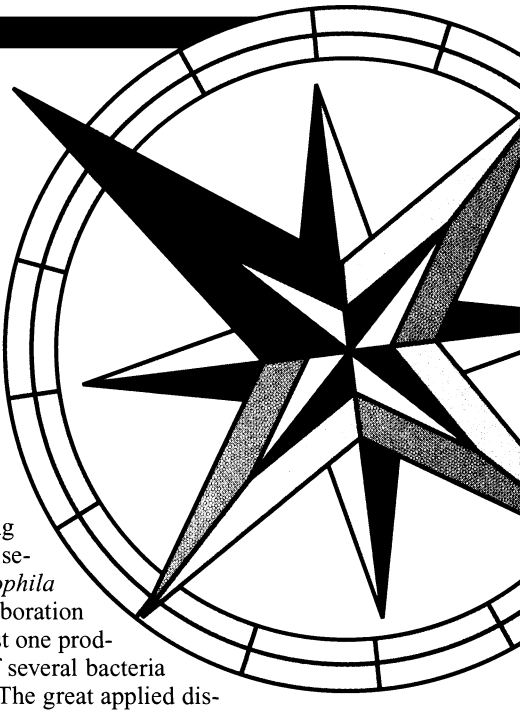

Breakthrough of the Year

Donald Kennedy

The traveling American Ralph Waldo Emerson, on viewing the Natural History Cabinet at the Paris Jardin des Plantes in 1833, wrote of his bliss in seeing the specimens and scientific objects displayed there. "The limits of the possible are enlarged," Emerson exclaimed, "and the real is stranger than the imaginary . . . Here we are impressed with the inexhaustible riches of nature . . . I am moved by strange sympathies; I say continually 'I will be a naturalist.'"

In reflecting on this year's gains for science, it is hard for this editor not to feel as though he had been admitted to such a realm of wonders. First among the marvels of discovery, surely, has been our Breakthrough of the Year 2000 selection: the explosion in genome sequencing, capped by the draft of the *Drosophila* genome. This accomplishment was achieved by a unique path-breaking collaboration between a publicly funded academic group and a corporate effort. But it is just one product of an outburst of sequencing activity that has deciphered the genomes of several bacteria and produced drafts of the genomes of half a dozen multicellular organisms. The great applied disciplines of the life sciences are poised for entry in the next round. We may expect agriculture to harvest new insights from the genome of that favorite laboratory plant *Arabidopsis* and, soon, of rice. And medicine will gain unforeseen benefits by building on the genomes of fly and mouse, not to mention our own.

Of course, the newly sequenced genomes are not the only items in this year's cabinet; it contains a whole array of breakthrough wonders. Here are stunning new analyses of ribosome structure. They reveal that the architecture of the protein component is such that RNA itself catalyzes the coupling of amino acids together to form peptide chains. Over there in a display case is a human skull 1.7 million years old; it belonged to what must have been one of the earliest travelers along the route of the first "out of Africa" diaspora. His journey was terminated in Dmanisi, Georgia, where this exhibit was discovered by a team of German and Georgian researchers. And next to that is a sample of cheap flexible plastic that has been made to conduct electricity as though it were a metal, along with some remarkable microelectronic components that have been devised with this material.

"[A] whole array of breakthrough wonders."

But the center exhibit belongs to the genome efforts. Among these, the *Drosophila* success teaches some special lessons of its own. One is a clear demonstration of the value of collaboration, even, and perhaps especially, between entities having different strengths and objectives. There is a message here, too, for the uneasy and sometimes hostile contenders in the human genome "race." Finally, it has become clear that biology, at least at this level, has moved firmly into the domain of "big science." The success of industrial-strength gene sequencing tells us that it's a new world, one in which some of the costly facilities needed for the work will be privately owned. In such efforts, private capital is put into public service, augmenting our national commitment to basic research.

The results of the genomics revolution tell us something else—about a unity of nature first grasped in the modern sense by Darwin in Patagonia. We now have the opportunity to compare our own set of genetic instructions with those of other species. Those comparisons yield a surprising degree of homology; we are, at this level, more like our fellow creatures than we ever imagined.

Perhaps the most important thing about this Breakthrough of the Year is that it's more of a break-in, exposing new worlds of exploration; not only of genes, their homologies, and the regulation of their expression, but of their protein products and their roles in constructing the organism. Churchill's remark about Rommel's defeat in North Africa, used and abused in the U.S. post-election mess, applies here: "Now this is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning." A cabinet of wonders is now opened for the remarkable community of scientists for whom we work at *Science*. We wish all of them a Happy New Year, in which the best is yet to come.

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