

Preface to First Edition

Hollywood movies often present a highly romanticized view of scientists--Sigourney Weaver as Dian Fossey forgoing the conveniences of civilization to save Gorillas in the Mist; the wonderful love story of Marie and Pierre Curie, portrayed by Greer Garson and Walter Pidgeon, and their exciting, ineluctable adventure into the unknown; and Paul Muni's Louis Pasteur, the courageous genius who developed vaccines, but was labeled a quack by the medical establishment. Then of course there's the opposite pole exemplified by Mary Shelley's Frankenstein, a ground-breaking morality play warning of the dangers of science.

These story book portrayals contain more than an element of truth, but they are nevertheless atypical. Scientists span the full range of personality types and passions: Some like the Curie's and the Fossey's are engaged 24/7; others who have escaped Hollywood's lens, enjoy a standard 40-hour week. Many no doubt would like to make the discoveries of a Curie or a Pasteur, but the efforts of most scientists are not nearly as consequential – they add only incrementally to knowledge, and become part of a collective that moves a field forward, priming it for the next breakthrough.

We practice science in part because of the enormous satisfactions of search, discovery, and understanding, but we also enter science because it brings a life whose rewards go well beyond those brought by only the technical. These include the deep satisfaction that comes from being part of a diverse global community; the inspirational and humbling experience of having immensely talented friends and colleagues; the deep sense of appreciation for, and admiration of, the kindness of encouraging mentors, knowing that you could not have traveled nearly as far without their support; and the feeling of fulfillment that comes from participating in the growth of generations of students as they become colleagues -- much as you feel as you watch the growth of your own children. Science moves inexorably forward as an international social enterprise that strikes a remarkably productive balance between fierce competition and deep collaboration, without which neither its global nor personal rewards can be achieved. What many of us love and can't do without, is the captivating, rewarding and inextricable linkage of the intellectual with the social, which is there even without the breakthroughs.

That's the common experience of science, but this is a memoir and it necessarily embeds the unique: the events of my professional and personal life beginning with a trajectory set early in grade school and propelled by a remarkable book, a provocative uncle, and the sad sight of environmental erosion that would influence me later in life. Almost everyone's life is punctuated by setbacks and trauma, and mine is no exception – it's replete with the struggles and the failures that teach, the chance events that guide triumph and tragedy, and the rewarding feeling of possibly having made some small contribution to the betterment of humanity.

Chance is important to the extent that it selects for a very specific life path, but the impact of chance is diminished by perseverance and preparation. I was fortunate to have been the Director of the Department of Energy's Health and Environmental Research Programs at a propitious moment, when the sluice gates that constrained oceans of genomic data needed only a nudge to

open. But I had been prepared by years of thinking, dreaming and persevering in the face of disappointment; and by the self-discovery that comes from getting things wrong.

The Human Genome Project has led to rapid advances in medicine and agriculture, and it has enabled a deeper understanding of human evolution, and the relationships among the various species with which we share the planet. It is also speeding the emergence of disruptive technologies that are improving, and will continue to improve, the human condition. But like all powerful technological shifts that occur in a complex planetary culture, the impact of the genomic revolution can be profoundly negative as well as profoundly positive. That fact embodies the dilemma of technological advance, and reflecting on some of the deep ethical and moral dilemmas that have been resurrected by modern technology – including one of the greatest challenges of all: climate change, and the possible role of genomic science in its amelioration – is central to the story of my career.

Almost everyone interested in science will be concerned about the scientific enterprise, and how we view it as a nation – but as a nation our view appears to be distressingly lethargic. We see many signs of this, but I reflect on the two that I know best – our response to climate change, and the impoverished supply of U.S Nationals entering our science and engineering graduate programs. The first requires global action to avert a potentially irreversible planetary calamity, but because it is global, progress will be extremely difficult; the second is within our control, and leaving it unaddressed could well lead to a national crisis in the near future, and the loss of American leadership that will be very hard to win back.

