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Catalyzing the Genomics Revolution: ATP's Tools for DNA Diagnostics Focused Program

Chemistry and Life Sciences Office
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Abstract

The Human Genome Project was launched in 1990 as a highly ambitious effort to determine the complete sequence of the DNA in the human genome. The project's goal was to discover all human genes and render them accessible for further biological study. Given the diagnostic capabilities that existed when the project was first proposed, it was estimated that sequencing all these data would take at least 15 years and cost up to $200 million a year.

As it turned out, the Human Genome Project was completed in 2003, some three years ahead of schedule and significantly below the estimated cost. This remarkable achievement was accomplished by scores of talented, dedicated scientists with the help of major advancements in the state of the art of DNA analysis technologies. Of the many efforts that helped advance the state of the art, one highly notable effort came from the Advanced Technology Program (ATP), which operates out of the National Institute of Standards and Technology under the Technology Administration of the U.S. Department of Commerce.

ATP is a unique federal funding program started in 1990 for the purpose of enabling highly innovative technological developments that are too risky to receive adequate private sector support. With ATP's support, industry was able to accelerate the development of a wide array of technological innovations that have proven to be essential for the analysis, understanding, and application of DNA information. This report summarizes ATP's contribution to the field of DNA technology and the Human Genome Project that came from a series of focused competitions entitled "Tools for DNA Diagnostics."

About the ATP Working Paper Series

Papers made available under the working paper series are intended to encourage sharing and discussion of research performed in-house by staff or by outside contractors, or to communicate aspects of the program's stakeholders. Working papers have not undergone the rigorous review and publication process that formal reports issued by the Advanced Technology Program under the NIST GCR or NISTIR titles require.

Acknowledgments

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Introduction

With the advent of genetic engineering techniques in the 1980s, scientists sought to gain greater insight and understanding into the function of DNA—the material used by living organisms to store genetic information and transmit it to their offspring. Among other things, scientists needed to determine the exact sequence of human DNA in order to unlock the treasure trove of information that could lead to understanding health, development, and disease. In 1990, the U.S. Government embarked on the ambitious road to sequence the entire human genome. The successful completion of the Human Genome Project was originally targeted for 2006.

By 1993, the Human Genome Project was starting to gain momentum, but it became clear that the current technology was slowing progress. The technologies being used were developed in the 1980s, and were slow and laborious, limiting the information that could be generated and applied to solve important biological and medical problems. Even as the technological needs of the project became clearer, the U.S. Department of Commerce's Advanced Technology Program (ATP) was hearing from industry, academic, and government leaders involved in the project that the current technology would not fill the bill. To generate the massive amounts of sequence data involved and to then make good use of all these genetic data, better, faster, and lower cost DNA analytical tools were needed. Although it was clear that development of these new tools could best be accomplished within the private sector, the research and development (R&D) entailed posed both high technological and high business risks to companies. These risks made sufficient investment from venture and commercial sources unlikely—which in turn led to concerns that only an accelerated R&D approach would bring the much-needed technologies to the market in a timely manner. The ATP focused program "Tools for DNA Diagnostics" proved to be the catalyst for acceleration by the private sector.

ATP started its Tools for DNA Diagnostics focused program in 1994. Its mission was to accelerate DNA analytical tools R&D that would lead to earlier commercialization of those technologies. This new program would fund the development of high-risk technologies with the aim of producing the low-cost, rapid-throughput tools needed to facilitate an effort like the Human Genome Project and for use in low-cost diagnostics, agriculture, toxicology, food quality, and environmental applications. ATP conducted the Tools for DNA Diagnostics focused competitions in 1994, 1995, and 1998; it also funded DNA tools projects in general/open competitions as well. Through 2002, ATP had committed over $138 million to cooperatively fund 42 R&D projects on DNA tools. In addition, ATP funded several workshops and organized conference sessions involving project participants throughout the program period to enhance creation of synergistic collaborations across the research community and further accelerate dissemination of advancements.

ATP's DNA diagnostics projects, funded through the focused program and ATP general/open competitions, produced many innovative, new technologies including rapid methods of genotyping, fully automated and much faster DNA sequencing, and novel biological reagents. They also provided the critical mass needed to enable the commercialization of these new technologies. As a result of the Tools for DNA Diagnostics focused program, this emerging industrial sector benefited broadly from the resultant intellectual property portfolios of the funded companies, from the growth of new small companies into sustainable private sector contributors, and from the discoveries being made using the technologies they developed.

State-of-the-Art DNA Analysis in the Early 1990s

The early 1990s saw improvements in the techniques developed in the 1980s for extracting, manipulating, and sequencing DNA. Scientists were finding new methods to analyze DNA that were faster, easier, and less expensive to perform. The fields of molecular biology and genome analysis were moving to the forefront of biotechnology research, stimulating the demand for new and better technologies. In the early 1990s, automated methods of sequencing DNA (the determination of the exact order of nucleotides making up the genetic code) were spreading into broad usage. These methods used enzymes to cut huge chromosomes into manageable pieces of DNA and stained the resulting pieces with

specialized fluorescent (light-emitting) dyes to tag the segments for detection while being sequenced on automated instruments. Extremely large capacity computers and advanced bioinformatic software was used to place DNA fragments into their original order, enabling scientists to read the DNA sequence. Scientists were thus able to identify genes and gene variants significantly faster than with previous methods. Other techniques were also coming into broader use. The most critical of these techniques included the polymerase chain reaction (PCR)—a method that could rapidly multiply specific gene sequences for further analysis, and gene expression analysis—determining which genes are turned on in different cells, which is critical for understanding the role of genes in health and disease.

