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Journal of College Science Teaching; May 1997; 26, 6; ProQuest
pg. 388

POINT OF VIEW

Reform of the College Science Lecture through Storytelling

The Game is Afoot: Stories Can Innovate Science Teaching

John A. Knox

In the 1990s, the phrase "innovation in teaching" usually conjures up visions of a quantum leap in educational technology for instructors of college-level science courses. In my own field of atmospheric science, recent Internet-based innovations such as Netscape and Java have brought up-to-the-minute weather observations and satellite pictures into introductory-level classes. These and other technological revolutions raise hopes that the college science instructor of the future will act as a facilitator of student-initiated, student-directed learning on the information superhighway.

However, this conception of innovative teaching and the hopes for a student-centered classroom both ignore a millennium of instructor-centered formal education in Western civilization. Technological innovations such as the printing press, chalkboard, lantern slide, filmstrip, television, VCR, and (so far) personal computer have yet to displace the instructor from the center of the classroom. The instructor-centered oral lecture is still the most prevalent teaching method in U.S. colleges and universities today, with 70 percent (Allen and Rueter, 1990) to perhaps 80-90 percent (Smith, 1990) of all courses employing the lecture format.

As a student in atmospheric science, mathematics, physics, and computer science at two state universities in the 1980s and 1990s, my own experience has been that 38 out of 39 (97 percent) nonseminar courses taken have relied primarily upon the lecture format. Instructor-centered education, for myriad reasons, clearly has "staying power" in academia in general and in the sciences in particular.

Despite its ubiquity, the lecture is frequently targeted by critics (*e.g.*, Smith, 1990; *Science* 1994) as an inefficient and outdated form of communication. Hence, innovation in teaching is easily construed to mean the removal of the instructor from the center of the classroom in favor of, for example, constructivist approaches (Brooks and Brooks, 1993; Shea, 1996). Regardless of the merits of these innovations, dislodging instructors from their time-honored roles as broadcasters of knowledge and wisdom will prove to be a significant challenge. Perhaps innovation can take place within the framework of instructor-centered education, instead of merely in opposition to its existence?

But before reformers can successfully innovate within the established, instructor-centered educational structure, a simple question must be answered: precisely what is wrong with the lecture? Many critics note that the lecture is a passive way of learning for students (Strauss and Fulwiler, 1989-90), but abundant anecdotal evidence attests to the fact that even passive learning can be a positive, life-changing experience (Woodward, 1991).

A more discerning critique of the lecture appears in Sheila Tobias' *They're Not Dumb, They're Different* (1990), in which the impressions of scientifically inclined nonscientists in introductory-level, "hard" science courses are recorded. The nonscientists' reactions emphasize that they sorely missed a narrative understanding of the facts that were presented, a "road map" that would permit a "remember-from-words" comprehension of the material. Several students felt so disoriented that they voluntarily wrote their own narrative overviews of the courses.

Do the sciences really suffer from a lack of narrative material, *i.e.*, stories? Traweek (1988) highlights how physicists convey the subculture of physics to their young (graduate students and especially post-doctoral associates) precisely through oral historical traditions! However, many

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scientists avoid using stories once they step into an undergraduate classroom. In a survey of introductory meteorology instructors at 79 U.S. colleges and universities by Ulanski (1993), only 13 percent of the respondents felt that the historical component was incorporated in their courses to a high or very high degree—the lowest percentage of 10 educational approaches analyzed in the survey. Even if narrative material penetrates the college science classroom, the stories frequently take the form of tepid history-of-science digressions that are "a kind of relief from having to concentrate so hard... not the focus of our work, not material with which students can creatively interact" (Tobias, 1990, pp. 35, 52).

Given the above statements, one possible means of innovating college science education is to reform the traditional lecture through the systematic introduction of *storytelling* as a way of teaching the core material of college science courses. To make this a viable alternative to traditional methods, several basic questions must be addressed:

Figure 1. Organization of a principle-centered lecture, from Kozma et al. (1978, p. 153).

