Notes on a Biology Watcher

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It may seem superfluous to write about Lewis Thomas in a journal for biology teachers. There are very few of us who have not read at least some of his work, and many of us have been inspired both by his ideas and by the way he presented them. But that's really why I feel the need to write about him here. His death last December just cannot go unnoted by a community that drew so much inspiration from his words, and for whom he cared so deeply.

I felt that I really had gotten to know Thomas when I read his autobiography, *The Youngest Science* (1983). I discovered that he was born in Flushing, a New York City neighborhood about two miles from my childhood home. His father was a physician; and Thomas followed in his footsteps, entering Harvard Medical School in 1933. In 1937, he interned at Boston City Hospital and learned of the medical problems facing the indigent. He notes that the two major chronic diseases he had to deal with on the wards were tertiary syphilis and alcoholism, and that syphilis and tuberculosis were the two diseases people feared most, much as we fear cancer today. He describes the amazement physicians like him experienced when they first saw sulfa drugs, and then antibiotics, bring dreaded diseases like pneumonia under control. His career spanned a time of tremendous change in medicine, but as the title of his book implies, he sees the science of medicine as still in its infant stages since so much of human disease remains very much of a mystery to us.

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A Life in Research

In his autobiography, Thomas also describes his life in research. Rather early in his career in medical education he was selected for administrative assignments. He moved from one medical school to another as he received positions of greater and greater prestige and influence. He eventually became dean of the medical schools of New York University and Yale. Later, he was president of the Memorial Sloan-Kettering Cancer Center in New York. Even while serving in these positions, he maintained a laboratory and directed research on various aspects of the immune system.

There are three areas of his research I want to mention. They may not be his most important contributions, but they are the ones that interested me the most. At one point, he was studying rheumatoid arthritis and mycoplasmas, organisms that can cause this condition. Obviously, this is an important area of research relating to human health, but Thomas admits that the reason he studied this aspect of immune function rather than some other is that he enjoyed looking at mycoplasmas under the microscope because, "to put it briefly, mycoplasmas are incredibly beautiful creatures. I cannot say why they are so lovely to look at, but they are." I've written enough about the aesthetic of biology in these columns for you to appreciate why I remember this particular part of his history.

A second area of his research that seemed intriguing is the discovery made by his colleagues about how mice can use the sense of smell to recognize individuals of their species. They found that in purebred mice, a difference in a single gene was enough to allow for recognition by scent. What makes this interesting is that the gene involved was one for a histocompatibility antigen. So it seems that the gene that allows the immune system to identify tissue is also involved in olfactory recognition.

I remember a third episode because it tells a lot about Thomas' personality. He was studying ways to modify the destruction of the kidney by bacterial endotoxin, which involves the buildup of fibrinogen in the kidney's glomeruli. He reasoned that if this buildup could be prevented, the tissue might survive. He had used a number of techniques to interfere with the buildup of this protein, and then decided to try the protease papain. This enzyme was selected because there was a jar of Adolf's Meat Tenderizer, a ready source of papain, on the back shelf of a colleague's refrigerator. This rather kitchen-oriented approach to research interested me, but it was what happened next that's really fascinating. Six hours after injecting papain into rabbits, there was no reduction in fibrinogen level and no slowing of the kidney damage; but the rabbits' ears had curled over, and after 24 hours the ears "hung down over the animals' shoulders rather like the ears of spaniels."

Thomas was intrigued by this phenomenon and decided to take a detour from his kidney research and study floppy rabbit ears instead. Two years of work, including collaboration with the British expert on vitamin A, Honor B. Fell, revealed that large doses of the vitamin have a similar effect on the ears, and that both papain and vitamin A produced this effect by destabilizing the lysosomes. These organelles leak digestive enzymes that destroy collagen, the structural protein which gives rabbit ears their rigidity (1962).

