center), Ovid, PubMed, PubMed Central, Scopus, Ulrich's periodicals directory.

FIGURE 5.1 Indexing information from selected journals.

some others. Once you've found a database that contains your initial article, notice how the article is indexed—that is, see what keywords or identifiers are associated with the paper. Then use those keywords to help you design a search for related articles.

Many indexing services also enable you to search "forward" from an article, by identifying other sources in which it was later cited. Subscription-based *Science Citation Index* and the open access *Google Scholar* (http://scholar.google.com/) both provide this type of citation tracking, as well as other search tools. Citation tracking is also a useful way for researchers to see how their work is being used and to assess its impact on the field.

Lastly, we noted in Chapter 2 that some individual journals and professional associations (and general services such as *Google Scholar*) offer their members various types of alert services to let them know about new research on a given topic as soon as it appears in digital (that is, searchable) form. Public Library of Science (PLoS) users can register to receive weekly or monthly alerts of newly published research, or newsfeeds providing summaries and headlines from PLoS blogs or journals on specific topics (http://www.plos.org/connect.html). This up-to-the-minute notification constitutes a more proactive or anticipatory search mechanism, adding in effect a "real time" option to the backward and forward searching described above.

EXERCISE 5.3

Either online or in print, find the indexing information for three to five major journals in your field. List the indexing and abstract services used by these journals. Put a star by those currently available through your university library.

EXERCISE 5.4

Working alone or with a partner, choose a topic in your field that you would like to know more about. It may be a topic you identified in Exercise 5.2; it may be an area you are currently exploring in another course or at work; or it may come from your own reading or browsing through journals in the library. Conduct a keyword or subject search on this topic in at least two different indexes appropriate for your field (print or electronic). Compare the outcomes of your searches. How useful was each search tool? Did the two systems produce similar sets of sources? What journals were cited in each search? Which database contained more relevant references on your topic? How easy was it to narrow the search in each system? Which provided greater flexibility in defining and combining keywords? Which search was more efficient? In what other ways did these indexes differ? List the advantages and disadvantages of each system you examined. Your instructor may ask you to compare these findings with those of your classmates.

5.4 Reading Previous Research

In most cases, you will be reviewing research as part of a research report or grant proposal. Thus, the goal of your literature search is to determine the context for your research: What does the field already know about this topic? What kinds of studies have been done? What methods have been used, and how useful have they turned out to be? What has been found? What kind of information is still needed? Your answers to such questions will help you design a project that represents a reasonable next step for your field. When you write the review itself, you will aim to help your readers see the trends that you have seen in this literature.

In conducting your search, use paper titles and abstracts to help you sort through the sources you've located. As you begin to identify the studies that seem most relevant, read the introduction and discussion sections carefully. Your goal in reading each paper is to understand why the authors conducted this research, what questions they hoped to shed light on, and what conclusions they came to. What were they trying to find out, and how does this relate to what you're trying to find out?

As you begin to compare and contrast the studies to be included in your review, skim the methods and results sections as well to see what kinds of materials were used (or sites or subjects observed), what kinds of measurements were taken or observations made, and what kinds of analyses were performed. Locate the major findings of the study. Recall from our discussion in Chapter 4 that in well-structured results sections major findings are highlighted in the text. Look for the authors' generalizations about their results, often contained in topic sentences.

5.5 Identifying Trends and Patterns

Whether your review is a stand-alone document or part of a report or proposal, readers will expect you to have read widely in the research literature and to have selected the most significant and most relevant studies to include in your review. Your goal is to present an overview of what this research has demonstrated. That is, you will want to sift and synthesize, pointing out similarities and differences in the findings these researchers report and, if pertinent, in the methods they used and the focus of their experiments or observations. This synthesizing goal will lead you to talk about the studies in groups or clusters, rather than describing each in isolation. (Notice in the sample texts in Chapters 9 to 13 that studies are frequently cited in clusters of two or three.) The review should not be a list of individual article summaries but a discussion of the trends that you noticed across studies.

A useful way to identify trends is to construct a grid to help you record distinctive features of the studies as you read them. List the studies down the left-hand side of the page, and mark off several columns across the top. Early in your reading, the grid might include column headings such as "research question," "methods," and "principal results." As you become more familiar with the literature and the issues raised by these studies, you will want to develop more specific column headings.

