History in Hypertext (Methodology & Sources)

For those interested in the scholarly method used on this site, below are sections on: Writing a Hyperlinked History, Disadvantages Compared with Conventional Print, Source Materials, Missing Pieces and Errors, and How You Can Help with comments or corrections, Printing or Referencing this Work, Author/credits. An Appendix gives some technical details on Web site construction.

Writing a hyperlinked history:

Traditional histories of science focused on "scientific revolutions," singular advances that overthrew old ideas and climaxed in a grand and satisfying synthesis. Climate change research is science of another type. The Earth's climate (like so much of importance) is conditioned by many different kinds of factors, all strong enough to count, all interacting with one another in fantastically complex ways. Over the decades scientists improved their understanding of how each factor acts and interacts, meanwhile adding new factors. No revolution could turn that type of understanding on its head, nor do scientists expect any terminus in the foreseeable future. We have no closed story but a ceaselessly developing set of partial understandings

Our knowledge of how this complex type of science works is primitive. Not only the public, but even most scientists, only see particular strings of incidents. Few have mentally organized an overall picture. We need a way to display the many lines of research and how they intertwined. Along with this we need to follow the general trend of scientific opinion. At each point dozens of recent results influence this opinion, and it influences in turn the direction of future research. Scientific opinion also interacts with public concerns, and public concerns interact with funding, and funding takes us back to the start by influencing which lines of research scientists can pursue.

The attempt to grasp all this has led me to a separate essay with reflections on the scientific process, which I offer for the attention of anyone interested in how scientists come to understand the world better.

The World-Wide Web gives us a new way to display complex information of this nature. Not only here but in various contemporary media, creators increasingly call upon their audience to navigate freely according to their own initiative. That's an expression of the complexity and choices that pervade many areas of contemporary experience. As the creators of an end-of-the-century exhibit at the Museum of Modern Art put it, "viewers are invited to explore the exhibitions in any order, constructing from them their own, personal narratives... The pathways

are laid out as an exploration... not as finished maps, but as possible ways of proceeding."[1] Of course novelists have long struggled with issues of simultaneity and multiple viewpoints.[2] Even the most linear sort of traditional history book, say a biography, will have a chapter on one aspect of its subject followed by a chapter on another aspect (say, scientific discoveries here, family life there). It is up to the reader to put it all together. That is the way our brains work: not laying down a single linear track but building a network of associated images and ideas. A Web site can mirror this cognitive process. The author can put each of the relevant stories on one Web page or another, linked to as many other story pages as needed. The only innovation is that the author, for better or worse, does not constrain the reader's choice in the order of exploring the stories and their connections.

[Added 2007] From several hundred comments received so far, I can conclude that in dealing with the hyperlinks, readers divide into three roughly equal groups. One group finds them puzzling and distracting, and after a few attempts reverts to the traditional mode of reading through the essays one by one. A second group is delighted by the hyperlinks and praises them highly. A third group takes a mixed approach, reading through an essay and then exploring some of the hyperlinks.

Making such an extensive cross-linked work involved some time-consuming technical software issues, discussed below.

But this is hard to read! Yes, we find it hard to read a long essay off a computer screen with current technology. The resolution is 72 dots-per-inch (so the letters are fuzzy), and the contrast is 70% (the "white" background is actually gray), which are far worse than a book's 300-plus dpi and 95%-plus contrast. When I started this work in the early 1990s, I thought laptop e-books with high resolution and high screen contrast would be common by now. Until the technology catches up, some readers will prefer to print out the essays using the page of PDF files. (Note on Web design: constraining the text to a fairly narrow newspaper-style column is important for readability on newer 1024-pixel-wide screens, since the eye has trouble finding its position in scanning back and forth across long lines.) [Added 2005: all necessary technology is now available. What seems be keeping inexpensive mass-production of useful e-books is disagreements over standardized software, largely due to publishers fearful of losing control over

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[1] An early example was an experimental "book" by B.S. Johnson, *The Unfortunates* (1964, reprinted Picador, 1999, reprinted New Directions, 2008), a boxed set of unbound chapters of memories and reveries; the first and last chapters were designated but the rest could be read in any order. A recent example is Alan Ayckbourne's double play "House" and "Garden" (Royal National Theatre, London, 2000), staged simultaneously in two theaters with actors going back and forth, and audiences viewing one or the other play each night. The "all-over" painting style of Jackson Pollack might be considered a visual precursor. The parallel-gallery museum style is catching on, e.g., in London's new Tate Modern. Quote: *MoMA* vol. 2, no. 8 (Oct. 1999), p. 5.