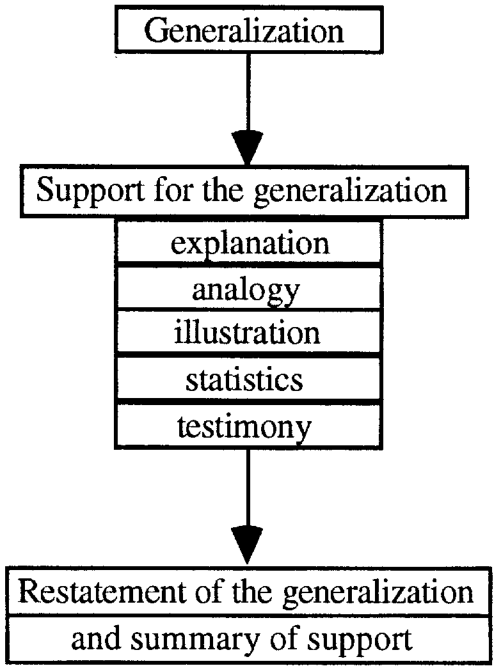
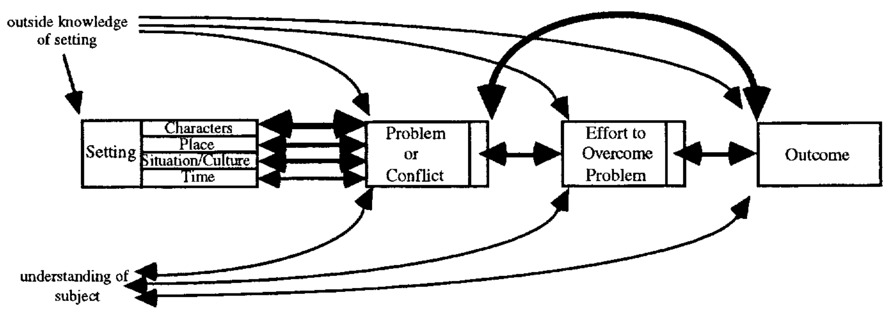


Figure 2. Data structure representation of a generic story in the form of a multiply-linked list.



WHAT IS A STORY?

A precise definition of "story" is problematic even in the cognitive, science research literature (*e.g.*, Brewer in Wyer, 1995, pp. 109-113). Carrithers (1991, pp. 310-311) describes a story as:

> "characters with their relationships...set in a flow of events, a plot, with its sense of plans, situations, acts and outcomes....By means of stories humans recognize not just thoughts and not just situations, but the metamorphosis of thoughts and situations in a flow of action."

There is also a strong connectedness of details inherent in stories. For example Aristotle, in describing the tragedy, states that (Mack *et al.*, 1985, pp. 843-847):

> "events ought to be so rooted in the very structure of the plot that they follow from the preceding events as their inevitable or probable outcome; for there is a vast difference between following from and merely following after....In the characters and the plot construction alike, one must strive for that which is either necessary or probable..."

And so a story consists of a web of characters, their relationships, and the metamorphosis of characters, situations and events in a way that is true to the setting.

WHY USE STORYTELLING AS AN EDUCATIONAL DEVICE?

A growing body of work in the cognitive sciences has focused on the intimate relationship between memory, comprehension, and stories (Wyer, 1995). For example, lists of words are more easily remembered if they are woven into a story (Bower and Clark, 1969). Even more convincing, textual material written in a narrative style is read more quickly and is better understood than expository text (Graesser, Hoffman and Clark, 1980; Graesser, Hauft-Smith, Cohen and Pyles, 1980; Haberlandt and Graesser, 1985). A journalism experiment conducted by the American Society of Newspaper Editors in 1993 reached similar conclusions.

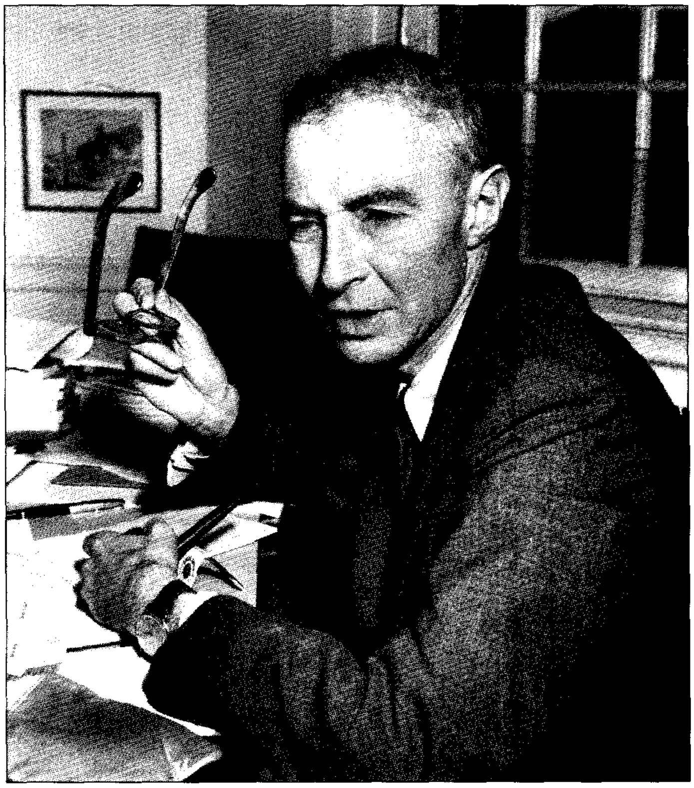
A noted cognitive scientist explains that stories, unlike lists of facts, are easily incorporated into human memory (Schank, 1990, pp. 11, 243):

