Beyond Measure
A profile of ATP health care investments

The most hopeful news in health care today springs from new technologies. Scientists are unraveling the genetic origins of disease. Surgeons are better informed and prepared, thanks to new virtual reality simulations. Diagnoses are more accurate because of new digital imaging technology. Burn victims are recovering faster through tissue engineering.

These breakthroughs and others in U.S. health care can be traced to the Advanced Technology Program. Through the funding of early-stage technology development, ATP, an arm of the Department of Commerce's National Institute of Standards and Technology, is helping to advance technology in the field of health care.

Since its inception in 1990, nearly $1 billion has been invested in health care, with ATP's share more than $523 million and another $465 million cost shared by industry. Private companies, often working in joint ventures with universities, seek out ATP awards for critical early R&D—often deemed too risky for other investors—but where the potential payoff to society is high.

One-fourth of ATP investments are in health care, and some of the era's most important health advances—DNA diagnostic tools, telemedicine, and tissue engineering, among others—trace their origins to young companies that opened frontiers with ATP funding.

The projected economic benefits from just a few ATP successes would pay for every ATP project funded since 1990, measured in dollars to the U.S. Treasury, and result in hundreds of products and processes, and in broad social benefits. One project alone—new prosthesis technology for repairing damaged knee ligaments—is expected to deliver more than $100 million in net benefits, according to ATP analysis.[1]

The value to humanity is difficult to measure. What is it worth, for instance, for a senior citizen to be able to remain in the familiar surroundings of home instead of moving to an assisted-care facility?

An automated system called the Independent LifeStyle Assistant™ (I.L.S.A.), under development by Honeywell, Inc., monitors the senior at home, noting activity level and whether medications have been taken on schedule. I.L.S.A. uses a variety of sensors, wireless communications devices, and servers located throughout the home. I.L.S.A. can remind the senior to take medication via telephone message or wireless web screen. The system maintains privacy—no cameras are used and communication is secure—and yet it can alert a third party, such as an adult child, when assistance may be required.

Advances such as Honeywell's I.L.S.A. have the potential to prolong independence and reduce costs for a rapidly growing part of society. It also frees up time for caregivers and provides peace of mind that the person is safe.

This and other breakthroughs in health care nurtured by ATP may improve quality of life for many by applying technology to very human problems.

Here is a snapshot of how ATP awards are expanding the boundaries of health care research across a wide range of topics.

Revolutionizing molecular medicine

Accurately diagnosing illness can be a slow process with many tests and hit-or-miss treatments that are refined slowly over time.

The innovation: An integrated system will acquire, analyze, and manage complex genetic information to provide rapid and accurate diagnoses of a wide variety of diseases using DNA biochip technology.

In the past 10 years, more than 45 ATP awards have supported the development of diagnostic tools used to isolate and evaluate genetic information. Indeed, ATP has been called the "Godfather" of the DNA diagnostic tool industry.[2] Developments include production of a nucleic acid microarray, a microfluidic system, an informatics package, and an integrated platform that offers faster and cheaper methods of producing genetic data on a routine basis.

In one example, ATP funded a joint venture between Affymetrix and Molecular Dynamics (now Amersham Biosciences) to develop miniaturized, integrated devices to perform sample preparation for genetic analysis. The ATP award has been in part responsible for the development of DNA-chip-based assays that are revolutionizing the study of biology at the molecular level. These chips are allowing researchers to more rapidly understand the molecular basis of disease, to diagnose different kinds of diseases that until recently were very difficult to identify, and to determine personalized, therapeutic regimens to treat disease.

The DNA chip created by Affymetrix has revolutionized the clinical analysis of genetic data and is expected to be routinely used

[1] Sheila A. Martin et al., *A Framework for Estimating the National Economic Benefits of ATP Funding of Medical Technologies* (NIST GCR97-737 April 1998).

[2] Neil Swan, "Smaller U.S. Firms More Aggressive with Federal Grants," *Nature Biotechnology* 16 (December 1998): 1306.

in hospitals and doctors' offices, allowing physicians to prescribe highly personalized treatments. For instance, bacteria identified by a particular DNA fingerprint may be treated with a highly targeted antibiotic—without exposing the patient to unnecessary and perhaps even harmful drugs.

Perfecting surgical techniques

Surgeons today are limited to practicing critical new procedures on cadavers or animals, a less-than-ideal situation.

The innovation: Just as flight simulators help airline pilots to practice and perfect techniques, new virtual reality software and computer simulations allow surgeons to rehearse specific operations.

Immersion Medical, Inc., of Gaithersburg, Maryland, has designed a virtual reality surgical simulation that allows surgeons to rehearse procedures using patient-specific data. Using its AccuTouch® Simulation System, a surgeon can practice, for example, an endoscopy on a virtual patient—a computerized head-and-shoulders dummy programmed to mimic the true patient's characteristics and symptoms, such as the location of a tumor or the size of an arterial blockage. More sophisticated than a virtual reality video game, the system mimics the feel of the patient for the practitioner; it even groans like a sedated patient.

