A Time to Abandon Hedgehogs

I refer not to the hedgehog *genes* that are so important for differentiation, but to the way the word is used in Isaiah Berlin's *The Hedgehog and the Fox.* The title of that famous essay runs deep, with many meanings, the most common taken from Archilochus--the Greek lyric-poet who portrayed the fox as knowing many things, and the hedgehog as knowing one big thing. Thus interpreted, we are not confronted with the choice between training hedgehogs and foxes—specialists and generalists--but with the challenge of creating their first generation offspring, of educating a new breed of researcher. This new breed will in fact be the mid twenty first century biologist—a scientist whose use of the computer as a creative analytical engine, rather than a large data repository, will usher in an era of predictive biology; and whose studied awareness of the social implications of the new technologies destined to emerge at a breathtaking rate, will pave a seamless continuum between university and industrial science.

The genomic revolution, like all revolutions, had distinct and characteristic precursors but, like all revolutions, it was nevertheless thrust upon us suddenly and forcefully, catching the educational community largely unprepared. The foment stirred by the draft human sequences--and the sequences of dozens of other genomes—has propelled us into new territory, only sparsely populated with researchers able to fully exploit the continually increasing data flood. The need to respond rapidly is compelling, but so too is the need to respond thoughtfully, and the two are not always easy to reconcile.
How should the educational community respond?

The community as a whole will, I believe, do well to strive for programmatic diversity. Educational programs are almost always multidimensional, and few universities have the resources to afford full coverage of the range of possibilities. Each program must consider where it stands on such matters as the applied / basic research spectrum; the amount of emphasis on development of new computational and mathematical methodologies, as opposed to biological applications; and the distribution of resources between professional MS level training and doctoral level training. Some universities will have comprehensive programs covering every dimension, but even among those that do, we expect to see differences in emphasis. What must be avoided is entrainment to a dominant educational motif; the programmatic meme: the repeated replication of programs characteristic of a few prestigious schools. A wide range of responses to the choices before us will provide the Nation with the pool of scientists and allied professionals required for a strong science base and a strong economy.

For any particular university, in contrast to the community as a whole, the response should be as dynamic and adaptive as resources and sound education permit. If history is a guide, we can expect to see sequelae to the genomic revolution, reverberations driving changes in science and society at a rate foreign to our past experience. The challenge is to develop programs that can anticipate change, without knowing precisely what shape it will take. This raises a complex set of issues and bears directly on the evolving nature of the relation between universities and industry.

The university's main mission of preserving and transmitting our intellectual heritage, while simultaneously creating new knowledge that can alter paradigms and occasionally shake the foundations of our world view, necessarily demands the rigorous scrutiny of new ideas, and discourse that is not temporally constrained, but allowed to run a natural course. As a consequence the time scale for change is typically longer than it is for most social establishments, and certainly longer than that of technologically based industry. These conditions, which bias in favor of developing a deep understanding of the world around us, are also fully commensurate with the best and most effective curricula.

Educational programs that track technology closely are costly, unstable and fundamentally flawed, preparing students for the past rather than the future, as rapid technological change quickly transforms present to past. Productivity in a world of technologies that cannot be anticipated is best prepared for by acquiring general problem solving skills, by becoming adept at methods applicable in a wide range of contexts, by mastering the fundamental principles that provide the basis of all current technologies as well as those to be developed during the next several decades, and by attaining a mastery of fundamentals sufficient to allow self education.[1] On those goals most people, I believe, will agree.

But we are now caught in a sea change that has produced a flood of new data, while we are nearly bereft of the large cadre of creative talent needed to convert it to knowledge at a rate commensurate with its importance. Under these circumstances, and indeed under most circumstances that we can foresee in the future, some coupling between universities and industry will be necessary if higher education is to meet its obligation to society.

University science and engineering programs can be industrially linked in a number of ways: through advisory boards that have strong industrial representation; by offering industrial internships and rotations to students, by collaborations between faculty and industrial researchers who jointly mentor students, and by appointing industrial colleagues as adjunct faculty. Our own Program uses all these methods, and others, to ensure a smooth flow between fundamental discovery and commercial products, and sound preparation for industrial leadership by those students who choose an industrial career. When research projects are chosen with care, and appropriate safeguards are developed to minimize conflicts of interest, collaborative relations can broaden a student's understanding of the relation between fundamental and applied research, and deepen her awareness of the difficult and sometimes tortuous route from scientific discovery to commercial product. We will then be educating scientists who are not only at ease in the several currently distinct academic disciplines that comprise bioinformatics, but who also possess a working familiarity with the complex social enterprise within which different forms of research act synergistically to change the world.

Charles DeLisi, 29 July 2001

[1] Less easily taught is the ability to ask questions, the importance of which is conveyed by Picasso's famous quip, "The trouble with computers is they only give questions".