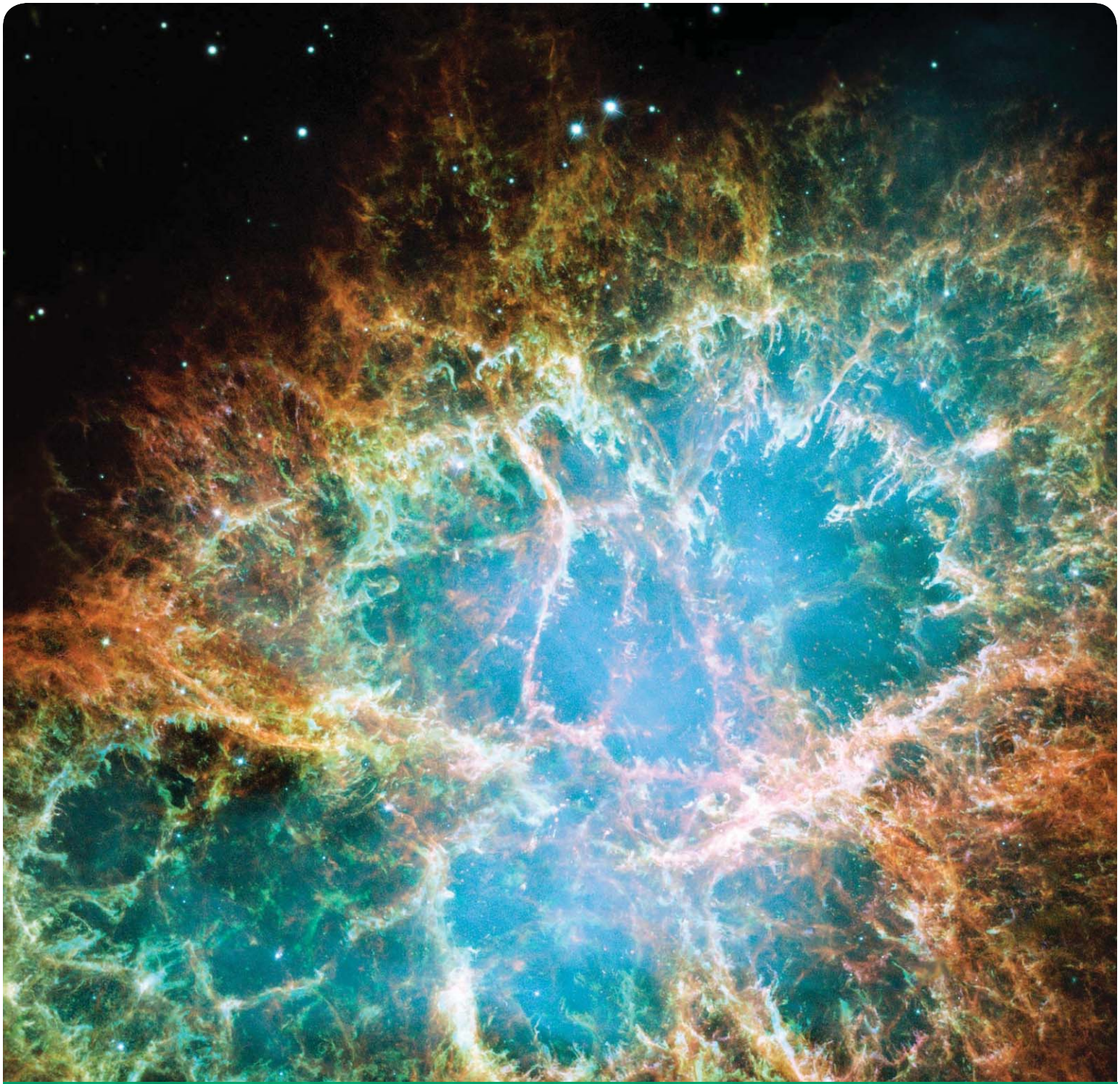


Introduction

A composite image of the Crab Nebula taken by the Hubble Space Telescope. After analyzing data from observations with NSF's Laser Interferometer Gravitational-Wave Observatory (LIGO), scientists concluded that only four percent of the energy from the Crab pulsar could be in the form of gravitational waves. *Credit: NASA, ESA, J. Hester and A. Loll, Arizona State University*

Advancing the frontiers of science and engineering depends, in part, on transformational facilities and instruments, and on the ability to use them effectively. For the National Science Foundation (NSF)—the only federal agency that supports fundamental research and education across all fields of science and engineering—providing a world-class research infrastructure is essential to the furthering of discovery, innovation and learning. Through advances in research infrastructure and collaborative environments, we ensure that the nation's scientists, engineers, teachers and students have opportunities to explore areas of exceptional promise.