The technical challenge of mastering the requisite algorithms, video compression, and graphic display made this a high-risk project, but one with a clear, broad economic benefit. The simulation improves training and quality of care, while reducing training costs. Physicians can simulate many more complications and view a much wider range of pathologies than they would encounter in the field.

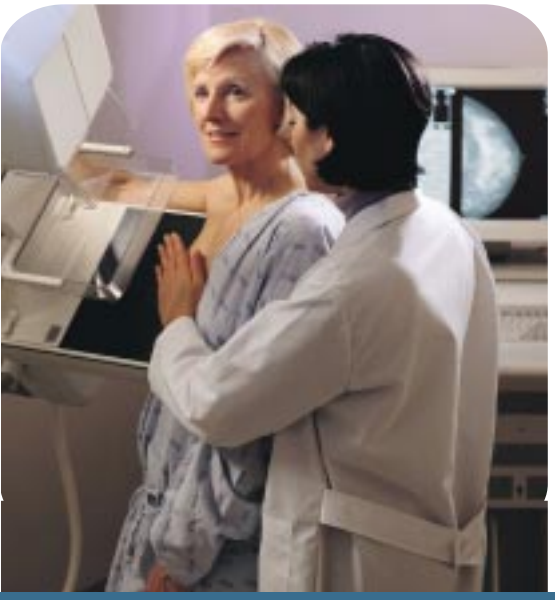
More broadly, the surgical preparation technology project is one of many ATP awards in the area of health care informatics, wherein the creative use of data is helping to slash health care costs while improving delivery.

The area of health care informatics has seen many other recent advances thanks in part to ATP funding, including the automation, validation, and distribution of clinical practice guidelines; the automation of clinical notes and the production of a database of codified clinical data; an open architecture to interface between independent health care information systems; and tools to develop a master patient index.

Detecting, diagnosing, and treating disease

The lives of millions of Americans depend on the precision of medical images used to detect and diagnose cardiovascular disease and cancer.

The innovation: New imaging technologies are allowing physicians to see diseases earlier, diagnose them more accurately, and provide minimally invasive treatment options to patients in lieu of major surgery. Because of an all-digital amorphous silicon (a-Si) based technology developed by General Electric (GE), physicians at hospitals across the nation now have access to images with unprecedented detail and clarity. This technology converts X-ray signals into digital images at the point of acquisition to produce images that give physicians a new level of clinical accuracy.



The Senographe® 2000D Full-Field Digital Mammography System is becoming more affordable and may soon replace standard film-based X-rays for breast cancer detection.

Photo: Courtesy of GE Medical Systems

Virtual surgery simulation technology enables surgeons to rehearse specific procedures for individual patients, improving preparedness and reducing error.

GE's breakthrough imaging systems for cardiovascular disease and oncology come at a time when the number of cases diagnosed has reached new heights. One in five American adults experiences some form of heart disease, which is the leading killer in the United States according to the American Heart Association. Nationwide, one in four people who die this year will do so as a result of cancer, which is the country's second leading killer according to the American Cancer Society.

ATP has helped enable all-digital imaging, which will have a significant impact on cardiovascular and cancer-related patient care by reducing cost-prohibitive barriers to designing and manufacturing the technology. The number of processing steps has been cut significantly, improving yields and ultimately lowering the cost of manufacturing the digital imaging systems. As a result, digital imaging technology is proving to be a valuable, cost-effective medical tool that is expected to make conventional film-based imaging obsolete.

ATP support was a catalyst for the technology infrastructure needed to transition GE's digital detector technology to PerkinElmer's manufacturing facilities, where the digital detectors are produced. The ATP project infrastructure played an important role in accelerating GE's a-Si digital imaging technology, which is being rapidly adopted nationwide in the digital transformation of health care.

Putting this technology in the hands of thousands of physicians is a critical step in the fight against cardiovascular disease and cancer. The company plans to expand its all-digital, medical imaging portfolio to address a broader range of disease states in the future.

Repairing heart muscle

Cardiovascular disease is America's No. 1 killer. More than 60 million people have some form of heart disease, according to the American Heart Association.

The innovation: Osiris Therapeutics, Inc., a Baltimore, Maryland firm, is looking at ways to repair damaged heart tissue using adult stem cells derived from bone marrow.

