Chaos, and the Limits of Modern Medicine

It didn’t take me long to realize that biomedical science is dominated by conceptual trends. When I was in medical school in the late 60s, half of all living phenomena were explained by cyclic AMP; the other half by uncoupling oxidation from phosphorylation. During my time at NIH, in the mid 70s, 75% of elevator conversations involved protein kinases. Had apoptosis (programmed cell death) been listed on a stock exchange 10 years ago, I would have sunk my IRA in it; it had the look of a sure winner. I am reminded of the Dean’s Christmas party when I was a medical student. It was held in the massive dining room at Vanderbilt Hall, the student dormitory. Periodically, huge platters of shrimp would be carried out and placed at one end of the hall or the other. Seen from the balcony overlooking the hall, the resulting stampede of the faculty toward the shrimp provided an apt metaphor for the reaction of the scientific community when a new idea comes along.

But enough of cynicism. I am indebted to biomedical trends. Early in my career I served up a small plate of shrimp at the scientific banquet, with the result that I am now more or less free to think deep thoughts. And it is in celebration of a coming trend in medicine that I write this piece. This trend is chaos theory.

American medicine is one of the last bastions of the modernist belief that all things are potentially knowable, and that, as our understanding grows, the condition of humanity—and humanity itself—will improve. This belief, spawned by the French Enlightenment, has experienced a slow death during the 20th century. Philosophers and artists bailed out first, unable to reconcile the modernist concept of progress with the century’s escalating displays of inhumanity and destruction. Political systems based on the assumption of the ultimate perfectibility of humans—Marxism being the best example—have gradually been abandoned. But modernist values live on in some of our institutions, particularly in medical care and in the educational establishment.

Belief in progress defines modern medicine. With each year we understand more, can treat and prevent and cure more. The unspoken and unexamined promise of modern medicine, in popular consciousness if not in the medical community itself, is that some day all disease will be conquered. With no more diseases, perhaps we will never die.

While the modernist concept of progress is not an unreasonable world view in which to practice science, it creates lots of problems for those who practice medicine. One is the feeling that we are all in some sort of grand experiment, in which individuals matter not so much as does the group. The fundamental obligation of the physician is to relieve the suffering of his or her individual patient. In a modernist world view, this goal can appear rather pedestrian when compared with the grander vision of vanquishing disease. I recently heard a seemingly thoughtful oncologist state that every man with prostate cancer in the United States should be enrolled in prospective clinical trials evaluating new treatments. This is not an uncommon view in academic medicine. Think about its implications. The patient is not a patient, but a potential soldier in the war on cancer. The physician is not a physician, but a general in that war. Possibly this will all result in better lives someday for somebody, but the fundamental values expressed have little to do with the job of the physician.

It is with the elderly that some of the contradictions of modern medicine are cast in clearest relief. By the time one reaches 75 one has experienced losses—of friends, perhaps of bodily functions. It is a rare older individual who has not accepted his or her mortality. Everybody dies. In this light, the concept of “conquering” disease loses some of its romance. The physician who assumes the role of the white-coated scientist seeking out and destroying disease can get into trouble with older patients.

Walker Percy, the physician turned novelist, was acutely aware of the havoc that the modernist worship of science has wrought upon Western popular consciousness. In his philosophical essays, Percy repeatedly returns to the simple point that science can tell us nothing about an individual. Science speaks in terms of probabilities, of means and standard deviations, the behavior of groups of electrons or proteins or people, not of individual entities. Everything that makes an individual an individual, everything that importantly defines an individual’s life, is outside the realm of science. The practice of medicine involves only individuals.

One common but not inevitable by-product of modernism is the concept that the ends justify the means: it’s OK to sacrifice a few thousand intellectuals or a few million kulaks to produce a future world free of poverty and strife. In modern medicine we have made a related error: the means have become the ends. Our traditional goal is to help, to heal, to cure. Diagnosing and understanding the disease are one means to that need. But in modern medicine there is a disconnect: diagnosis and understanding have acquired value independent of their possible usefulness in helping the patient. Cure without understanding is suspect; understanding without cure is worthy.

This brings us to the concept of chaos. Chaos theory represents an organized assault on modernism from within the scientific community. Chaos theory does not attack the established findings of traditional science; it simply points out the limitations of a linear, reductionist approach in our attempt to describe natural phenomena. It developed in several disciplines in parallel. In the 1960s, Edward Lorenz, a meteorologist at MIT, constructed a series of computer programs to model weather formation, employing equations to express the relationships between temperature, atmospheric pressure, wind speed, humidity, etc. He discovered what was later termed “sensitive dependence on initial conditions.” Infinitesimal changes in the initial information concerning one or more factors (wind speed, for example) would eventually produce enormous changes in the computer-generated weather patterns. Thence came the “butterfly effect,” the now-famous statement that a butterfly beating its wings in Brazil might lead 2 weeks later to a tornado in Texas. Until then, it was thought that the predictability of a complex system such as the weather represented merely a lack of sufficient data. The traditional scientific outlook was that everything was predict-
able, given enough information. Lorenz was in essence stating that to predict weather long range would require individual data on every molecule in the earth's atmosphere, and, of course, measuring the molecules would alter them. In other words, some systems are unpredictable and always will be unpredictable.

Over the past 3 decades chaos theory has evolved from the observation of chaotic systems to the discovery of laws that describe the behavior of these systems. This activity is called by several names; perhaps "complexity theory" is the best known. Indeed, the principle of self-organization and concepts such as fractals have already begun to contribute to biology and medicine. However, the great gift of chaos theory to the practice of medicine has been the simple but profound negative statement: traditional science cannot predict complex systems.

People are complex systems. We have spent this century of scientific medicine studying only what we could measure. This is understandable. However, we seem to teach and value only those aspects of medicine that we study. This is indefensible. Thus, for example, suffering, the relief of which has always been the primary goal of the physician, is entirely subjective and not measurable in "objective" terms and has consequently been excluded from our discourse.

I suspect that part of our justification for ignoring individual differences or subjective experience—the true core of medical practice—has been that we would eventually master these complexities as soon as our methodology improved to the point that we could study them scientifically. Chaos theory disabuses us of that notion. It gives us the concepts and vocabulary to articulate the fact that much of the practice of medicine is outside the realm of the modernist reductionist model of science.

The physician labors in a sea of uncertainty, but our vocabulary—the product of scientific medicine—communicates a degree of determinism that does not exist. Chaos theory will provide us with a new vocabulary, equally "scientific" and respectable as that of scientific medicine, with which to do battle with our reductionist colleagues. We can use the conceptual framework of chaos theory to teach our students valid ways of analyzing complex systems that do not promise total understanding or total predictability. When complete understanding is abandoned as a goal, the traditional tasks of the physician—listening, witnessing, relieving suffering—will no longer be relegated to a small corner of medicine, the so-called art of medicine, but will be returned to the core of medical practice and medical education.

James S. Goodwin, MD
Galveston, Tex