At the same time that Thomas was getting entangled in the floppy ears, Aaron Kellner, who studied heart disease, had seen the same phenomenon after injecting rabbits with papain to create heart muscle damage. Unlike Thomas, Kellner chose to stay on course and not get sidedtracked with ear research. The sociologists of science, Bernard Barber and Renée Fox (1958), wrote an article on Thomas' and Kellner's different responses to a serendipitous situation and what it says about styles of research. They found several reasons why Thomas chose to divert his research efforts in a new direction, including the fact that the work on the kidney seemed to have reached a dead end, and that he found the development of floppy ears in a rabbit to be a "dramatic and humorous event." I think this shows, as many of his essays do, that Thomas never took himself too seriously and was always ready to follow his hunches, even if others might find the reasons rather frivolous.

The Lives of a Cell

I suppose many of us first discovered Thomas' work with the publication of his first book of essays, *The Lives of a Cell*, which was subtitled "Notes of a Biology Watcher" (1974). The title essay develops two themes that remain very important to Thomas throughout his essay-writing career. The first is the origin of the eukaryotic cell in symbiotic relationship; in particular, the origin of the mitochondrion as a bacterial symbiont. This idea fascinates him, in part because it is so surprising; who would have thought that we carry bacterial descendants around with us in all our cells? It is also an intriguing idea because it is indicative of the intimate relationships that exist among all organisms. This is Thomas' second theme: We are very dependent on all the living things sharing the Earth with us. The operative word here is "share," a word we do not pay nearly enough attention to. We use the resources of the Earth and hardly think about sharing them with each other, let alone with other species.

Thomas is quite insistent that we humans have been very negligent in our relationship with the other creatures on Earth and with the Earth itself, but his insistence is very gentle. He is not at all strident, but rather gets his points across by using irony and wit. I did not know Lewis Thomas personally, but from his writings I think of him as a man who accepted his life and the people around him with humor and respect, and could, most importantly, laugh at himself. I think he was a good man, and I consider him a friend from whom I have learned a good deal.

I only heard him speak in person on one occasion. I have to admit that I was rather disappointed with his presentation. He did not appear to me to be a very exciting speaker; the gentle humor that is so obvious in his writing just didn't come across at the podium. This is really not that surprising. There are very few people like Stephen Jay Gould who both write and lecture well. For many writers, the written word provides a way for them to express themselves much more fully than they can orally, and Thomas seems to me to fit into this group.

Thomas' second book of essays, *The Medusa and the Snail* (1979), reveals more of himself than he did in his first book, and in doing so he reveals even more of his humanity. He can even find a kind word to say about committees, seeing them as an indication of "the unique capacity of unique, individual human beings to comprehend each other." One essay I particularly liked, perhaps because I am an expert on the subject, is about making mistakes:

> *Mistakes are at the very base of human thought, embedded there, feeding the structure like root nodules. If we were not provided with the knack of being wrong, we could never get anything useful done.*

He then ties human error to the errors that occur in DNA, since these are also creative in that they are important for the continuance of evolutionary change.

I think one reason why so many biology teachers like his essays is that Thomas takes facts with which we are very familiar and gives them a new twist. It can get a little boring when you are teaching DNA replication for the 30th time, but nothing in biology is boring to Thomas because he looks at everything with eyes of wonder. That's what makes him such a good biology watcher; he sees a connection between DNA and human error, between mitochondria and the fate of the Earth.

I can tell how important a book is by what kind of shape it's in; the more it means to me, the worse it looks. My copy of Thomas' third book of essays, *Late Night Thoughts on Listening to Mahler's Ninth Symphony* (1983), is a mess. There is underlining everywhere, there are notes in the margins, and the binding is worn out from being pulled from the shelf over and over again. I keep it on the top shelf of my bookcase along with the *Bible*, my mother's prayerbook, and a copy of my husband's doctoral dissertation.

