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Research in Basic Science Brings Innovations that Improve Our Lives.

In the 21st century, scientific discoveries affect how we live, how we work, how we communicate with the world around us. Yet scientists did not set out to develop many of these now vital technologies.

The history of science is rich in stories of how the study of very abstract concepts gave rise to unanticipated major technological advances.

In the 1600's, Isaac Newton questioned why objects move and the best way to describe their motion. He introduced a new and abstract concept called gravity and pondered how it could reach across space, even to the planets and stars. His questions became key to mechanical engineering, the use of satellite observatories, the understanding of the geology of our planet and to flight.

In the 1700's, electricity was a rare phenomenon — only exhibited in a few places like lightning. But this provoked the curiosity of scientists who gave us electric motors and generators. And in the 19th century James C. Maxwell connected magnetism and electricity with the vibrations of "electromagnetism," giving rise to the control of light, radio, radar and microwaves.

By the late 1800's, the behavior of substances heated so that they glowed from dull red to "white hot" caught the attention of physicists. Bohr, Planck, Einstein, Heisenberg and Schroedinger could not have predicted that their discoveries would result in transistors, televisions, computers, the Internet and cell phones.

The practical applications that emerged from scientific curiosity account for a large portion of the total Gross Domestic Product of all industrial nations and dominate not only our economy, but also our social behavior.

IN THE UPCOMING WEEKS WE WILL BE SHARING STORIES OF HOW OUR COUNTRY'S COMMITMENT TO FUNDING BASIC SCIENCE EXPLORATION HAS REVOLUTIONIZED OUR LIVES.

Science is an important investment for America, even when government resources are scarce.

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Research in Basic Science Brings Innovations That Improve Our Lives...

... like MRI.

The most powerful, yet non-invasive, diagnostic tools of the 21st century provide doctors immediate access to detailed images of their patients' bodies. Yet scientists did not set out to invent MRI.

Beginning in the 1930's, scientists in the United States began to understand the fundamental nature of particles, matter and energy, by using accelerators, or "atom smashers", to collide atomic particles at increasingly high energies. Meanwhile, condensed matter physicists began to illuminate the behavior of atomic particles in the presence of strong electromagnetic fields. Federal funding for research in nuclear, high energy, and condensed matter physics fueled research into the nature of these atomic particles and their interaction with matter, as well as the increasingly sophisticated and large magnets needed for the machines to accelerate atomic particles. What began as solely laboratory based phenomena evolved into the invention of new tools for the diagnosis and treatment of disease.

Today, magnetic resonance imaging (MRI) scans are able to look at the size and shape of organs and body structures, allowing doctors to identify strokes, soft tissue injuries and tumors quickly and prepare a medical response.

In short, MRI saves time, saves money, and most importantly, saves lives.

Today, universities and national laboratories are exploring new techniques for using this technology. Breast biopsies are now being guided in real-time by MRI – a new, important advance in diagnosing breast cancer.

Researchers are also developing methods to measure precisely and non-invasively patients' blood flow while they exercise. That information yields a better understanding of vascular disease and may ultimately lead to improved diagnosis and treatment. Which, in the end, are the results we all want.

SCIENTISTS DID NOT SET OUT TO INVENT MRI – IT EMERGED BY APPLYING KNOWLEDGE LEARNED THROUGH OUR COMMITMENT TO FUND BASIC SCIENTIFIC EXPLORATION.

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Research in Basic Science Brings Innovations That Improve Our Lives...

... like Satellites.

The most powerful communication tools of the 21st century provide us with the split-second ability to send sounds, pictures and numerical data. Yet scientists did not set out to invent satellite technology.

In 1907, a young student named Robert Goddard attracted unwanted attention in a cloud of smoke from a powder-fueled rocket fired in the basement of a campus physics building. To their credit, instead of expelling young Goddard, school officials took an immediate interest in his work. After two decades of research, Goddard launched his first liquid fuel rocket in 1926.

Then, in the 1950's, the world was changed forever by the launch of the Russian satellite Sputnik.

Sputnik captured the world's attention and the United States responded with dedicated federal funding for new research in basic science. The innovations that grew out of this support include microwave and optical technology, detection and digital processing of signals, precision timing and global positioning systems. What began as solely laboratory-based phenomena evolved into the invention of new communications tools.

Today, satellite communications allow news organizations to provide worldwide live, on-the-spot broadcasting, cell phone networks to keep businesses and families in touch, financial access to ATM machines and the simple pleasure of satellite TV and radio.

In short, satellites save time and money. Most importantly, they keep us in touch with the people who matter most to us.

Today, universities and national laboratories are exploring more advanced technologies that make use of navigation software and Global Positioning System (GPS) receivers. Further miniaturization of satellite systems using nanotechnology and microelectronics research may make even smaller satellites possible, saving resources and reducing space flight payload sizes. And these technologies hold the possibility of allowing for more cost effective and reliable communication. Which, in the end, are the results we all want.

SCIENTISTS DID NOT SET OUT TO INVENT THE TECHNOLOGY BEHIND SATELLITE COMMUNICATIONS — IT EMERGED BY APPLYING KNOWLEDGE LEARNED THROUGH OUR COMMITMENT TO FUND BASIC SCIENTIFIC EXPLORATION.

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... like Solar Energy.

Research in Basic Science Brings Innovations That Improve Our Lives...

Using technology to harness the sun's energy now complements the sun's primary role in sustaining life on the planet. Yet scientists did not set out to invent solar energy technology.

In 1839, a 19-year-old physicist, Edmund Becquerel, first observed what is called the photovoltaic effect - the generation of electric current using a light sensitive device. Sixty years later, at the dawn of the 20th century, physicists Max Planck and an unknown Albert Einstein suggested that light consists of bundles of energy, which came to be called photons, and provided key scientific underpinnings for the later realization of solar energy technology.