For example, when he began reading the clinical research on *Campylobacter pylori*, Blaser (1987) might have used a column headed "conditions associated with *C. pylori*" to organize his notes. After a while, he would notice by reading down this column that some researchers documented the presence of *C. pylori* in patients with gastritis, others found associations with peptic ulcer, others with still other conditions. The grid would thus help him notice clusters or subgroups of studies that could usefully be discussed together in his review and may suggest subheadings he could use to organize the body of the paper. (Skim the subheadings in Blaser's review in Chapter 9 to see where the gastritis and peptic ulcer "clusters" were included.) Blaser could then use a similar grid to help him notice differences and similarities within each cluster. For example, he could compare the different types of methods used to study gastritis to see if results were consistent under different conditions. In fact, the table Blaser created to summarize the results of the gastritis studies looks very much like the sort of grid we have been describing (see Table 2 on page 237). Rublee et al. (2005) provide a similar table in their review of methods used for detecting *Pfiesteria* (Table 1 on page 314). Both the Blaser and Rublee tables may well have functioned as planning devices for the authors as they sorted through their respective research bases.

Whether you use a formal grid or some other note-taking system, your primary goal is to identify trends in this body of research. Are findings consistent across the set of studies? If the phenomenon was studied in different regions, at different times of year, with different methods, or under different conditions, were the findings similar or different? Is there theoretical consensus in the field, or have different interpretations been put forward? To help readers understand the current state of the field's knowledge on the topic, your review should highlight consistent patterns and points of agreement as well as inconsistencies and issues that are unresolved.

Consider two examples. First, read how Blaser synthesizes the findings from the gastritis studies he had listed in Table 2 of his review (see page 236, under the heading "Association of Gastric Campylobacter-like Organisms with Gastritis"). Since the presence of *C. pylori* and the condition of gastritis were strongly associated in all but one of these studies, Blaser highlights this consistent trend in the topic sentence that opens the paragraph. Contrast this emphasis on consensus with the example in Figure 5.2. In this mini-review excerpted from a research report, astrophysicists Fulbright and Reynolds (1990) describe an unresolved issue in shock acceleration theory, the question of whether quasi-parallel or quasi-perpendicular shocks are more efficient in accelerating electrons. Their review emphasizes the lack of consensus in the field, a gap in the field's knowledge that their study will go on to address.

Notice in both examples that the authors offer conclusions or *generalizations* about the set of studies under review, and they cite the *specific studies* on which their conclusions are based. Notice also that, as discussed in Chapter 4, generalizations tend to be stated in present tense (because they describe the current state of knowledge), whereas past tense is used to describe the results of specific studies (which were conducted in the past).

The most obvious mechanism to produce a bipolar structure is the compression by a factor of 4 of magnetic field where it is perpendicular to the shock normal, compared to no amplification where it is parallel (van der Laan 1962; Whiteoak and Gardner 1968). However, this mechanism can produce only a limited amount of azimuthal modulation of intensity. Roger et al. (1988) and Leckband, Spangler, and Cairns (1989) point out that another possible mechanism for producing bipolar structure in shell remnants is a systematic dependence of the efficiency of shock acceleration on the obliquity angle θ_{Bn} between the shock normal and the external magnetic field, if the field is assumed to be fairly well ordered on the scale of the remnant diameter. Shock acceleration theorists are divided on whether quasi-parallel ($\theta_{Bn} \sim 0°$) or quasi-perpendicular ($\theta_{Bn} \sim 90°$) shocks are more efficient in accelerating electrons. The quasi-parallel geometry seems more adapted to classical diffusive shock acceleration (see reviews such as Drury 1983 or Blandford and Eichler 1987), while quasi-perpendicular geometry allows the so-called shock drift mechanism (Pesses, Decker, and Armstrong 1982; Decker and Vlahos 1985, among others) in which electric fields along the shock front accelerate particles, a process which can be considerably more rapid (Jokipii 1987). Leckband, Spangler, and Cairns (1989) attempted to study this issue by examining the limb-to-center ratios of SNRs, inferring the direction of the external magnetic field for each remnant using a model of the galactic magnetic field, and comparing with model calculations for profiles of SNRs. They could not come to a definite conclusion.

