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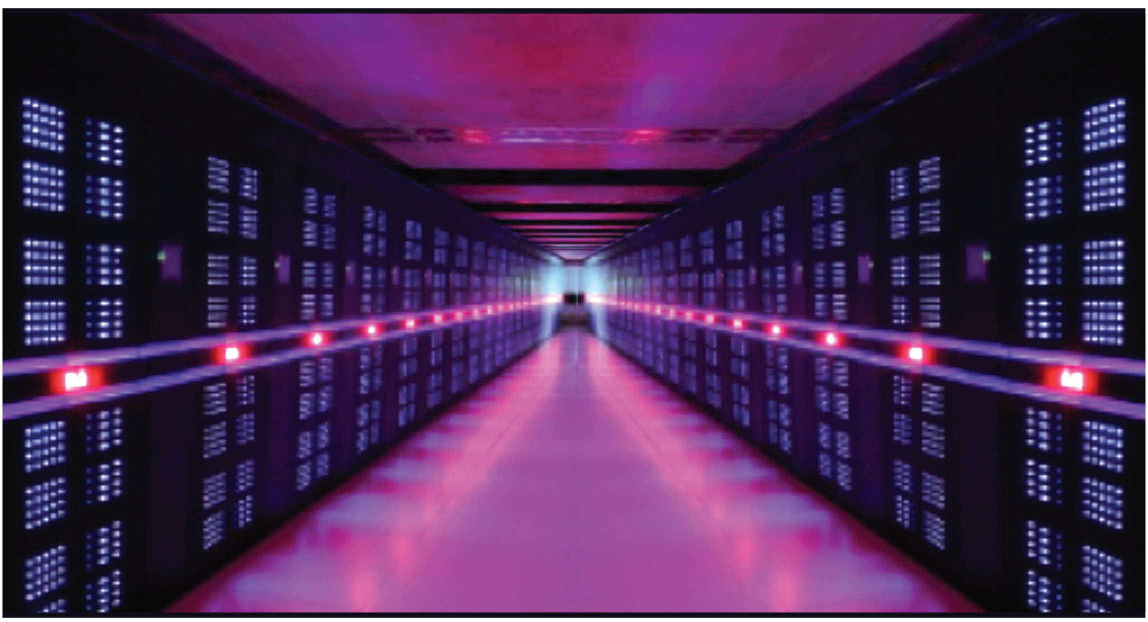
THE FUTURE POSTPONED

Why Declining Investment in Basic Research Threatens a U.S. Innovation Deficit

Illustrative Case Studies



A Report by the MIT Committee to Evaluate the Innovation Deficit

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SPACE EXPLORATION

Is there life on other earth-like planets? What exactly are "dark matter" and "dark energy" and how have they shaped the universe? Only research in space can answer such questions.

The U.S. role in space has been significantly reduced in recent years. What captured the public's imagination in this past year was the dramatic rendezvous with a comet—somewhere out past the orbit of Mars—by a European spacecraft. The mission was not only daring—it took a decade for the spacecraft to reach and match orbits with the comet—but also yielded important science: water on the comet is isotopically different from that on Earth, making it unlikely that comets were the source of Earth's abundant water resources. This past year, too, India has placed a spacecraft in orbit around Mars with instruments that are as sophisticated as those used by NASA, and China has successfully launched a spacecraft that orbited the moon and returned safely to Earth.

But the secrets of our solar system are not the only mystery out there in space. Are we alone in the universe? A definitive finding of life elsewhere would galvanize public attention around the world. Space telescopes including the U.S. Kepler mission have identified over 1000 confirmed planets circling other stars in our galaxy. Of these, a dozen are close enough and of a size—up to about 1.6 times the mass of Earth—that they appear to be rocky planets like Earth and with densities and apparent compositions to match. Some of them appear to be at the right distance from their stars to have liquid water, and thus could in theory support life. A new U.S. space observatory focused on such planets, the Transiting Exoplanet Survey Satellite, is to be launched in 2017, if budget cuts do not delay it.

A still more profound mystery concerns the basic "stuff" the universe is made of, how stars and galaxies evolved, and how the universe is still evolving. We know the broad outlines: our universe is almost 14 billion years old; about 5 percent of it is composed of normal matter—atoms and molecules; a much larger portion, about 27 percent, is made up of the still mysterious "dark matter" which helps to shape galaxies and the universe itself through its gravitational pull; and the rest is the even more mysterious "dark energy" that is pushing the universe to continue to expand outward, enlarging in size. The physics of both dark matter and dark energy—the dominant features of our universe—are still completely unknown, as are the details of how the push and pull of these forces controlled the evolution of the universe in the first few billion years after the Big Bang. Breakthrough discoveries here would not only transform astrophysics, but physics itself.

The James Webb telescope will again give the U.S. a leadership role in astrophysics. But its cost and recent budget cuts will likely delay or prevent other high opportunity missions. Meanwhile, other nations are pressing ahead.

The centerpiece of the U.S. program of space science in the coming years is the launch of the James Webb space telescope, which will focus on star formation, the evolution of galaxies, and the earliest moments of the universe itself. Scientists hope that it will help shed light on both dark matter and dark energy as well as related astrophysical phenomena. The Webb telescope is far larger than the 20-year-old Hubble space telescope, for which it is the successor: the main mirror is 6.5 meters across (the Hubble main mirror was 2.5 meters). More importantly, the Webb telescope is designed to see deeper into the universe and further back in time, and for that reason will observe mostly in infrared wavelengths (faraway objects are "red-shifted), as compared to the optical and UV observing design for the Hubble. For the same reason, the new telescope will not be in Earth orbit, but instead will orbit the sun in tandem with the Earth but at a distance from us of 1.5 million kilometers, where there is less "noise" in the infrared spectrum.

This new capability will again give the U.S. a leadership role in astrophysics, but the cost of the telescope and recent budget cuts for space science will likely delay or prevent other high opportunity missions as well as related theoretical and computation research. Meanwhile, other nations are pressing ahead.

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