Epilogue

My primary aim in writing this memoir is to convey, at a personal level, the rewards and frustrations of a career in science and, at a social level, the complex interplay between science's benefits and risks. There are also some subdued themes, and bringing them to the surface here will, I hope, help complete the story.

One of the themes is discovery: discovery of the natural world and discovery of self. Neither is localized in the narrative because neither happened all at once, they occurred gradually over decades with, however, some punctuated episodes. One such episode occurred in grade school when the discovery of astronomy literally changed my view of my place in the universe; another episode, which in some ways was more important, was my experience in graduate school when my discovery that I harbored an entirely unrecognized prejudice against a Caucasian scientist from the South forced a reflexive question about other unrecognized biases I might hold.

That incidental discovery made in early adulthood and other related though fewer jogging episodes, are the loose threads of the more general theme of diversity: understanding that differences in backgrounds and experiences shape personality and deeply influence a world view. Interactions among diverse populations can promote understanding, and the ethnic mix in a New York City grade school and the much greater mix in a New York City high school were eye-opening. But ethnic differences have roots that are centuries deep and reflect complex mixtures of war, peace, economics, art, and much else, and a more complete understanding can only be obtained by deep immersion in different cultures. Studying the humanities and social sciences can help, and should therefore be strongly encouraged, but they can take us only so far.

When I graduated from college, more than 50 years ago, campus cultures were largely homogenous. One of the most important – perhaps the most important– educational changes in the last half-century is in the mix of races, ethnic groups and national origins of students on our college campuses. Entire generations of students are now educated in environments in which they live, study and socialize with other men and women representing the entire spectrum of traditions, histories, and views of the world. There's reason to hope and expect that this multidimensional experience will have a profoundly positive impact on the United States in the coming decades.

Another more obvious theme is the importance of perseverance. I have heard the *stay with it* advice from numerous successful people since my high school days and I've experienced its importance first hand. Social scientists now tell us that the typical person can become outstanding in almost anything with enough directed practice. The key to perseverance, however, is passion. For me, perseverance was easy, it was no longer work when I enjoyed what I was doing.

Different people have different skill sets and interests, and the world is full of interesting things to do—and it's always possible to find something that resonates with your skill sets and interests, though the search for resonance might be lengthy. During my years as Dean of Engineering, my advice was occasionally sought by students who were having difficulties, and I frequently concluded the conversation with my passion-trumps-grades advice: if you love it enough to stay with it, success will follow.

But there are limits: I'm not a believer in abandoning that which doesn't immediately captivate. For most people, and it was true for me, a taste for some human activities—some forms of music, for example, is developed over time by repeated exposure. Perhaps even more important is the development of mental discipline: the words attributed to Euclid, *there's no royal road*, don't simply imply that attainment is difficult, they imply that the journey requires mental discipline, and even courage. Mental discipline also isn't acquired quickly: again, speaking for myself, it started in high school, changed gradually over the course of a decade, and reached an inflection point during my association with Crothers and Bell. At Los Alamos, I once heard a senior physicist say that part of his role was to keep the young Turks honest, by which he meant helping them to discipline and clarify their thinking— to avoid the pitfalls of bias.

Einstein purportedly said that education is what remains after forgetting the facts learned in school. William Johnson Cory, the British poet and teacher at Eton College said it in greater and compelling detail more than 150 years ago:

At school you are engaged not so much in acquiring knowledge as in making mental efforts under criticism. A certain amount of knowledge you can indeed with average faculties acquire so as to retain.... But you go to a great school not so much for knowledge as for arts and habits; for the habit of attention, for the art of expression, for the art of assuming at a moment's notice a new intellectual position, for the art of entering quickly into another person's thoughts, for the habit of submitting to censure and refutation, for the art of indicating assent or dissent in graduated terms, for the habit of regarding minute points of accuracy, for the art of working out what is possible in a given time, for taste, for discrimination, for mental courage, and for mental soberness. Above all, you go to a great school for self-knowledge.

I know of no better description of education.