FIGURE 5.2 Sample review paragraph from Fulbright and Reynolds (1990, p 592): Bipolar supernova remnants and the obliquity dependence of shock acceleration. *The Astrophysical Journal.*

EXERCISE 5.5

Choose a sample paper or proposal in your field. Modify one paragraph of a research review section by stripping out research citations. Type up the "research-free" review paragraph, and exchange with another member of the class. Read the paragraph you've been given, and note in the text where you think the authors would need to cite prior research and why. Compare your analysis with the original review.

5.6 Organizing the Review

There is no standard organizational format for the research review, for the scope and purpose vary widely. Though review articles originally tended to survey historical trends (Day and Gastel 2006), today they are more likely to concentrate on recent history, as indicated by *Nature*'s (2008d) emphasis on "recent developments in a topical area." In Noguchi's (2006) sample, reviews tended to be organized around one of four goals: "presenting [an] historical view of a facet of the field; describing the current situation in a field; proposing a theory or model to resolve some issue in the field; [or] calling attention to some issue in the field" (p 120). Swales (2004) views these goals as parameters that reviews may exhibit to greater or lesser degrees and in various combinations. Blaser (1987), for example, includes a section titled "Historical Developments" at the start of his review article on *C. pylori*, although the goal of that review is clearly to assess the current state of the field's knowledge. This section is particularly appropriate in Blaser's review because a notable feature of Marshall and Warren's discovery was the fact that gastric bacteria had been observed for decades but largely ignored. Now as the relationship between these bacteria and gastrointestinal conditions is becoming clearer, this "old" evidence is suddenly interesting. In this situation, a brief discussion of past history helps to contextualize the more recent advances discussed in the main body of the review. The main body of the review is then organized not by chronology, but around those advances.

Whether you are writing a review article or the literature review section of a proposal or report, use basic principles of good writing as your guide:

- Introduce your discussion by establishing the significance of the topic. It is helpful to give a quick preview of the major trends or topics to be covered in the review.
- Organize the body of the review to reflect the clusters or subtopics you have identified, using headings if the review is lengthy.
- Use topic sentences at the start of paragraphs and sections to highlight similarities and differences and points of agreement and disagreement.
- Conclude with an overview of what is known and what is left to explore.

Notice that the headings in Blaser's review identify the major subtopics he covers (e.g., "Microbiologic Characteristics of *Campylobacter pylori* and Related Organisms"; "Pathological Associations With Gastric *Campylobacter*-like Organism Infection"). These *topical* or *content* (Swales 2004) headings are quite different from the *functional* headings of the IMRAD form followed in research reports. The IMRAD headings—introduction, methods, results, and discussion—let readers know what function each section of the report serves: the introduction introduces, the methods section describes methods, and so forth. Functional headings are useful because they enable readers who are familiar with a standard format to quickly locate the kinds of information they expect the document to include. But unlike the research report, the review article is rarely subdivided by function and therefore follows no standard functional format. Some reviews will include an explicit description of the methods by which studies were selected for inclusion (which may or may not be labeled as a separate functional section), but in general, the sections within the body of a review all have the same goal or function: to review research. Each section does, however, describe a distinctive trend, feature, or area of that research, and headings should be used to highlight those subtopics (CSE 2006). Thus, in a research review, headings signal shifts in the focus or content of the discussion.

A striking example can be found in the background section of the research proposal by Burkholder and Rublee (1994) in Chapter 10 (see pages 282–306). Burkholder and Rublee's first two headings summarize not just the major areas of research they will describe but the major claims they are basing on that research: that a linkage between fish kills and *Pfiesteria* has been established, and that highly specific molecular probes are needed to detect the pathogen. In this text, topical headings are used to outline the "plot" or argument of the review (Myers 1991).

EXERCISE 5.6

Carefully examine the headings that Rublee et al. have used to organize their 2005 research review in the *Journal of Eukaryotic Microbiology* (reprinted in Chapter 10). Use the title and abstract of this review to help you understand its focus and primary goals. Given this agenda, how would you characterize the major subdivisions in this article (Application of Methods, Sequence Analyses, Conclusions)? Are these functional headings, topical headings, or a mix?