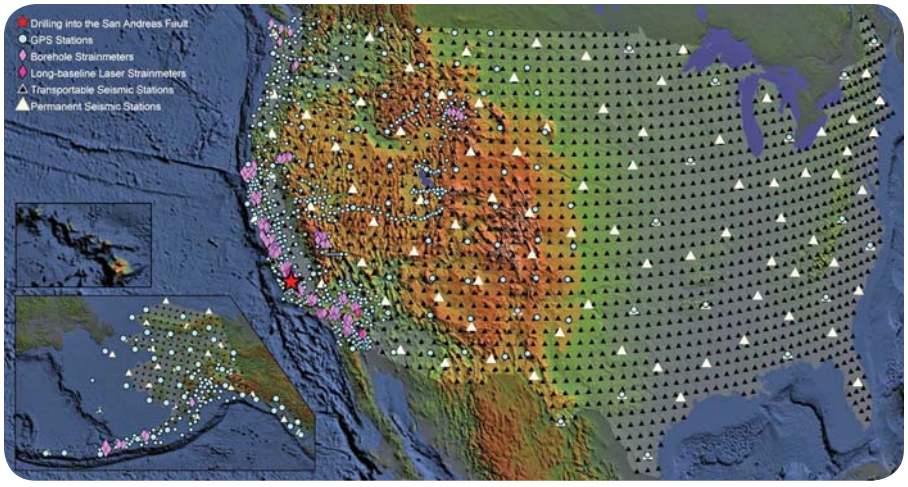
NSF is known for supporting science and engineering ideas, but, perhaps, less well known for our support of new and powerful tools and dynamic research centers. And yet, NSF has a mission to make advanced equipment, facilities, and shared cyberinfrastructure broadly available to the entire research community. Infrastructure and center investments have enabled researchers and educators to pursue fundamental questions, unravel newly revealed mysteries, transform fields and disciplines, and expand people's understanding of the universe and their place in it. These investments are essential to maintaining the overall leadership of the U.S. science and engineering enterprise.

A few examples demonstrate the potential for unprecedented discoveries and transformative innovations:

- Using NSF's Laser Interferometer Gravitational-wave Observatory (LIGO) facility based in Hanford, Wash., and Livingston, La., scientists are moving closer to detecting gravitational waves—Einstein's long-theorized ripples in the fabric of space and time. An analysis of the Crab Pulsar in the Crab Nebula by LIGO scientists found that no more than four percent of the pulsar's energy loss is caused by the emission of gravitational waves, disproving one theory that gravitational waves significantly slow down the spinning of neutron stars. While LIGO has not yet detected any actual gravitational waves, this analysis did provide an exciting first look at the interior of a neutron star.

- Massachusetts Institute of Technology researchers and colleagues, partially funded by NSF's Materials Research Science and Engineering Centers (MRSEC) program, have created a waterproof adhesive bandage that is inspired by the gecko's uniquely adhesive feet. The bandage's surface has nanoscale hills and valleys similar to those on the gecko's foot that enable the lizard to cling to walls and ceilings. The new bandages could join sutures and staples as a basic operating room tool for patching up surgical wounds.

Close-up views of gecko feet, showing different toe pad structures. A team of researchers reported evidence for dry adhesion of gecko setae (hair-like structures) by the weak molecular attractive forces known as van der Waals forces. The discovery paved the way for researchers to design synthetic dry adhesives inspired by geckos. *Credit: Image courtesy professor Kellar Autumn, from Autumn, K., et al. 2002. Evidence for van der Waals adhesion in gecko setae. Proc. Natl. Acad. Sci. USA 99, 12252-12256.*



This map depicts the footprint of EarthScope, a distributed, continental-scale, multipurpose, geophysical instrument array that enables researchers to study the structure and dynamics of the North American continent. *Credit: EarthScope*

- Scientists working with seismic data from NSF's continental-scale EarthScope facility are gaining important insights into the processes in the Earth's crust that give rise to Episodic Tremor and Slip (ETS) events, such as those that occur regularly in the Pacific Northwest. In contrast to a "typical earthquake" with a duration of just seconds, these recently discovered "slow earthquakes" may have a duration that extends from two to several weeks. In one part of the Cascadia zone, ETS events have been detected with a regular 14-month period, allowing successful prediction of 5 additional events. ETS events are very important to understand because they are believed to influence the size and timing of future large earthquakes.

- A joint team of physicists and ophthalmologists from the NSF-supported Center for Ultrafast Optical Science at the University of Michigan and the university's Kellogg Eye Center developed a procedure that significantly improved LASIK surgery procedures. The improvement involves using an ultrafast laser to make clean, high-precision surgical cuts in the human cornea. Using the ultrafast laser instead of a mechanical blade enables surgeons to create a precise corneal flap. The femtosecond laser "scalpel" provides surgeons much higher precision and accuracy. The Michigan center was an NSF Science and Technology Center (STC) from 1990-2001; today, it's an interdisciplinary research center in the university's College of Engineering. The researchers' work has already benefited hundreds of thousands of people who have undergone vision correction procedures since 2001. Two members of the Michigan research team founded the IntraLase Corporation to commercialize the femtosecond laser technology. Advanced Medical Optics, Inc. agreed to acquire IntraLase for about $808 million in 2007.

- Students and staff members at the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign, one of the early NSF-supported supercomputer centers, developed NCSA Mosaic, the first freely available Web browser. Mosaic allowed Web pages to include text and graphics, significantly improving the utility of Internet applications. Mosaic and its successors spurred a revolution in communications, business, education, and entertainment that has had a trillion-dollar impact on the global economy.

This small selection of examples demonstrates the returns to the nation from NSF's investments in research infrastructure. Many more such examples are presented in the main section of this report. As they illustrate, the knowledge generated at NSF-funded centers and using NSF-funded facilities, equipment and shared cyberinfrastructure contribute daily to discovery, innovation and learning in the U.S.