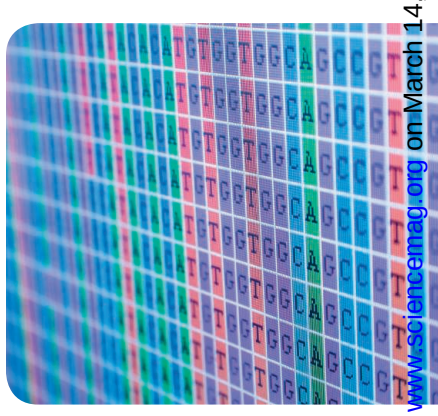
Bruce Alberts is Editor-in-Chief of *Science*.

Lessons from Genomics

IN FEBRUARY 2001, *NATURE* AND *SCIENCE* PROVIDED THE FIRST DETAILED LOOK AT THE HUMAN genome: a string of some 3 billion nucleotides whose unique sequence forms the genetic blueprint for each individual. This momentous occasion made headlines around the world. Now that a decade has elapsed, where has this achievement led us and where are we going with other such ambitious endeavors? Throughout this month in *Science*, the News and Commentary sections will present viewpoints and analyses of the effects of the genomics revolution on science and society (see http://scim.ag/genome10). Many lessons can be derived from the Human Genome Project that should be helpful in guiding other large science projects through their inevitable challenges.*

I have a close personal connection to this topic. Sitting in my office at the University of California, San Francisco, I received a surprising phone call from the U.S. National Academy of Sciences (NAS) in 1986. A prestigious committee had been established to produce a report on the advisability of establishing a new program in the United States to sequence the human genome. This 15-member committee included three Nobel Prize winners, a soon-to-be Nobelist, and a future president of Princeton University, among other luminaries. Some of these scientists were strongly in favor of such a program, while others were strongly against it (most biological scientists were against the idea at the time). The NAS had decided that I should chair this group. I had never even thought about the issue, and I was stunned. But, in retrospect, my lack of previous involvement was probably critical for helping the committee reach a consensus.



This was my first incursion into science policy, and it would trigger a major change in my career. Our 14-month study, released in early 1988,† laid out a strategy that was quickly adopted by the U.S. government. We unanimously supported the goal of obtaining a complete genome sequence of humans, but argued that it should be preceded by work on the much smaller genomes of model organisms. More specifically, any large-scale sequencing of human DNA should be delayed until the development of new technologies dropped the cost below 50 cents per nucleotide. To speed progress, the program that we recommended also emphasized that all genetic and genomic data must be quickly and efficiently shared; business as usual would not do.

Within 7 months of our report's release, James Watson, an influential member of the NAS committee, was appointed as the Director of Human Genome Research at the U.S. National Institutes of Health (NIH). In partnership with the U.S. Department of Energy, NIH Director James Wyngaarden jump-started a cooperative international effort that would set new high standards for data sharing, precisely as our committee had hoped. The publications of the genome sequence that *Science* commemorates this month appeared less than 12 years later, the results of competing public- and private-sector efforts.

Sequencing of the human genome was completed ahead of schedule and below the projected budget of $3 billion. Rarely are such goals achieved in big science projects. Might other such efforts fare better if initially designed by committees dominated by non-involved experts, as for the Human Genome Project? And should more projects begin by supporting competitive efforts aimed at driving down the cost of the major technologies required, setting an efficiency goal to be reached before the next stage of the project proceeds? The rapid evolution of economical and scalable DNA sequencing is an inspiring example of the technological innovations that are possible. Within a few years, "third-generation" sequencing technologies are expected to yield the 3 billion base pairs in a human genome for $1000, a task estimated in 1988 to require 30,000 person-years of effort (3000 scientists sequencing DNA for 10 years each!).

– Bruce Alberts

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*F. S. Collins, M. Morgan, A. Patrinos, *Science* **300**, 286 (2003). †National Research Council, *Mapping and Sequencing the Human Genome* (National Academy Press, Washington, DC, 1988); www.nap.edu/catalog.php?record_id=1097.

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