5.7 Citing Sources in the Text

The Council of Science Editors identifies three primary citation systems used in scientific journals: name-year, citation-sequence, and citation-name (CSE 2006). A glance at the reference lists of journal articles in your field will reveal which system or systems are conventional in your research community. This information will also appear in the instructions to authors, typically posted along with editorial goals and guidelines at the journal's website and/or published annually in a hard-copy issue of the journal. Full descriptions of these documentation systems can be found in comprehensive style guides such as the CSE's *Scientific Style and Format*, now in its seventh edition (2006) or the National Library of Medicine's *Citing Medicine: The NLM Style Guide for Authors, Editors, and Publishers* (Patrias 2007). Some journals will simply refer you to a pertinent style manual for guidelines on handling citations. Others will include samples of their required citation and reference formats in their instructions to authors. For example, the journal *Gastroenterology*, in which Blaser's review was published, uses a citation-sequence system and provides sample reference entries at its website (http://www.gastrojournal.org/authorinfo#prep). *The Astrophysical Journal*, where the Reynolds team's Kepler report appeared, uses a name-year system and provides extensive guidelines for citing sources (http://www.journals.uchicago.edu/page/apj/instruct.html). Our descriptions here are based on the guidelines compiled by the CSE (2006).

Figure 5.3 illustrates how references are cited in the text in these systems (these are called "in-text citations" or "in-text references"). Under the **name-year system**, which we are using in this textbook, any sources referred to in the text are identified by the author's last name and the date of publication. These sources are then listed alphabetically in the list of references or works cited at the end of the text. This system is followed in such journals as the *Journal of Eukaryotic Microbiology*, *The Astrophysical Journal*, and *Geology* (see sample articles in Chapters 10–12).

The **citation-sequence and citation-name systems** differ only in the order in which sources are listed in the reference list at the end of the paper. Under the **citation-sequence** system, cited sources are listed and numbered in the order in which they are mentioned in the text, whereas under the **citation-name** system, all cited sources are listed alphabetically at the end of the text and then numbered in

Sample In-Text Citations

Name-Year System

Example A
Oldach et al. (2000) also utilized a heteroduplex mobility assay (HMA) for detection of *Pfiesteria* species.

Example B
We used the nonequilibrium-ionization (NEI) version 2.0 thermal models, based on the APEC/APED spectral codes (Smith et al. 2001) and augmented by addition of inner-shell processes (Badenes et al. 2006).

Citation-Sequence or Citation-Name System

Example C
Gastric bacteria now are being observed with regularity (2–4), and recently, Marshall and Warren (5,6) were able to isolate a spiral bacterium that had never been cultivated before.

Example D
Recent studies have suggested that the eradication of *Helicobacter pylori* infection affects the natural history of duodenal ulcer disease such that the rate of recurrence decreases markedly (2–6).

Example E
A worldwide increase in toxic phytoplankton blooms over the past 20 years[1,2] has coincided with increasing reports of fish diseases and deaths of unknown cause.[3]

FIGURE 5.3 Sample in-text citations from the following sources included in Chapters 9 through 12: *A.* Rublee et al. (2005); *B.* Reynolds et al. (2007b); *C.* Blaser (1987); *D.* Graham et al. (1992); *E.* Burkholder et al. (1992). Sample reference list entries for A–D are presented in Figure 5.5.

that order. In either case, the resulting numbers are used as identifiers for citations in the text itself. Numbers may be inserted in superscript (above the line) or in parentheses, depending on journal style and software capabilities. Of the journals represented in this textbook, the citation-sequence system is used in *Nature*, *PNAS*, *Clinical Toxicology*, *Science*, and in the four medical journals: *Annals of Internal Medicine*, the *Lancet*, *Gastroenterology*, and the *British Medical Journal* (see sample articles in Chapters 9–13). Journals using the somewhat less common citation-name system include the *Journal of Bacteriology* and the *Journal of Scientific Computing*. (You'll be able to recognize this system quickly by checking the list of works cited to see if the numbered sources are listed alphabetically.)

In addition to the basic form of the citation, the examples in Figure 5.3 illustrate a number of other variations in citation practices, as described below.

Direct Versus Indirect Citations. Authors may be identified directly in the text, as in Examples A and C of Figure 5.3, or they may be cited indirectly, using parenthetical or numerical identifiers as in Examples B, D, and E. That is, the citations may be integral or nonintegral to the structure of the sentence in which they are mentioned (Swales 1990). Swales (1984) notes that direct or integral citation focuses discussion on the researcher(s) who did the work; in contrast, indirect or nonintegral citation features the research claim or finding as the subject of the sentence and thus focuses attention on the research itself. Writers use these different "reporting formulae" not only for variety but also to

emphasize the contributions of individual researchers or to highlight trends in the research.