Stem cells are essentially primordial cells of a person, capable of becoming many of the 210 different kinds of tissues in the human body—from bone to cartilage to skeletal muscle. Stem cells are of particular interest in heart research because the cardiac muscle typically has limited capacity for self-repair. Osiris researchers are harvesting adult mesenchymal stem cells (MSC) from bone marrow, and developing therapies based on the in situ differentiation of the mesenchymal stem cells in the body. Short of becoming cardiomyacytes, the MSCs still seem to have benefit. Implanted in the heart, MSCs improve function to damaged heart tissue. The challenge is to optimize the culture and conditions that induce the best maturation into cardiac muscle.

It's an exciting, novel approach that pushes the boundaries of tissue engineering. In contrast to typical tissue engineering projects involving implanted materials, the MSCs undergo their transformation inside the body. In Osiris animal studies, heart tissue is already showing strong signs of regeneration.

As occurs in many ATP projects, Osiris is conducting the work with university researchers—in this instance from Johns Hopkins University, the University of Florida, and Emory University. More than one-half of ATP awards include a university researcher among the principals, which speeds the dissemination of the new technologies across the field.

In March 2003, Osiris Therapeutics and Boston Scientific Corporation initiated a strategic alliance to develop and commercialize a new therapy to treat cardiovascular disease by administering adult MSC technology to patients who have suffered a heart attack.

Fingerprinting blood

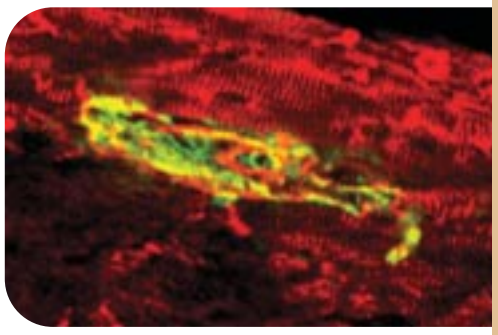
About 1,500 people die every year from ineffective blood screening techniques that lead to transfusions of mismatched or infected blood.

The innovation: SurroMed, Inc., a biotech company, is developing an exceptionally powerful biological assay tool for on-the-spot testing of blood, or "blood fingerprinting."

Currently, tests are performed on the 13 million units of whole blood donated every year in the United States to keep the blood supply safe. Limitations associated with these tests may contribute to additional health issues. With nanotech partner Quantum Dot Corporation, SurroMed is casting a wide net to search for relevant molecular markers of disease in the blood, thereby continuing to expand the safety of donated blood products.

SurroMed's breakthrough technology, called blood fingerprinting, uses laser scanners to identify specific molecules that have been tagged with nanometer-sized semiconductor crystals, which emit light at different wavelengths. Once the technology is commercialized, clinical practitioners will be able to rapidly identify blood-carrying infectious agents or blood that doesn't match a recipient. Matches will be precise down to cell-surface markers, pathogens, and biologically important soluble factors. The result should be a safer blood supply, added assurance that transfusions are well matched, and ultimately, lives saved.

***For more information on health care projects and other ATP-funded innovations, visit* www.atp.nist.gov.**



Human MSC engrafted in an adult mouse heart at about 60 days.

Snapshots of profiled projects

Information technology
Sponsor: Honeywell International, Inc., Minneapolis, MN
ATP funding: $1.9 million
Nov. 1, 2000 to April 30, 2003

DNA diagnostics
Sponsor: Affymetrix, Inc., Santa Clara, CA
ATP funding: $31.5 million*
Feb. 1, 1995 to Jan. 31, 2000
Other participants: Amersham Biosciences (formerly Molecular Dynamics, Inc.), Sunnyvale, CA.; Molecular Applications Group, Palo Alto, CA; Lawrence Livermore National Laboratory; Stanford University; University of California (Berkeley); California Institute of Technology; University of Washington

Tissue engineering
Sponsor: Osiris Therapeutics, Inc., Baltimore, MD
ATP funding: $2 million
March 1, 1998 to Feb. 28, 2001

Medical informatics
Sponsor: Immersion Medical, Inc. (formerly HT Medical Systems, Inc.), Gaithersburg, MD
ATP funding: $1.9 million
Oct. 1, 1997 to Sept. 30, 1999

Digital imaging
Sponsor: GE Global Research, Schenectady, NY
ATP funding: $1.6 million*
Sept. 18, 1995 to Sept. 17, 2000
Other participant: PerkinElmer, Sunnyvale, CA

Biotechnology
Sponsor: SurroMed, Inc., Mountain View, CA
ATP funding: $5.59 million*
Jan. 1, 2001 to Oct. 31, 2003
Other participant: Quantum Dot Corporation, Hayward, CA

**Joint ventures*

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The Advanced Technology Program is part of the Department of Commerce's National Institute of Standards and Technology. ATP's mission is to *accelerate the development of innovative technologies for broad national benefit through partnerships with the private sector.*

Cover image: Red blood cells on a capillary wall. ***Dennis Kunkel Microscopy, Inc.***

ADVANCED TECHNOLOGY PROGRAM

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