[2] e.g., Joseph Conrad, "The Secret Agent" (1907)..

copyrighted material.] Even so, I hope that the explicit display of interactions will promote a way of comprehending history that would not be possible if all the information were beaten into a single, linear story. After all, this is the way we learn the history of any large subject: we read a bit here and a bit there, and put it together in our heads.

What else do we lose by not publishing conventionally?

A scholarly publisher will submit a scholarly work for "peer review," and most reviewers take the task seriously. They can point out both specific and general errors, and along with the press's editor can give advice on organization and tone. I partly substituted for this by e-mailing a couple of dozen scientists and historians, asking them to review specific essays (which I attached), and as much else of the site as they wanted to. I also wrote and published peer-reviewed articles, and gave talks on aspects of the subject at History of Science Society meetings and elsewhere. This produced quite a few comments on particular details, which were useful. However, very few people gave advice outside their immediate area of interest, some essays were not reviewed by anyone, and nobody commented on the overall structure in terms of balance among the topics, use of hypertext, and analysis. Scientists and other scholars evidently won't work as hard in response to an author's request as they will for a publisher (and why should they?).

On the plus side, after you publish a work on the Web, some people will email you to point out problems, which you can quickly correct online. This has helped me revise many passages that were potentially misleading or outright in error. I am also receiving a few comments per week through a feedback form. This rarely produces information beyond the specific questions the form asks, but it gives me a good idea of who are my most committed readers and what they need. Also, I published a short book simultaneously, and this inspired reviews and emails that pointed out other difficulties that I could correct on the Web site (and sometimes in subsequent printings of the book).

The peer review has an additional benefit in endorsing the scholarly validity of a work. One could request reviews for a Web site. Anyone who agreed to do this, however, would find it hard to evaluate a sprawling site that different people are supposed to read in different ways. Most of the reviews of the associated book have mentioned the Website, but only as a good source of additional information. Hardly anyone has "reviewed" the Web site's content or structure beyond a sentence or two.[1] This is not a crucial problem for me, since I have a well-established reputation, plus the endorsement from the publication and favorable reception of the associated peer-reviewed book. But if I were a younger scholar, especially one seeking tenure in academia, I would have had to focus on conventional peer-reviewed publications. Aside from obstacles due to conservatism or outright ignorance of the Web, we cannot expect the people who award jobs and tenure in universities to evaluate work in a distant specialty by themselves. (As for the notorious problem that you can't make any money by putting stuff on the Web, writing rarely

[1] The only (but brief) exceptions are Michael DuVernois in *Physics and Society* **33**(3):16 (July 2004), the newsletter of the American Physical Society's Forum on Physics and Society, and Chris Ware in *Isis* **97**(4): 804-806 (2006).

pays for scholars anyway, except insofar as it helps them win an academic position.) It is also more difficult at present to get professional recognition simply as useful material. Traditional scholars have cited my short summary book in their footnotes but have hesitated to cite a Website. There is some justification, since a sentence cited from one of my Web essays may have changed by the time somebody looks at it in a later year.

A publisher should also provide a copy-editor, who will suggest changes in almost every paragraph—pointing out places where the author has been obscure, as well as grammatical solecisms and simple spelling and punctuation errors. I am a pretty good writer and copy-editor, and the copy-editing was not seriously missed. Still, for the second (2004) version I took the time to apply a spell-checker, which caught a small number of errors, and the WordPerfect "Grammatik" grammar- and style-checker, which tediously pointed out quite a few minor improvements and reminded me I use the passive voice too much. Yet even the best author and software will miss things that a good copy-editor can point out. Nowadays scholarly presses are becoming less able to pay for decent copy-editing, and even authors of works in print may be well advised to hire a freelance copy-editor.

On the plus side, year after year this Website has been getting about 1000 visitors a day, well beyond the readership of the book (although that is selling well enough) in numbers and variety. Users responding to my survey include students, concerned citizens, and a surprising number of academic, corporate and government professionals involved with climate or climate impacts.