In 1954, Becquerel's century-old discovery, illuminated by the work of many others, resulted in the introduction of the first solar photovoltaic device to produce a useful amount of electricity. And by 1958, solar cells were being used in small-scale scientific applications and for the space program. Industry developments and federal funding of research in the 1970's made remote applications of the technology possible. What began as a laboratory curiosity is now providing solar energy to power devices essential to our lives.

Today, photovoltaic solar cells convert sunlight into electricity. The simplest cells power watches and calculators, while more complex systems can light houses and provide power to large scale electric grids. In short, solar energy can save money and is conserving our valuable non-renewable resources.

The new millennium has seen universities and national laboratories exploring even more research and production advances. Next-generation photovoltaic materials currently under development may bring dramatic decreases in price as well as greater availability. And smaller systems that produce hydrogen fuel by using electricity could help to bring about the transition to a hydrogen-based economy.

Work on photovoltaic solar cells may bring a future of cleaner, cheaper forms of energy. Which, in the end, is the result we all want.

SCIENTISTS DID NOT SET OUT TO INVENT THE ABILITY TO HARNESS SOLAR ENERGY — IT EMERGED BY APPLYING KNOWLEDGE LEARNED THROUGH OUR COMMITMENT TO FUND BASIC SCIENTIFIC EXPLORATION.

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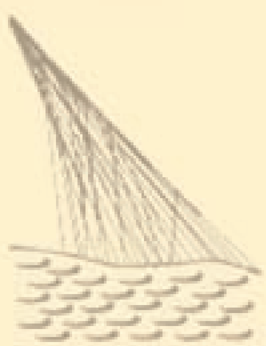

Where will Cosmic Rays Take Us?

A mystery of our universe that has scientists probing the frontiers of knowledge involves the study of highly energetic particles that bombard the earth from all directions of space – cosmic rays.

In 1912, Austrian scientist Victor Hess piloted a balloon to a then daunting altitude of 17,500 feet. He found that radiation at high altitudes is more intense than it is on the ground and concluded that this “cosmic” radiation must come from outer space.

Then in 1938, French physicist Pierre Auger discovered that cosmic rays collide with molecules high in the earth’s atmosphere to create a veritable shower of invisible particles that rain down on the earth’s surface.

But even today, nobody knows how the most powerful of these cosmic rays are made or where they come from. Some produce huge particle showers over an area as large as a city and have an energy 10 million times greater than we can make with any particle accelerator here on earth. Scientists believe that they must come from somewhere far outside our solar system or even from outside our galaxy.

With the help of federal research funding, physicists from the United States and around the world have recently come together to construct the world’s largest cosmic ray observatory on the Argentine high plain near the Andes. When complete, it will have 1,600 detectors spaced across an area the size of the state of Rhode Island. Each detector is self-powered with a small solar energy panel. When a particle shower strikes a group of detectors, they transmit their data to a central computer using ordinary cell phone technology. And, satellite-based Global Positioning System (GPS) devices tell scientists exactly when each event occurs.

The Pierre Auger Cosmic Ray Observatory will reveal clues about the engine that powers our universe’s cosmic ray accelerator.

WHEN WE PROBE THE MYSTERIES OF OUR UNIVERSE, THERE’S NO TELLING WHERE THE DISCOVERIES MIGHT LEAD US OR HOW THEY MIGHT REVOLUTIONIZE OUR LIVES – THE ONLY WAY WE’LL FIND OUT IS BY FUNDING BASIC SCIENTIFIC EXPLORATION.

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... like Lasers.

Research in Basic Science Brings Innovations That Improve Our Lives...

Some of the most powerful laser inventions of the 21st century allow for precision in areas like manufacturing, telecommunications and medicine. Yet scientists did not set out to develop these now vital technologies.

At the dawn of the 20th century, physicists Max Planck and a then unknown Albert Einstein developed a theory which explained that light does not consist of continuous waves, or of small, hard particles. Instead, it exists as bundles of energy called photons, which possess the characteristics of both waves and particles. Each photon has an energy that corresponds to the frequency of the waves in the bundle.

In the 1950's, federal funding for research linked to Planck and Einstein's original work led to the development of the precursor to the laser. What began as a solely laboratory based phenomenon to help scientists study molecular structures is now used in a multitude of tools essential to our lives.

Modern telecommunications relies on photons, as tiny semiconductor lasers transmit light pulses carrying billions of bits of information per second over glass fibers. High power CO_2 lasers are used in manufacturing for drilling, cutting, welding, heat-treating and alloying. In medicine, lasers are used to correct vision, to diagnose and destroy cancers, to help heal wounds and to perform microsurgery. From the copy machines and laser printers in our offices, to the scan bar codes at the supermarket, the laser has fueled a flood of industrial activity.

And there is no ebbing of this trend in sight. Universities and national laboratories are exploring innovative techniques for using laser technology. New understanding of coherent ultra-short wavelengths may be the only practical way to manufacture nanotechnology structures the size of a grain of sand. And lasers may even offer the potential for unlimited energy – Inertial Confinement Fusion uses lasers to compress and heat hydrogen fuel to temperatures of 100 million degrees Celsius, and uses the inertia of the fuel to confine it long enough for fusion to occur.

Scientific innovation promises new opportunities for improving not only the lives of our families, but of society. Which, in the end, are the results we all want.

SCIENTISTS DID NOT SET OUT TO REVOLUTIONIZE OUR LIVES THROUGH LASER TECHNOLOGY – IT EMERGED BY APPLYING KNOWLEDGE LEARNED THROUGH OUR COMMITMENT TO FUND BASIC SCIENTIFIC EXPLORATION.

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