

BIG SCIENCE, BIG CHALLENGES

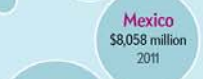
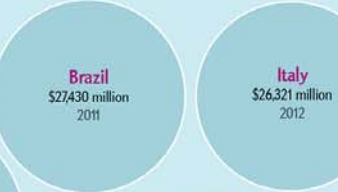
HOW BIG IS SCIENCE?

MAMMOTH INSTRUMENTS OF SCIENCE SUCH AS CERN'S Large Hadron Collider are often held up as symbols of the human commitment to decoding the world. But how highly does humanity as a whole actually regard science? How big *is* science—all of it? This is not an easy question to answer, but by gathering what credible data exist, we can approximate an answer.

—The Editors



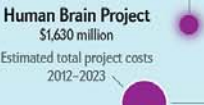
THE BOMB
The Manhattan Project, which developed the first atomic bombs, cost more than \$23 billion and employed 130,000 people. For better or worse, it became a model of what "Big Science" could achieve.



HUMAN SPACEFLIGHT
Putting astronauts in space—and in the case of the International Space Station, keeping them there—has been one of the most costly and labor-intensive projects in the history of science. By comparison, deploying robotic probes such as the Mars Science Laboratory is a bargain.



*All country R&D values expressed in purchasing parity dollars, a currency conversion designed to reflect the varying cost of living in different countries.



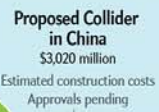
BRAIN STUDIES
One of the greatest remaining scientific mysteries is how the three-pound lumps of meat in our heads produce consciousness. Several large, well-funded initiatives, including the Human Brain Project in Europe and the BRAIN Initiative in the U.S., aim to develop basic tools to help scientists solve this puzzle and cure brain diseases.



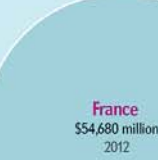
THE GENOME
The \$4.7-billion, 13-year Human Genome Project, which in April 2003 finished sequencing the entire human genetic code, was arguably the first true Big Science project in the realm of biology and medicine. New efforts include the 100,000 Genomes Project, which aims to sequence the full genomes of 100,000 U.K. National Health Service patients to search for genetic links to disease.

GLOBAL SCIENCE SPENDING
No single data set captures every dollar spent on scientific research worldwide, but by looking at R&D spending by the world's biggest economies, we can get a sense of the scale of global research.

* All project values converted to 2015 U.S. dollars.



PARTICLE COLLIDERS
They are expensive, enormous and, for physicists, essential: there is no way to test certain theories without replicating the conditions immediately following the big bang. The 27-kilometer Large Hadron Collider near Geneva is the world's largest, but China has proposed a collider that, if built, will be almost twice the size.



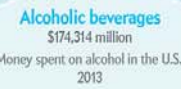
BIG TELESCOPES
The largest telescopes in development today, particularly the nearly \$8-billion James Webb Space Telescope, rival the cost and ambition level of particle colliders.



BIG ENERGY
Humanity's greatest problem—powering civilization without destroying the planet—is urgent enough to justify massive undertakings such as ITER, a collaboration among China, the European Union, India, Japan, South Korea, Russia and the U.S. Once completed, ITER will be the biggest fusion reactor ever built.



USEFUL PERSPECTIVE
Even at the highest levels, spending on science is dwarfed by consumer expenditures and military budgets. For example, \$2.65 billion for the Mars Science Laboratory sounds like a lot of money—and it is—but it is still less than the worldwide box-office gross for the film *Avatar*. The F-35 Lightning II provides perhaps the ultimate point of reference: the stealthy fifth-generation fighter cost some \$391 billion to develop.



Graphic by Jen Christiansen, Research by Amanda Hobbs
SOURCES: UNESCO INSTITUTE FOR STATISTICS (pendent on research and development, by country); THE MANHATTAN PROJECT, THE APOLLO PROGRAM, AND FEDERAL ENERGY TECHNOLOGY R&D PROGRAMS: A COMPARATIVE ANALYSIS, BY DEBORAH D. STINE, CONGRESSIONAL RESEARCH SERVICE REPORT FOR CONGRESS, JUNE 30, 2009 (Manhattan Project); APOLLO BY THE NUMBERS: A STATISTICAL REPORT, REVISED, BY RICHARD W. ORLOFF, NASA, SEPTEMBER 2004 (Apollo project); EUROPEAN SPACE AGENCY (International Space Station); NATIONAL HUMAN GENOME RESEARCH INSTITUTE (Human Genome Project); "HUMAN GENOME: UK TO BECOME WORLD NUMBER 1 IN DNA TESTING," BY U.K. PRIME MINISTERS OFFICE ET AL., AUGUST 1, 2004 (100,000 Genomes Project); THE HUMAN BRAIN PROJECT: A REPORT TO THE EUROPEAN COMMISSION, BY HBP-PS CONSENSUS, APRIL 2012 (Human Brain Project); WHITE HOUSE BRAIN INITIATIVE (BRAIN Initiative); "THE GENOME," BY CERN, FEBRUARY 2009 (Large Hadron Collider); FAQ FUNDING AND COSTS (European Spallation Source); "CHINA PLANS SUPER COLLIDER," BY ELIZABETH GIBNEY, IN NATURE, VOL. 518, JULY 24, 2014 (proposed collider in China); "ALMA INAUGURATION HERALDS NEW ERA OF DISCOVERY," BY EUROPEAN SOUTHERN OBSERVATORY ORGANIZATION, MARCH 13, 2013 (ALMA); ITER WEB SITE (ITER); NASA (James Webb Space Telescope, Mars Science Laboratory, New Horizons); "DEPARTMENT OF DEFENSE SELECTED ACQUISITION REPORTS (SARs) (AS OF DECEMBER 31, 2014)," BY U.S. DEPARTMENT OF DEFENSE, MARCH 19, 2015 (F-35); BOX OFFICE MOJO (Avatar); FOOD EXPENDITURES, USDA ECONOMIC RESEARCH SERVICE (alcohol)