In fact, the use of reporting formulae can become a strategic dimension of a scientific argument. In a section titled "Modern Controversies" in their *Clinical Toxicology* piece, Spiller, Hale, and De Boer (2002) discuss one researcher, Amandry, by name, but they use indirect citation to refer to similar conclusions by several other archaeologists (see page 331). Spiller et al. hold Amandry responsible for discouraging scientific interest in the Gaseous Vent Theory in the 1950s, a theory that their new evidence now supports. Using direct citation in this instance enables the authors to focus attention (and, in this case, blame) on this particular scientist's conclusions, underscoring their argument that ancient accounts of the oracle had been wrongly discounted. Highlighting the role of this individual researcher and downplaying the line of research he represents makes it easier to discredit this work, for it comes across as the mistaken assumption of one man.

The practice of direct citation is more often used to allocate credit than to place blame, however, as can be seen in the introduction to the letter by Marshall (Warren and Marshall 1983) contained in Chapter 9 (pages 231–233). Note how Marshall uses direct citation when highlighting the fact that earlier researchers had observed bacilli in the stomach lining of ulcer victims, a finding that supports Marshall and Warren's own claim. But Marshall uses indirect citation when reporting the fact that other researchers failed to confirm those observations or recognize their importance. The effect of indirect citation here is to downplay the negative findings of these other researchers. These two examples illustrate the potential impact of stylistic choices such as reporting formulae.[1]

As the Amandry example illustrates, it is conventional to refer to authors by last name only when using direct citation; first names and titles are not included. Once you have included the authors' names in the sentence, it is unnecessary (in fact redundant) to include them in the parenthetical citation. If you are using the name-year system, insert only the date of the source in parentheses immediately after any author mentions in your text, as in Example A of Figure 5.3. In the citation-sequence and citation-name systems, the numerical identifier remains the same in direct and indirect citations.

Placement of Indirect Citations. Indirect citations appear most frequently at the end of a sentence, as in Examples B, D, and E, but they are also commonly found at the ends of clauses or phrases (Examples B and E). A parenthetical or numerical citation should be inserted immediately after the statement, word, or phrase to which it is directly relevant (CSE 2006), so that it is clear to readers which part of your claim or observation is based on that particular source.

Citing Work by Multiple Authors. Whether you are citing directly or indirectly, always acknowledge all the authors of a work. If the cited work has two authors,

[1]In reviewing and citing, scientists indicate what work they consider valuable as well as what work remains to be done. In so doing, they are engaging in what might be considered "epideictic" argument, or the rhetoric of praise and blame (see Sullivan 1991), one of three types of classical argument that we will talk more about in Chapter 7. For further discussion of how scientists use citations strategically, see Latour (1987) and Paul (2000).

include both names, as in Example C. For works with more than two authors, use *et al.*, as in Examples A and B. An alternative form suggested by the Council of Science Editors (2006) is to replace the Latin abbreviation with the English equivalent: "Koyama and others (1995)."

EXERCISE 5.7

Compare a research report or proposal using the name-year citation system with one using the citation-sequence or citation-name system. What do you notice about the effects of these different systems on your reading? List the advantages and disadvantages of each of these approaches.

EXERCISE 5.8

Obtain copies of the instructions to authors for three major journals in your field. What citation systems do these journals follow? What style guidelines do they offer? Which style manuals are recommended? Where can these manuals be found on your campus? Are they available online?

5.8 Preparing the List of Works Cited

Any sources cited in your text should be included in a reference list, alternatively called a works cited list, at the end of the paper. The general format for journal references is basically the same in the three systems, except for the placement of the year of publication. In the name-year system, the year of publication must appear directly after the authors' names, so that references can be easily recognized from their name-year citations in the text. In the citation-sequence and citation-name systems, the year appears later in the reference. The basic formats for print and Internet references, as prescribed by the Council of Science Editors, are presented in Figure 5.4.

