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*

Manhattan Project
$23,000 million–$27,000 million ($2,200 million in 1945)
Total cost 1942–1945

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.

BRAIN Initiative
$300 million+
Federal investment through 2015
Launched in 2013

Human Brain Project
$1,630 million
Estimated total project costs 2012–2023

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.

U.S.
$453,544 million*
2012

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

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.

Human Genome Project
$4,730 million †
Total project costs 1990–2003

100,000 Genomes Project
$471 million
Current investments 2012–2017

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.

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

Proposed Collider in China
$3,020 million
Estimated construction costs
Approvals pending

Large Hadron Collider
$5,370 million
Personnel, materials, R&D, tests and preoperation costs
Operational in 2008

European Spallation Source
$2,260 million
Projected construction costs
Broke ground in 2014

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.

China
$243,293 million
2012

South Korea
$58,380 million
2011

Japan
$148,389 million
2011

Germany
$100,248 million
2012

BIG SCIENCE, BIG CHALLENGES

Brazil
$27,430 million
2011

Italy
$26,321 million
2012

India
$36,196 million
2011

Canada
$24,801 million
2012

Indonesia
$795 million
2009

South Africa
$3,986 million
2010

Saudi Arabia
$503 million
2009

Mexico
$8,058 million
2011

Australia
$20,469 million
2010

Turkey
$11,302 million
2011

Russian Federation
$37,854 million
2012

International Space Station
about $140,000 million
Includes development, assembly and running costs over 10 years
First segment launched in 1998

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.

New Horizons Pluto Mission
$700 million
Spacecraft and instrument development, launch vehicle, mission operations, data analysis and outreach
Launched 2006

Apollo Program
$104,270 million
Total budget appropriations
1960–1973

U.K.
$39,110 million
2012

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.

Mars Science Laboratory
$2,650 million
Total cost
Launched 2011

ALMA
$1,430 million
Total construction costs
2013

James Webb Space Telescope
$7,998 million
NASA's cost to build, launch and commission
Target launch date: 2018

France
$54,680 million
2012

ITER
$19,660 million
Estimated construction costs
Target completion date: 2027

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.

Avatar
$2,788 million
Worldwide box-office gross
Released 2009

F-35 (fighter jet)
$391,100 million
Program cost
for a total of 2,457 planes
as of December 31, 2014

Alcoholic beverages
$174,314 million
Money spent on alcohol in the U.S.
2013

Graphic by Jen Christiansen

SOURCES: UNESCO INSTITUTE FOR STATISTICS (*expenditure 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 MINISTER'S OFFICE ET AL., AUGUST 1, 2014 (*100,000 Genomes Project*); *THE HUMAN BRAIN PROJECT: A REPORT TO THE EUROPEAN COMMISSION*, BY HBP-PS CONSORTIUM, APRIL 2012 (*Human Brain Project*); WHITE HOUSE BRAIN INITIATIVE *www.whitehouse.gov/brain* (*BRAIN Initiative*); *LHC: THE GUIDE*, BY CERN, FEBRUARY 2009 (*Large Hadron Collider*); FAQ FUNDING AND COSTS *http://europeanspallationsource.se/faq-funding-and-costs* (*European Spallation Source*); "CHINA PLANS SUPER COLLIDER," BY ELIZABETH GIBNEY, IN *NATURE*, VOL. 511; 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 *www.iter.org* (*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*)