> "Human beings are naturally predisposed to hear, remember, and to tell stories...(t)he more information we are provided with about a situation, the more places we can attach it to memory...Thus, a story is useful because it comes with many indices. These indices may be locations, attitudes, quandaries, decisions, conclusions, or whatever."

It is noteworthy that cognitive scientists describe stories as building blocks for memory and human cognition; these arguments are similar to the justifications for constructivism in science education (Shea, 1996).

HOW MIGHT STORYTELLING DIFFER FROM THE TRADITIONAL LECTURE?

One way to compare the two is to represent both the lecture and the story as verbal "data structures," borrowing from computer science concepts of the linked list (*e.g.*, Headington and Riley, 1994). **Figures** 1 (based on Kozma *et al.*, 1978) and 2 show subjective structural depictions of the traditional fact-based lecture and the generic story. The advantage of the story over a fact-based lecture is clear: a traditional lecture moves from one point to another in a linear "steamroller" fashion, whereas stories by their very nature connect to listeners' knowledge and ideas and "hang together" internally because of linkages between the characters in the story, the plot of the story, and the setting.



Dr. J. Robert Oppenheimer, former head of the Los Alamos group of scientists who developed the atomic bomb.

WHAT KINDS OF SCIENCE STORIES EXIST?

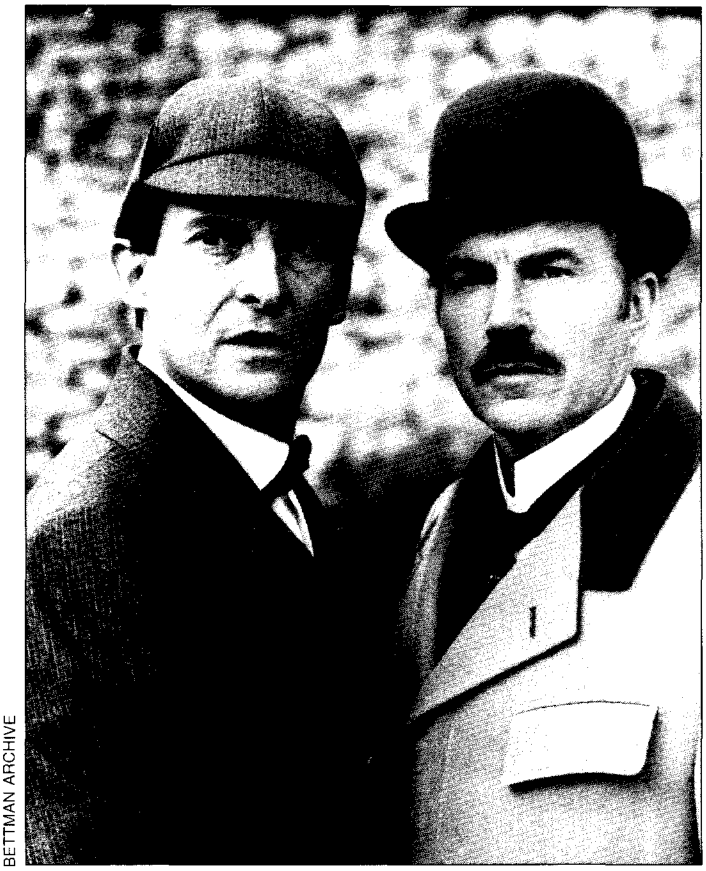
Obviously, the professional (and personal) lives of great scientists constitute stories. But teachers are not limited to relating the exploits of famous men and women, since the definition of the story requires only characters, situations, and outcomes. Some other examples which satisfy the definition of "story" are:

Myths, which can be used to relate overarching goals of a course or discipline to the overarching belief systems of civilizations. For example, physicist J. Robert Oppenheimer explicitly made the connection between the Manhattan Project and the ancient Hindu scripture *Bhagavad-Gita* in a famous quote after the detonation of the first atomic bomb (Rhodes, 1986, p. 676): "Now I am become Death, the destroyer of worlds." More commonly known myths, such as *The Odyssey* (Clarke, 1991), *Frankenstein* (Shelley, 1981) and Dante's *Inferno* (Niven and Pournelle, 1976) can also be linked easily to science's exploration of the unknown. These linkages can provide an overarching theme for a science course (see Knox and Croft, 1997).

Historical narrative, in which the event takes center stage rather than the particular personalities. These stories often can help explain a particular topic in a science course. Meteorology is replete with examples: the discovery of the jet stream by U.S. bombers during World War II (Plumley, 1993); the key role played by a developing extratropical cyclone in the sinking of the Great Lakes ore freighter *Edmund Fitzgerald* (Knox and Ackerman, 1996); and so on *ad infinitum.*

The detective story, in which science's quest to explain the unknown is cast in the well-known form of a Sherlock Holmes-like mystery. The discovery of the structure of DNA (Watson, 1968) and the recent investigation into the possibility that a meteorite impact may have led to the Cretaceous-Tertiary extinction event (Alvarez, 1987) are subjects that might be addressed easily in this format.

A discipline's encounter with a topic



Jeremy Brett (left), the latest reincarnation of fiction's most immortal detective, with actor David Burke as Dr. Watson. The detective story, as in science, seeks to explain the unknown.

or problem, such as the debate concerning the nature of light in the nineteenth century (Buchwald, 1989) or the evolution of the sociobiology controversy (*e.g.*, Wilson, 1980). Glen (1994) also discusses the Cretaceous-Tertiary extinction debate from this perspective. These stories can simultaneously communicate facts about science and a sense of how science operates in the real world.

The important point is that there is a much wider range of stories at teachers' disposal than merely biographical sketches.

HOW CAN INDIVIDUAL STORIES BE MOLDED INTO A COHERENT COURSE-LONG LESSON PLAN?

In **Figure 3**, I present a schematic timeline for a story-based college science course. Stories that describe the discipline, specialty, and course act as multiple "umbrellas," giving an overarching sense of why we scientists do what we do and why a student is in a particular course.

Stories near the beginning and the end of a course (large ovals) should act as bridges between past, current, and future courses and disciplines. Stories on individual topics (rectangles), which would presumably make up the core of a story-based course, should interconnect by means of ministories (depicted as arrows) that explain the transition from one topic to another. Mathematical derivations or other tough-to-narrate blocks of instruction (small rectangles) can be made more digestible by relating them to stories—*i.e.*, "we need this tool in order to solve the mystery I just told you." The order and choice of stories are determined by the traditional flow of topics in the course, and the ability and ingenuity of the instructor to mine for stories in the abundant literature of the history of science (*e.g.*, Morris, 1990) and from science's rich oral traditions.

The timeline can be made even more sophisticated using Schank's story classification system (1990). Schank describes four types of stories: firsthand and secondhand accounts, stories told in the role of an authority figure (such as a teacher trying to instill the ways of science in novices), and culturally familiar myths (*e.g.*, Frankenstein); and among those types, whether the stories support or challenge accepted norms.

My classroom experience suggests that from this Schankian perspective, there is a natural rhythm of storytelling in a college science course (see Figure 3): culturally common myths (such as the Dante discovery myth) help to set the tone and context of a course, followed by firsthand and secondhand accounts to personalize the material, and a series of official stories to teach how the scientific discipline as a whole studies particular topics. A sprinkling of personal-opinion stories within the latter third of the course can provide balance and perspective to those stories that establish the culture of science in the students' minds.

The hope is that with this storytelling model in hand, an instructor has a narrative road-map for virtually any college science lecture course. A few individuals gifted at storytelling have done so with "tall tales" and parables (*e.g.*, Herschbach, 1990; Ficken, 1992); the framework presented here gives any teacher the ability to implement storytelling in the classroom, using the full range of story types available.