Focusing first on references to standard print journal articles, we've reprinted some sample reference entries in Figure 5.5. You'll notice that though the general ordering of reference components is relatively consistent, some formatting details vary from journal to journal. For example, though CSE's format includes the issue as well as the volume number, issue numbers tend to be omitted if pagination is continuous throughout a volume. You'll find that some journals require first and last page numbers; others allow only the starting page number. Some put dates in parentheses; others do not. Some journals will limit the number of author names; others will not. (The *NLM Style Guide* now requires that all authors be listed [Patrias 2007]. *Astrophysical Journal* allows only up to eight authors in a reference entry; articles with more than eight authors are listed by first author only, followed by "et al." [http://www.journals.uchicago.edu/page/apj/instruct.html].) Some

reference formats omit article titles altogether, as in Example B in Figure 5.5. Most journals do not use quotation marks around article titles in references (but some do!). Punctuation around authors' initials and journal title abbreviations varies across journals, as does capitalization and the use of italics and boldface. The bracketed content designator in Fig. 5.4 allows you to indicate if the article is something other than a research report, e.g., an editorial or a research review; such information may or may not be required by your journal. The format of in-text references varies as well: some journals require a comma between name and year in parenthetical name-year citations, others do not.

Though these differences may seem arbitrary, in most cases the modifications were adopted in an effort to save space, enhance consistency, or make typesetting processes more efficient. Unfortunately, journal staffs have tended to experiment with these modifications independently, making a common set of rules difficult to maintain. For this reason, even if you're following the general formatting guidelines in Figure 5.4, it is important to read the journal's instructions to authors and to use a sample reference list from the target journal as a model.

Components of End References

Print Journal Articles

Name-Year System	Citation-Sequence/Citation-Name System
Author(s)	Author(s)
Date	Article title
Article title	Journal title
Journal title	[Content designator]
[Content designator]	Date
Volume/Issue	Volume/Issue
Location (Pagination)	Location (Pagination)

Internet Sources

Name-Year System	Citation-Sequence/Citation-Name System
Author(s)	Author(s)
Year of publication	Article title
Article title	Journal title
Journal title	[Medium designator]
[Medium designator]	Year of publication
[Date updated; date cited]	[Date updated; date cited]
Volume/Issue	Volume/Issue
Location (Available from: Internet address)	Location (Available from: Internet address)

FIGURE 5.4 Components of end references for journal articles and Internet sources. Based on CSE (2006), guidelines 29.3.6 and 29.3.7.13, pp 504, 557–558.

Sample References

Name-Year System

Example A

Oldach, D. W., Delwiche, C. F., Jakobsen, K. S., Tengs, T., Brown, E. G., Kempton, J. W., Schaefer, E. F., Bowers, H., Steidinger, K., Glasgow, H. B. Jr., Burkholder, J. M. & Rublee, P. A. 2000. Heteroduplex Mobility Assay guided sequence discovery: elucidation of the small subunit (18S) rDNA sequence of *Pfiesteria piscidida* from complex algal culture and environmental sample DNA pools. *Proc. Natl. Acad. Sci. USA*, 97:4303–4308.

Example B

Smith, R. K., et al. 2001, ApJ, 556, L91

Citation-Sequence or Citation-Name System

Example C

2. Steer HW. Ultrastructure of cell migration through the gastric epithelium and its relationship to bacteria. J Clin Pathol 1975:28:639–46.

Example D

2. Coghlan JG, Gilligan D, Humphries H, McKenna D, Dooley C, Sweeney E, et al. Campylobacter pylori and recurrence of duodenal ulcers—a 12-month follow-up study. Lancet. 1987;2:1109–11.

FIGURE 5.5 Sample references from the following sources included in Part 3: *A.* Rublee et al. (2005); *B.* Reynolds et al. (2007b); *C.* Blaser (1987); *D.* Graham et al. (1992). In-text citations are presented in Figure 5.3.

As outlined in the lower half of Figure 5.4, Internet citations differ from the formats specified above primarily in identifying the Internet as the medium and including the URL and copyright date, if available, as well as the date the material was accessed and cited. Because web materials can be continually updated (and even discontinued), the date cited serves to identify which version of the source you read—in effect rendering a potentially transitory source permanent by fixing it in time. Sample Internet references from CSE are reprinted in Figure 5.6.