Source materials:

The next question is, what to include? The basic problem of any historian is selection of material (even an apparently self-contained topic like a biography can come to seem limitless). In print we are limited by the economics of how many pages a book can reasonably contain. For a Web site, our limit should be a realistic appraisal of how much time a normal reader will really want to spend on a given topic.

The scientific literature. Historians may claim that their ideal is to treat the past on its own terms, but we cannot give equal space to each year of each research effort. Among the thousands of scientific papers scattered like seeds in the past, we are naturally most interested in those that have borne fruit. Uncertainties impede such a selective approach for a topic that is still unfolding. We don't know exactly which geophysical forces are most important for climate change, nor which scientific approaches point toward the best explanations. Some controversies have remained unresolved for decades. Matters now considered minor (as carbon dioxide once was) may eventually loom large, and vice-versa.

I have therefore been liberal in identifying the papers to include here (see the bibliography). One

source for references was contemporaneous reviews.[1] Another source was the scattering of historical writings, popularizations, and historically-aware textbooks that have addressed the question, mostly by scientists. Works by professional historians have been few (although the number is rising) and focus on narrow topics; works that purport to be comprehensive often give undue emphasis to the events or topics that the authors are most familiar with.[2] I found many other significant references by keeping abreast of the current literature on climate change, relying perhaps too much on scientific articles and news reviews in the leading journals *Nature* and *Science*. Articles here often refer to older papers that the authors consider foundational for their subject: among many references to papers published recently, one often finds a few references to papers ten years old or more. My next step was to review the papers identified by all these methods. These papers often gave in turn references that reached back another decade, and so forth.

Thus I built my text largely around the papers that respected scientists, five or ten or twenty years later, remembered as important. Unfortunately the papers themselves did not always in fact say what others remembered they had said. The historian must make some assessment of the contents of each paper, and I have looked at (if not read entirely) nearly every item that I cite. However, the historian should hesitate before saying that a piece of work was less or more important than scientists later thought, for the impression a paper made at the time can be as significant as its retrospective technical content. On the other hand, scientists sometimes properly cite a paper not for its main thrust but for some idea or item of data that the authors themselves didn't emphasize at the time—something they tossed in on the side, but which later turned out to be crucial.

My method of looking only at older references passes up more than nine papers in ten, overlooking many thousands of studies that were useful enough for scientists to cite a few years later. Some of these were important but missed by my procedure. Only late in my work did I get to some bibliographies compiled by scientists, and a glance at them shows the extent of the problem. Of 29 pre-1988 papers on "stable isotopes in polar ice" listed in a 1995 historically-oriented bibliography, I had seen only five; of 20 recommended pre-1988 historical references on

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[1] For example, Bolin (1952); Bolin (1972); Carson (1999); Charlock et al. (1993) (actual closing date ca. 1986); Hobbs et al. (1974); Jones and Henderson-Sellers (1990); Landsberg (1958); Landsberg (1970); Meehl (1990); Rossby (1959); Shapley (1953), and reports by the National Academy of Sciences, the Intergovernmental Panel on Climate Change, etc. Further reviews on particular topics are referenced in the various essays.

[2] Early works include Ausubel (1983); Broecker (1995); Christianson (1999); Edwards (2000b); Fleagle (1992a); Fleming (1998); Handel and Risbey (1992); Hart and Victor (1993); Imbrie and Imbrie (1986); Jones and Henderson-Sellers (1990); Kellogg (1987); Lamb (1977); McGuffie and Henderson-Sellers (1997); Miller and Edwards (2001); Nebeker (1995); O'Riordan and Jäger (1996); Pearson (1978), ch. 2; Randall (2000); Rodhe and Charlson (1998); Schneider and Londer (1984); Smagorinsky (1983); Smagorinsky (1991); Stevens (1999). Further articles and books on particular topics are referenced in the various essays, and see also the online links pageat www.aip.org/history/climate/links.htm#hist.

climate modeling in a 1997 text, I had seen only seven.[1] On the other hand, references that said they pointed to especially important work were almost always citing papers I had already seen. If not, I had usually seen a paper that represented much the same body of research, but that had been published a bit earlier or later. For example, of the nine papers by a leading modeler that I later found had been most cited in other publications, I had already seen eight, and the ninth was recent.[2] From such "catch-and-release" samplings, I estimate that I have caught well over nine-tenths of the hundred or so most important studies, but not quite all.

