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The Breakthroughs of 2009

EVERY DECEMBER, THE EDITORS OF *SCIENCE* FACE THE CHALLENGE OF REVIEWING WHAT SCIENCE HAS accomplished around the world in the past 12 months, so as to select our “breakthroughs of the year.” The task is an invigorating one, providing a powerful reminder of both the enormous scope and the continual advance of science. For this year’s selections, the range is staggering. From the discovery of pulsars created by neutron stars that are many thousands of light-years distant, to the production of a new single-atom-thick material such as graphene, the same natural laws and logic have generated new understandings over a more than 10^{30} -fold difference in scale. And there is usually special excitement when an advance directly concerns humans, as in the discovery of an ancient ancestor or a successful application of gene therapy to cure disease.

This year’s selection for the Breakthrough of the Year is the reconstruction of the 4.4-million-year-old *Ardipithecus ramidus* skeleton and her environs, published in *Science* as a major series of 11 articles in October. This choice does not come easily, given the distaste of our editors for self-promotion. But this work changes the way we think about early human evolution, and it represents the culmination of 15 years of highly collaborative research. Remarkably, 47 scientists of diverse expertise from nine nations joined in a painstaking analysis of the 150,000 specimens of fossilized animals and plants [see *Science* **326**, 62 (2009) for photos and locations of each author].

The 11 *Ardipithecus* papers, requiring 89 pages of text plus 295 pages of supporting online material, provide an enormous amount of data for scientists around the world to reexamine. As described on p. 1598 in the current issue, some of those scientists are certain to challenge some of the findings, as further advances are built on those already published. With time, we will come to understand much more, and some current conclusions will probably be modified. This is both to be expected and hoped for: Science can only advance as a highly collaborative global endeavor, through which new knowledge improves on old knowledge based on logic and confirmable evidence.

Our Runner-Up Breakthrough of the Year is “opening up the gamma-ray sky,” as represented by the discovery of gamma-ray pulsars with the Fermi Gamma-ray Space Telescope. Astrophysicist Michael Turner, a member of our Senior Editorial Board, emphasizes the telescope’s astounding capability to scan the entire sky in less than 3 hours, with a sensitivity orders of magnitude better than its predecessors, superior angular resolution and energy coverage, and time coverage ranging from milliseconds to months. The Fermi Telescope has thereby revealed, with unprecedented detail, a very restless high-energy universe, and it is solving old mysteries while making new, unexpected discoveries.

A glance at the remaining eight breakthroughs on our list similarly reveals a heavy dependence of new science on remarkable engineering feats. Most obvious are the Hubble Telescope repair and the giant x-ray laser created at the Stanford Linear Accelerator. But it would be hard to overestimate the benefits to modern science from the development of sophisticated new technologies in essentially every discipline. Indeed, new understandings of the natural world derived from science are constantly being used to generate new techniques and instruments that greatly speed the next scientific discoveries, helping to explain the accelerating pace at which science advances.

To take an example from my field of biology, advances in the techniques for sequencing DNA will soon have moved us from a \$3 billion human genome to a \$3000 human genome in less than 20 years—a reduction in cost of a million-fold, attributable to collaborations of scientists with engineers.

Today, more than ever, scientists and engineers across the globe need each other if we are to continue to achieve the remarkable advances in human understanding that we celebrate in *Science*’s final issue every year: the kind of breakthroughs that the world will always require to improve the welfare of human beings.

– Bruce Alberts