The Art of Teaching Science

While there are many wonderful essays in this book, the one that means the most to me is "Humanities and Science." It is a reworking of an essay that originally appeared in *The New York Times* under the title "The Art of Teaching Science." I don't think there is any article that made more of an impression on me in terms of my teaching. Under either title, the main point of the essay is that we are teaching science all wrong. Now, since Thomas never taught high school or undergraduate biology, you might think it presumptuous of him to make such a statement, and that teachers would take offense at such audacity. But Thomas writes so convincingly, so politely, so gently—I must use the word gentle again because it is precisely the right word—that one can only agree with him and become as enthusiastic as he is about his solution to the problem.

Thomas argues that science is taught backwards; that instead of teaching students what is known about science we should tell them what is not known. He thinks this approach may be useful because the other one has failed so miserably in giving students both a true picture of science and an appreciation for science. By filling students with information, we turn them off to science because they can't absorb all that's thrown at them. We also give them the idea that science is a finished edifice. A thousand-page textbook would give anyone the impression that *everything* worth knowing about biology is already known, while, in fact, the opposite is very true, that we know very little about how the living world works.

According to Thomas, telling students about what we *don't* know would serve a number of purposes. First, it would put teachers on the same level with their students; they would all be fellow seekers for understanding, with no one having all the answers. Also, it would make science into an adventure as we all try to comprehend the world around us.

Finally, this approach would lead students to expect less of science, to appreciate why all cancers cannot be cured and why environment issues are so difficult to deal with. If nonscientists have the idea that scientists know all the answers, then it is no wonder that they are disappointed with science's record in dealing with human misery, and that negative attitudes toward science develop. Thomas' approach would make such disappointment less likely because nonscientists would have a more realistic view of the limits on scientific knowledge and on the advancement of science.

I cannot say that reading this essay led me to revolutionize my teaching techniques, and that I have since become brilliant in the classroom. Miracles just don't happen, but it is true that I have not taught in quite the same way since reading this essay. I start each semester with a class in which I ask students to ask me any question they want about biology, any question at all. I am secure in doing this, because I'm sure that no matter what they ask I *won't* know the answer. Last semester, for example, someone asked a question about diabetes, and of course, I could answer about insulin and the pancreas, but I could not tell them precisely why some people develop this disease and others don't or precisely why the side effects of this disease develop as they do. No one knows the answers to these questions, and there are a great many questions like that in biology.

I do not spend the semester telling students that we don't know this, and we don't know that, about the living world. I do cover some material because I don't think I could get away with giving a test on nothing at the end of the semester. But with each topic discussed, I do make it a point to mention the areas of ignorance involved. I also try to emphasize throughout the course another major point Thomas makes in this essay: that teachers present the ideas of science as if they were somehow better, more solid, more true, than the ideas of art and literature. I think he very consciously put the humanities first in the title because he wanted to argue against this view. Besides being an accomplished researcher, Thomas was also an accomplished poet. In fact, he had poetry published in *The Atlantic Monthly* and in other magazines before he had published any scientific papers. His interest in poetry, and his understanding of the truth that only poetry can get at, made him appreciate that humans strive to understand the world around them in many different ways and that all these ways of knowing have value and can't be ranked as more or less important than any other.

Critics of Science

There is still one more point that stuck with me from this essay, which is really a gold mine of wonderful ideas. After writing on the "deeper need to teach science to those who will be needed for thinking about it, and this means pretty nearly everyone," Thomas adds that, "it is time to develop a new group of professional thinkers, perhaps a somewhat larger group than the working scientists, who can create a discipline of scientific criticism." He argues that while there are a number of perceptive philosophers of science and historians and journalists of science, there are no critics of science comparable to art critics such as Ruskin or literary critics such as Edmund Wilson.

He only wrote a paragraph on this subject and then dropped it, discussing it no further in this essay or in his other writings. It seems to be just a throwaway idea that he didn't consider worthy of further discussion, but to me, it is an important point. Science does need critics who will ponder the discoveries of science, put them in context, and mull over the whole question of where science is going, just as art critics do for the latest creations of the artistic community. And another function of science critics would be to put the science of today in perspective with relation to the science of the past; only in this way can we have some conceptual foundation upon which to evaluate the discoveries of the future.

