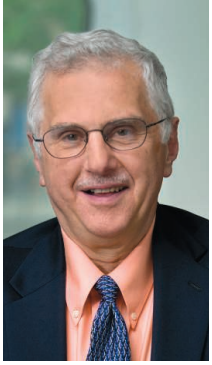

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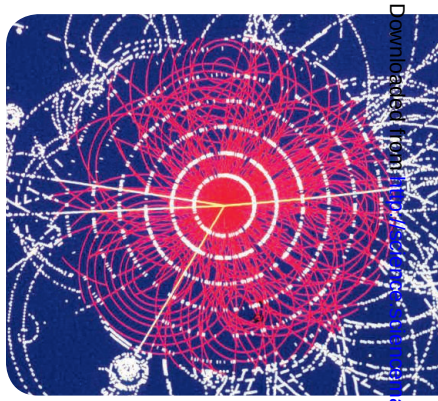
The Breakthroughs of 2012

WE AT *SCIENCE* HAVE ONCE AGAIN HAD THE CHALLENGE OF CHOOSING 10 SCIENTIFIC accomplishments to highlight in this final issue of the year. Our 10 choices reveal that 2012 has been a remarkable one for the physics of particles (the Higgs boson, neutrinos, and Majorana "quasiparticles"), as well as for biological discovery (the production of eggs from stem cells, the derivation of some modern human genes from Denisovan ancestors, and the greatly enhanced cataloging of human genetic regulation). Three technological breakthroughs also appear on our list: functional brain/machine interfaces, TALENS as a tool for genetic engineering, and the x-ray laser determination of a protein structure. And finally, there is one feat of physics and engineering virtuosity: the Curiosity rover's remarkably precise, gentle, "sky crane" landing on Mars.

The top Breakthrough of the Year—the discovery of the Higgs boson—was an unusually easy choice, representing both a triumph of the human intellect and the culmination of decades of work by many thousands of physicists and engineers. The two teams at the CERN Large Hadron Collider that detected this elusive particle have in this issue provided a more widely accessible version of their detailed findings published earlier this year in *Physics Letters B*. These articles are accompanied by a historical summary and overview of this seminal discovery (p. 1560).



The physicist Pierre Hohenberg suggests that it would be useful to distinguish "between the activity of scientists and the product of that activity by denoting the former as (lower-case) science and the latter as (upper-case) Science."* In this view, "Science emerges from science" as "collective, public knowledge…universal and free of contradiction" only after being repeatedly tested by independent scientific investigations. The "standard model" of particle physics, which explains how interactions among the most basic subatomic particles lead to observed matter and forces, is now confirmed by the Higgs boson discovery. It certainly represents big "S"cience, having been challenged and refined over the course of the past 40 years through the efforts of tens of thousands of physicists. And yet, a great deal of mystery still remains at a fundamental level about how the universe behaves.†

An example of outstanding "s"cience forms the basis for this year's breakthrough on Majorana fermions, the first report of a "particle" that is its own antiparticle, formed from the collective motion of many interacting electrons.‡ But further work will be needed, both by the discoverers themselves and by other scientists, to be certain that there is no other way of explaining the results. Only then will this new science become Science.

The success of Science over the past few centuries has enabled humans to reach a remarkable understanding of the natural world that makes our lives much more stable and predictable, just as it enabled scientists and engineers to deliver a 3.3-metric-ton cargo—the Mars rover and its landing craft—onto the surface of a distant planet after traveling for 563 million kilometers. Thus, it is through Science that we know that cigarette smoking over several decades has a high probability of inducing lung cancer; and that, over an even longer time span, human-induced greenhouse gas emissions will endanger life for our descendants on Earth.

Individuals, communities, and nations must all make wise long-range decisions based on what scientists do and do not know. Everyone therefore needs to understand the difference between science and Science and the critical, evidence-based process of getting from one to the other. It is deeply discouraging that in the United States, many political leaders feel comfortable denying the Science of climate change. The acceptability of this stance represents a general failure of science education and communication. It is but one grave example that should spur scientists to focus much more effort on the critical task of ensuring that students, and the general public, understand exactly how Science is derived from science. **– Bruce Alberts**

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*http://physics.nyu.edu/~pch2/What_is_Science-December_2010.pdf.
†www.sciencemag.org/site/special/astro2012/index.xhtml. ‡V. Mourik *et al.*, *Science* **336**, 1003 (2012).

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