We have focused on citing journal articles in this chapter, but of course scientists make use of many other types of source material as well. For guidelines on

Citing Journal Articles from the Internet

Name-Year System

Savage E, Ramsay M, White J, Beard S, Lawson H, Hunjan R, Brown D. 2005. Mumps outbreaks across England and Wales in 2004: observational study. BMJ [Internet]. [cited 2005 May 31]; 330(7500):1119–1120. Available from: http://bmj.bmjjournals.com/cgi/reprint/330/7500/1119 doi:10.1136/bmj.330.7500.1119

Citation-Sequence or Citation-Name System

1. Savage E, Ramsay M, White J, Beard S, Lawson H, Hunjan R, Brown D. Mumps outbreaks across England and Wales in 2004: observational study. BMJ [Internet]. 2005 [cited 2005 May 31]; 330(7500):1119–1120. Available from: http://bmj.bmjjournals.com/cgi/reprint/330/7500/1119 doi:10.1136/bmj.330.7500.1119

FIGURE 5.6 Sample CSE reference entries for journal articles from the Internet (CSE 2006, pp 557–558).

formatting references to other types of sources, such as conference proceedings, technical reports, monographs, chapters in books, and homepages and other online sources, consult the appropriate style manual in your field or find an example in the reference list you're using as a model. Style manuals will also provide guidelines for citing multiple articles by the same author, citing authors with the same last name, citing organizations as authors, citing unpublished work, and many other documentation variables.

5.9 The Research Review Abstract

Finally, if you are writing a review article—as opposed to a review section embedded in a research report or grant proposal—you will also need to prepare an abstract summarizing the focus and scope of the project. As we noted in Chapter 4, the abstract is a contingent genre; that is, its form is contingent upon the form of the paper it is intended to represent. Your review abstract may be either informative (summarizing the trends you observed in the literature and the conclusions of the review) or indicative (identifying the topics you will cover but not what you found). Check the journals in your field to see which is preferred. In either case, the abstract should preview the major topics under which you have organized the review itself.

EXERCISE 5.9

Read the abstracts for Blaser's (1987) review article (see page 234) and/or the abstract for the review by Rublee et al. (2005; see page 313). What major topics does the abstract highlight? How does this set of topics map onto the content and structure of the review itself? Is this an informative or indicative abstract? Write an alternative abstract in the other mode.

Activities and Assignments

1. Choose a research report on a topic in your field. Read the introduction carefully. Find three to five of the works cited in this section. Write a one-paragraph summary of each cited paper and a one-sentence explanation of why it is cited in the review.
2. Conduct an electronic search on a topic in your field or a topic assigned by your instructor. You may want to limit your search to the 10 to 15 most recent publications. Find and read as many of the sources as you can. Summarize the critical features of these studies in a grid that you could use to plan a literature review on the topic.
3. Use the grid you developed in Activity 2 to help you write a two- or three-page review of recent research on a topic in your field. Follow a citation format appropriate for a primary journal in your field.

CHAPTER 6

Preparing Conference Presentations

6.1 The Role of Research Conferences in the Sciences

Although this book is primarily concerned with writing, much if not most day-to-day communication in science occurs orally in informal discussions, lab meetings, and seminars, as well as more formal participation in professional conventions—all of which may take place face to face or, increasingly, via virtual media such as Webinars, teleconferences, and Second Life. In fact, these newer communication technologies are extensions of traditional modes of socializing and communicating (Weaver and Morrison 2008), and thus rely on many of the techniques and strategies for oral and visual presentation discussed in this chapter. While online social networking has become a popular and even conventional form of social gathering (Weaver and Morrison 2008), it is through oral, more personal modes of interacting that much of the work of science gets done.

No matter what the medium, the ability to interact and orally communicate with other scientists is essential for scientific progress. At a time that would later be recognized as the beginning of a technological revolution in scientific communication, Reif-Lehrer noted that for an individual to participate in the knowledge-sharing and consensus-building business of science, publication is not enough (Reif-Lehrer 1990). Conferences therefore represent another formal mechanism that, like the journal article discussed in Chapter 4, has developed to facilitate the exchange of scientific knowledge. Like research journals, conferences vary in size, scope, and audience. Most are sponsored by professional organizations whose membership and areas of interest vary widely. For example, an ecosystem science student Bethany Ryan reports that researchers in her field belong to several associations in environmental and related sciences, such as the Society for Environmental Toxicology and