The method of relying on citations of older articles to suggest those that scientists found especially important will not work past the mid 1990s, and for this period I have fallen back especially on the articles selected by the editors and science reporters of the leading journals *Nature* and *Science.* Since the appearance of Google Scholar (http://scholar.google.com) I have found it useful for identifying papers on particular topics and finding which ones are most frequently cited by other scientists; these are often the most important papers. Someone who has a lot of time and a university account for the Web of Knowledge http://www.isiknowledge.com could do still better through detailed investigation of the citation data there.

Now what about those holes—the papers that only turned up late in my study, representing publications I could easily have missed entirely? These mostly turned out to be findings that exerted an influence in concert with others. Different scientists will recall different papers as the ones that first intrigued them or finally convinced them. Many of the almost-missed papers were not cited for anything surprising, but for some ancillary technical point, such as a particularly good set of data, or a correction or embellishment to an ongoing theoretical argument. As this study shows abundantly, in geophysics what drives a change of scientific opinion is often the cumulative pressure of several varieties of evidence and thinking. In short, I think the history I have written accurately represents the scientific *process*, but am not everywhere reliable in assessing the exact influence of specific pieces of work. So let me offer an—

Apologia. Even for quite important bodies of research, I cite papers chiefly to serve as examples, sometimes almost random samples, of the work of a larger community. Each stands in for other papers that published related data, calculations or techniques. Those other papers often involved different principal authors or coauthors, people I could perhaps have cited in addition to, or instead of, those named in the bibliography. And that's not even to mention the hundreds of collaborators and students concealed in "et al." Further, I have deliberately gone into some detail on a few particular lines of research while entirely overlooking others that helped at least as much to move knowledge forward. To include it all would have taken more time on my part, and would demand more time from readers, than anyone could well give. My apologies to you, scientists, I wish I could tell all your splendid accomplishments.

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[1] Broecker (1995); McGuffie and Henderson-Sellers (1997); my coverage was no better for the hundred or so pre-1988 references in IPCC (2001).

[2] Bibliography compiled by S. Manabe of his work with citation numbers, papers with over 200 citations..

A related problem is that this narrative, by concentrating on the best work, gives a distorted view of how science is done. I have made a picture by connecting the dots among roughly a thousand of the most important scientific papers in climate science. Each of those papers stands for another ten or so of nearly the same importance. And for each of those ten thousand, the community of scientists had to look through perhaps ten more that turned out to be less significant—papers that gave some minor corroboration, or that had errors either obvious or misleading, or that were just not relevant. Even while wishing to show the history in its full complexity, I have pulled the main developments above this distracting noise. The picture is clearer than working scientists could ever see at the time.

Scientists may see little of interest in a paper that later turned out to be significant, or they may just miss reading it among the many publications in many fields. My narrative is distorted most of all where it seems to show that something was widely "known" once it was published. In fact, time and again I came across ideas and findings that were introduced in plausible publications, but that most scientists scarcely noticed through the next decade or so. When readers of these essays reach a given point in the story, they understand the "state of knowledge" at that point better than any scientist of the time did, for the knowledge was dispersed among many individuals.

Popular writings. Popular and semi-popular books and news articles by climate scientists, and still more by journalists who interviewed them, tell another part of the story. Here we see particular features of scientific development penetrating the public consciousness, and the public influencing science in turn through its enthusiasms and its influence on sources of funding. My most useful guides were the *Readers' Guide to Periodical Literature* and the *New York Times Index*. These are restricted to a U.S. view, but public views and government funding in the U.S. were representative, when they were not well in the lead, of world opinion during most of the period covered here. I have not done so well in covering European public opinion and politics in the post-1988 period, when the Europeans moved ahead of the U.S. in important respects. I simply ran out of time and energy to investigate that huge subject. In addition, I have relied on science journalists such as Walter Sullivan and later Andrew Revkin of the *NY Times,* Richard Kerr of *Science* magazine, the editors of *Science* and *Nature,* and for more recent developments also the editors and writers of *New Scientist* (especially Fred Pearce)*, Eos, Discover,* etc., whose close contact with scientists pointed them to problems of intense interest at a given time. These problems have received special (and possibly disproportionate) emphasis in my narrative, and here too, the recent emphasis has been perhaps too narrowly Anglo-American. In my annual updates of the Website and for the second edition of the book, I have increasingly made use of the enormous volume of information on the Web.