Though Thomas did not spend a great deal of time on the idea of science critics, he obviously thought their function was important since he felt their numbers should be "somewhat" larger than those of scientists themselves. This is a rather astounding idea, that there should be more people interpreting and criticizing the work of scientists than people actually doing science. I think Thomas was trying to call attention to the fact that scientists are so involved with their own research that it is difficult for many of them to see the larger picture, to put their work in the context not only of other research but of the culture and society as a whole. Most scientists are so busy with their work that it is difficult for them to do this. There must be a group of people for whom their major work is science criticism, not in the sense of science-bashing, but in the sense of taking the long view of science and its implications.

The idea of the importance of science critics to the development of science and to its understanding and appreciation of nonscientists has meant a lot to me. Not that I think of myself as such a critic, but I do seek out the works of authors who seem to me to be serving this function. One of my favorites at the moment is Richard Lewontin, author of *Biology as Ideology* (1991). In this book, he dissects the implications of biological determinism as well as the consequences of the Human Genome Project. He argues that scientists want to sequence the human genome, "despite its limited usefulness, because they are so completely devoted to the ideology of simple unitary causes that they believe in the efficacy of the research and do not ask themselves more complicated questions." He sees the importance of the Project, not in its practical consequences, but "in its validation and reinforcement of biological determinism as an explanation of all social and individual variation." Such comments, such getting below the surface of research, is, I think, what Thomas has in mind when he writes of science criticism. Such criticism is very constructive in that it forces scientists to look more closely at their goals and examine their intentions; it forces them to do precisely what Lewis Thomas, perhaps our best science critic, has done: ask hard questions about where we are going in science.

While I've dwelt on "Humanities and Science" because it has meant so much to me personally, there are many other great essays in this volume. In "On Smell," Thomas mourns the passing of leaf burning and the odors it produced. In "Seven Wonders," he discusses seven problems in biology that fascinate him, from bacteria that live in thermal vents to the planet Earth itself. The last essay, which provides the title for the book, contains Thomas' ruminations on the threat of nuclear war. While this may seem far from the world of medicine and biology, it is obviously the largest threat to life on Earth and to the humanizing impulses that are so important to Thomas. He writes that he cannot listen to the "last movement of the Mahler Ninth without the door-smashing intrusion of a huge new thought: death everywhere, the dying of everything, the end of humanity. . . . All through the last notes my mind swarms with images of a world

in which the thermonuclear bombs have begun to explode."

The Fragile Species

Thomas also writes of this theme in his last book of essays, *The Fragile Species* (1992). These essays are different from his earlier ones; they are longer and more philosophical. More and more, Thomas takes the long view as a master critic of science, and applies his perceptive focus to the most distressing issues facing the human species today: AIDS, environmental decay, nuclear warfare. These are topics that are written about by a large number of people, but no one brings the combination of insight, commitment, and optimism to these subjects as Thomas does. I use the word optimism because I can't think of a better one. I do not mean to imply that Thomas sees a rosy picture in which science saves us from ourselves, but rather that he sees the human species as having the capacity to deal with its problems and overcome them. This view is what makes the reader of his essays, despite their often depressing topics, feel so uplifted at their conclusion.

I think that what comes through in all his writing is that Thomas loved life, loved people, and loved learning more about both. As a hobby, he studied the origin of words, but as with all his interests, he was not content to learn about them, he had to share his knowledge with others. In 1990, he published *Et Cetera, Et Cetera*, which is subtitled "Notes of a Word-Watcher." He discusses the origin of words ranging from *love* to *human*, and in each case his wit and excitement in learning comes through. In reading this, and all his books, there is the joy of being a Thomas-watcher. The beginning of a new school year seems an appropriate time to pursue this pastime, renew our acquaintance with his work, and thus recharge our love of biology.

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