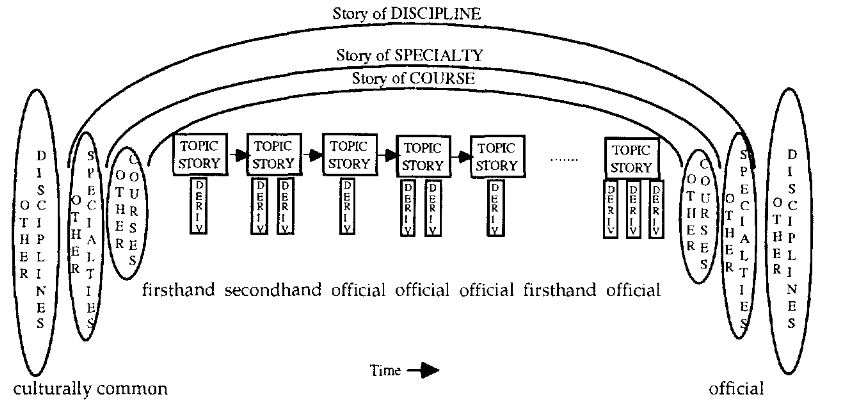
Science loses its luster and much of its audience when it does not tell its stories. Burgeoning interest in storytelling in the pre-college science classroom (*e.g.*, Egan, 1989; Lipke and Lipke, 1992) and in nonscience college courses (Coles, 1989) has yet to translate into anything approaching coherent reform in the college science lecture hall. This modest proposal, drawn from classroom experience and cognitive science, might hold promise to stanch the leakage of women and members of non-European cultures from the "science pipeline"—especially since these groups tend to value and respond better to narrative approaches

(Bennett, 1979; Tobias, 1989; Goss and Barnes, 1989).

Stories also afford the opportunity to interweave issues such as scientific practice and ethics into the curriculum naturally. As a teaching tool, storytelling can easily branch into more active learning scenarios (*e.g.*, Morrow, 1985) and so provides a pedagogical "middle ground" between entrenched traditional practices and even bolder innovative approaches.

A coherent attempt to reform the college science lecture with storytelling is not the most *avant garde* pedagogical innovation. But our society, alienated from the process of science and sometimes ambivalent about the fruits of science, requires practical and doable solutions in the short term. Before we dispense with the notion of instructor-centered education, it seems logical to give this most immortal form of human communication a fair chance to revolutionize the college science classroom.

Figure 3. Diagram of the temporal structure of a generic college science course, and its relation to other courses, specialties, and disciplines, augmented with Schank's (1990) story classification.



Acknowledgements

The author would like to thank Paul Croft, Steve Ackerman and Joleen Kugi for sharing their thoughts on teaching and storytelling. Portions of this work were presented at the American Geophysical Union Chapman Conference on Scrutiny of Geoscience Education and the American Meteorological Society Fifth Symposium on Education.

References

Allen, R. R., and T. Rueter. 1990. *Teaching Assistant Strategies: An Introduction to College Teaching.* Dubuque, IA: Kendall/Hunt.

Alvarez, L. W. 1987. *Alvarez: Adventures of a Physicist.* New York: Basic Books.

American Society of Newspaper Editors. 1993. *Ways with Words.* Madison, WI: American Society of Newspaper Editors.

Bennett, R. 1979. Hoopa children's storytelling. Ph.D. diss., University of California, Berkeley.

Brooks, J. G., and M. G. Brooks. 1993. *In Search of Understanding: The Case for Constructivist Classrooms.* Alexandria, VA: Association for Supervision and Curriculum Development.

Buchwald, J. Z. 1989. *The Rise of the Wave Theory of Light: Optical Theory and Experiment in the Early Nineteenth Century.* Chicago: University of Chicago Press.

Carrithers, M. 1991. "Narrativity: Mindreading and making societies." In *Natural Theories of Mind: Evolution, Development, and Simulation of Everyday Mindreading,* edited by A. Whiten. 305-317. Oxford, England: Basil Blackwell.

Clarke, A. C. 1991. *2001: A Space Odyssey.* London: Century.

Coles, R. 1989. *The Call of Stories: Teaching and the Moral Imagination.* Boston: Houghton Mifflin.

Egan, K. 1989. *Teaching as Story Telling.* Chicago, IL: University of Chicago Press.