Unpublished documents and recollections. Writing history from published papers is like flying over a clouded terrain where isolated peaks rise above the clouds. You get a general idea of the range but you can be seriously deceived about the relationship between individual peaks. Did scientist A write a paper, which scientist B then read before writing a new paper? Perhaps A and

B had discussed the matter at a conference years earlier. Or perhaps B had spoken with C, who had corresponded with A, while an earlier obscure report by D offered a clue... etc. Instead of a uniform forward march of logic, we see a scurrying about of many half-formed ideas. The real history surely has many more cross-links than I could see. For example, except for a page in the autobiographical reminiscences of James Lovelock, I would not have known that meteorologists' concern about industrial haze stimulated his work on a gas that turned out to be significant.

To get a better view, I made forays into some archives, where old letters and the like tell much about the human processes of funding, carrying out research, and publication. Of course I could only survey a tiny fraction of the materials that exist in scientists' files. And in many of the files I did see, a lot of paper had been thrown away. I also conducted some oral history interviews. The weaknesses of human memory are notorious, yet it is rightly standard practice for historians to tape-record the recollections of the principal surviving figures from the events they are studying. Once you take into account the well-known hazards, such recollections may give you the only hint of important matters for which no documentary record is known—personal viewpoints, twists and turns of scientific thinking, human interactions. (Of course the same problems of memory, particularly the human tendency to assign credit to oneself and one's colleagues, infect even the most austere published papers.) The archives and interviews have had some influence on my general conclusions, and perhaps more valuable, they have opened some holes in the clouds. In a few of the side essays I explore the rugged terrain between the peaks, to serve as examples and warnings of what is missing from the rest.

Missing pieces and errors — how you can help:

This is a work in progress in serious need of additions and corrections. As mentioned in the discussion of source materials, I have had to rely on the fallible memory of scientists and on my own quick reading of scientific papers in fields where I am no expert. Sometimes when I went back to a paper after learning more, I found that I had misjudged it—and I have not been able to go back to all the papers.

Special problems arise when you try to write a history of recent events. I have signaled this by separating out sections for events after 1988. These sections necessarily lack a good historical perspective, can be criticized for bias under the pressures of contemporary politics, and inevitably miss pieces of the story that will turn out to be significant. Regrettably, I don't doubt that these essays also contain outright errors (readers have kindly helped me to correct a few).

In a more general sense, these pages offer only a narrow view of science. The people have mostly been stripped out. The statistician angrily defending an idiosyncratic climate theory against all comers, the voluble oceanographer in an office cluttered with mementoes from the seven seas, the computer modeler who is nowhere happier than burrowing into equations—it was personalities like these who pushed the science ahead. You will read only a little about them here. To select what I would cover, I relied on my view of science as an ecosystem of ideas. It is a particular kind of system (not at all like, say, war or politics), in which personalities can

influence the pace and direction of change, but not the final scientific results.[1]

You can contribute suggestions for revisions and corrections. These essays are incomplete, some of the explanations are obscure, and surely a few things are just plain wrong: where so many different scientific fields and events are covered, I have not been able to check everything for complete accuracy (indeed I have not been able to see about 5% of the publications I cite, but rely on references to them). I urge **climate scientists** to provide further information: (1) personal comments and recollections on any specific subject, (2) additional references to the scientific literature, and (3) pointers to the location of unpublished correspondence, research notes, proposals or other documents that may be useful to historians. **Historians and all other readers** are invited to contribute especially by: (1) complaining about obscure or inconsistent interpretations, (2) drawing attention to missing information, and (3) commenting on the hypertext presentation. To make a suggestion, please send an email to **sweart@aip.org**, or write: Spencer Weart, Center for History of Physics, One Physics Ellipse, College Park, MD 20740 USA.

Printing and referencing this work:

You are welcome to download and print out for your personal or classroom use PDF files of these essays. If you cannot do this, contact the Center for History of Physics, American Institute of Physics email: chp@aip.org, mail: One Physics Ellipse, College Park, MD 20740 USA, and we will mail you a copy at cost. A "record copy" is stored in the archives of the Center's Niels Bohr Library; this printed version represents the text mounted on the World Wide Web as of August 2003. The PDFs match revised versions mounted at intervals since then, but may not incorporate small recent changes in some pages.

 You are welcome to give a URL link to any point in the site. If you wish to give a reference to a particular passage in this work, I suggest you give the author and essay title, overall title, Web site URL and date, and page number of the printed text, for example:

> Spencer Weart, "The Carbon Dioxide Greenhouse Effect," in Weart, *The Discovery of Global Warming*, http://www.aip.org/history/climate/co2.htm, July 2007, p. CO2-7 of PDF.

Alternatively, to quote directly from the Website you could omit the PDF page number and refer to the location of the passage in fractional terms from your Web browser's "print preview," e.g., "Web page 14 of 22." Note that entire passages, including footnotes, can change from one version to the next, so *be sure to include the date* given at the top of the Web or PDF page.

Author/Credits: This text is by Spencer Weart, supported by the American Institute of

[1] Weart (1997).

Physics (Center for History of Physics). I developed the GCM essay from an essay by Paul Edwards, and the solar essay from one by Theodore S. Feldman. My work was also supported by grants from the National Science Foundation's Program in Science & Technology Studies and the Alfred P. Sloan Foundation. For research assistance I thank Drew Arrowwood, Stephen Norton, and Niem Dang. I am particularly grateful for the indispensable help provided by the scientists who generously gave me interviews, extensive comments, or access to documents, especially A. Arakawa, W. Broecker, K. Bryan, R.A. Bryson, J. Eddy, J. Fleagle, P. Foukal, J. Hansen, C.D. Keeling, S. Manabe, K. Masuda, J. Smagorinsky and R.M. White.

Related:
Reflections on the Scientific Process

Appendix: Technical Details

I wrote this work in WordPerfect 6 and 9, and kept the bibliography in EndNote 4 software. Where I decided to put a cross-link, I inserted it in the text enclosed in special character combinations never used elsewhere and a unique number, e.g. <:internat ^f0123:> indicated link number 0123 from the essay that would become internat.htm. The corresponding "to" link was similarly put in that essay. The program "Search and Replace" (Funduc software) was useful in making sure I used each number once and only once. Altogether the site displays more than 700 cross-links between its essays. The number of hyperlinks, including both directions for the cross-links, links to endnotes and from endnotes to bibliography, a few dozen external links, etc., totals more than 7000.

When ready to convert for the Web, I devised an EndNote style that would insert ("expand") references in the text. It included the reference identification number and other material enclosed in special character combinations (e.g., [999<$>Author (year)<#>Label]). I incorporated all essays into a master document so that the bibliography could be compiled. I then cut that out and put it in a separate document.

I spent a few weeks devising WordPerfect macros to carry out a variety of tasks, starting with various cleanups of messy fonts etc. in the text. The macros used simple Search, Cut, Paste, and Replace operations, without any elaborate logical structure (I used ON NOT FOUND GOTO along with FOR-NEXT loops to avoid possible endless looping). For each separate essay, a WordPerfect macro located the special characters delineating notes, and put the material into endnotes. I then used the WordPerfect "Save as" facility to save the text as HTML. From that point on I worked in the HTML code, bringing it into WordPerfect as ASCII and running macros to rework the code. During the writing I had inserted a special character (viz., ^) to indicate places where I would need to do hand-coding of HTML, and I now took care of those places.

A macro gave each essay appropriate header material and enclosed the text in an HTML table.

Macros put each paragraph in a separate row in a cell, then located and extracted cross-links and placed them in an adjacent cell. The link numbers needed to be extracted again and placed in anchors at the start of each paragraph. Other macros located the endnote citations by their special character combinations, then created links to the endnotes themselves, and linked the references in the endnotes to anchors in the bibliography. Another macro placed these anchors in the bibliography, using the reference numbers. In general, all code that looked similar in all of the essays was put there by macros. For final polishing such as insertion of illustrations, I used DreamWeaver MX software.

None of this is recommended to anyone except those familiar with, and not unduly frustrated by, writing and debugging simple code. (I've been writing code since I did my doctoral thesis on solar physics in the days of punched cards and batch processing.) I trust that eventually someone will write general purpose software for this sort of work. In principle one could write an entire work like this from scratch using a program like DreamWeaver. In practice, however, personal computers are not yet fast enough nor the software well enough designed to make that feasible.