Ficken, G. W., Jr. 1992. Use of the anecdotal technique to illustrate science concepts for nonscience majors. *Journal of College Science Teaching* 21:265-266.

Glen, W., ed. 1994. *The Mass-Extinction Debates: How Science Works in a Crisis.* Stanford, CA: Stanford University Press.

Goss, L., and M. E. Barnes, eds. 1989. *Talk That Talk: An Anthology of African-American Storytelling.* New York: Simon and Schuster, Touchstone.

Graesser, A. C., K. Hauft-Smith, A. D. Cohen, and L. D. Pyles. 1980. Advanced outlines, familiarity, text genre, and retention of prose. *Journal of Experimental Education* 48:209-220.

Graesser, A. C., N. L. Hoffman, and L. F. Clark. 1980. Structural components of reading time. *Journal of Verbal Learning and Verbal Behavior* 19:131-151.

Haberlandt, K., and A. C. Graesser. 1985. Component processes in text comprehension and some of their interactions. *Journal of Experimental Psychology: General* 114:357-374.

Headington, M.R., and D.D. Riley. 1994. *Data Abstraction and Structures Using C++.* Lexington, MA: D.C. Heath and Co.

Herschbach, D. 1990. Paradigms in research and parables in teaching. *International Newsletter on Chemical Education* 33:14.

Knox, J. A., and S. A. Ackerman. 1996. Teaching the extratropical cyclone with the *Edmund Fitzgerald* storm. American Meteorological Society Fifth Symposium on Education.

Knox, J. A., and P. J. Croft. 1997. Storytelling in the meteorology classroom. *Bulletin of the American Meteorological Society.*

Kozma, R. B., L. W. Belle, and G. W. Williams. 1978. *Instructional Techniques in Higher Education.* Englewood Cliffs, NJ: Educational Technology Publications.

Lipke, B., and P. Lipke. 1992. Tales from science. *Science Scope* 16:28-31.

Mack, M., general ed. 1985. *The Norton Anthology of World Masterpieces.* Vol 1. New York: W.W. Norton and Co.

Morris, P. 1990. The history of physics for physics majors. *Journal of College Science Teaching* 18:274-278.

Morrow, L. M. 1985. Retelling stories: a strategy for improving young children's comprehension, concept of story structure, and oral language complexity. *The Elementary School Journal* 85:647-661.

Niven, L., and J. Pournelle. 1976. *Inferno.* New York: Pocket Books.

Plumley, W. J. 1994. Winds over Japan. *Bulletin of the American Meteorological Society* 7:63-68.

Rhodes, R. 1986. *The Making of the Atomic Bomb.* New York: Simon and Schuster.

Schank, R. C. 1990. *Tell Me A Story: A New Look at Real and Artificial Memory.* New York: Charles Scribner & Sons.

Science 1994. Innovations on campus. *Science* 266:843-893.

Shea, J. H. 1996. Constructivism in science education. *Journal of Geoscience Education* 44:242.

Shelley, M. 1981. *Frankenstein: or, the Modern Prometheus.* New York: Bantam.

Smith, P. 1990. *Killing the Spirit: Higher Education in America.* New York: Penguin.

Strauss, M., and T. Fulwiler. 1989-90. Writing to learn in large lecture classes. *Journal of College Science Teaching* 19:158-163.

Tobias, S. 1989. Entering each other's nightmares. *Radcliffe Quarterly* 31.

Tobias, S. 1990. *They're Not Dumb, They're Different: Stalking the Second Tier.* Tucson, AZ: Research Corporation.

Traweek, S. 1988. *Beamtimes and Lifetimes: The World of High Energy Physicists.* Cambridge, MA: Harvard University Press.

Ulanski, S.L. 1993. An analysis of the liberal arts in introductory meteorology courses. *Bulletin of the American Meteorological Society.* 74:2203-2209.

Watson, J.D. 1968. *The Double Helix: A Personal Account of the Discovery of the Structure of DNA.* New York: Atheneum.

Wilson, E.O. 1980. *Sociobiology.* Cambridge, MA: Belknap Press.

Woodward, K.L. 1991. The life of a great teacher. *Newsweek* 122:60

Wyer, R.S., Jr., ed. 1995. *Knowledge and Memory: The Real Story.* Hillsdale, NJ: Lawrence Erlbaum Associates.