Despite the advances of the early 1990s, technology was still too costly, time consuming, and laborious to bring widespread application of DNA analysis into mainstream use in diagnostics, agriculture, toxicology, food quality, and environmental applications. Further, the Human Genome Project was just getting started and, as it turned out, would benefit greatly from the significant improvements in DNA analytical technology resulting from the ATP-funded projects.

The Human Genome Project

The Human Genome Project began in 1990 as a multi-participant initiative led by the National Institutes of Health (NIH), U.S. Department of Energy (DOE), and U.S. Department of Agriculture (USDA) to sequence the entire human genome by 2006. The development of a complete map and sequence of the human genome would provide the information needed to better understand the genetic basis of health and disease and open the door to a multitude of new applications of genomic information. The availability of this new genomic information would enable entirely new ways of analyzing and using DNA data, particularly in diagnostic applications. However, with the technology of the day, it was unlikely that the human genome sequence would be completed by the target date.

The Opportunity for ATP

In the early 1990s, public funding of DNA analysis technology was primarily spearheaded through efforts at NIH and DOE via the Human Genome Project. These agencies funded projects targeted toward the sequencing and mapping of large genomes, but it was not the intent of these projects to develop technologies needed for commercially viable, cost-effective analysis methods with broad applicability. Many companies were well positioned to develop DNA diagnostic tools but were hesitant to push forward without adequate financial support. Betting on one technology was generally considered too risky to receive significant investment because any of a number of competing technologies could have turned out to be the one most suitable for DNA diagnostics. Technologies with high technical risk were considered inappropriate for internal corporate funding because spending was limited mostly to revenue-generating projects. Development of unproven technologies with uncertain payback was too much of a business risk. Venture funding was scarce as well. Venture capitalists required companies to focus on lower risk projects that could be quickly commercialized in established markets. Spurred by the risk-averse funding environment of the time and the biotechnology industry's input to ATP on their scientific vision for the broad application of DNA technologies, ATP believed that a strategic investment in DNA diagnostics could be of critical importance to accelerating the practical application of the emerging genomic information generated by the Human Genome Project.

ATP Funds Innovation

ATP provides funding for the development of early stage, high-risk technologies across a wide variety of industries, including biotechnology. Awards are given directly to individual U.S. companies, joint ventures, and other commercial research entities that pass rigorous peer-reviewed funding competitions. ATP is a cost-sharing program, in which award recipients are required to cover a portion of project expenses with

their own funds. ATP's unique blend of technical and economic/business criteria target proposals that fall in the private sector funding gap between basic science and product development. Research proposed to ATP must be commercially promising—provided the technical hurdles can be overcome—but too technically risky to attract sufficient venture capital or other private funding. ATP's main objective is to speed promising basic laboratory research to the marketplace as useful tools to stimulate the U.S. economy.

Most ATP funding is currently awarded through competitions open to all technology areas. Between 1994 and 1998, however, ATP also supported "focused" competitions, developed with input from industry. Focused competitions were well-thought-out efforts to bridge technological gaps that hindered U.S. industry from being competitive in a variety of areas. As part of the planning for focused competitions, ATP worked with representatives from industry, academia, and government to define key fields of technology where further progress was impeded by major technological barriers. Focused programs were designed to overcome technical barriers rapidly, leading to a quicker route to commercialization than could be achieved with only private investment.

Tools for DNA Diagnostics Focused Program: A Public-Private Partnership

In the early 1990s, ATP recognized that most DNA-based diagnostic tests were limited in scope and required a high level of sophistication by the end user. This limited their application to only the most advanced laboratories, which raised costs and hindered dissemination. In 1993, ATP initiated a process of developing a broad range of focused programs with a call for white papers from industry, academia, and government entities describing their perceived needs for new technology. A significant number of white papers were received from industry leaders in the pharmaceutical, biotechnology, and analytical instrument sectors indicating a need for improvements in the field of DNA analysis techniques. The white papers were summarized and discussed at a public meeting in 1994, and, with additional private sector comments, ATP produced a final recommendation that provided the technical and business goals for the Tools for DNA Diagnostics focused program.

The program's overall technical goal was to develop cost-effective methods for sequencing, interpreting, and storing DNA sequences such

that a patient's DNA sequence could be rapidly determined and made available for use by his or her physician. In essence, what the ATP was creating was the technological basis for what is now becoming known as "pharmacogenomics." The white papers indicated that such methods needed to be highly automated, miniaturized whenever possible, easy to use, inexpensive, and able to determine and analyze DNA sequences rapidly and accurately.

The overall business goal was to create a technological base that would enable a new multibillion-dollar industry in DNA diagnostics that could preserve the U.S. lead in biotechnology and widen the scope of industrial applications. For the technologies to be commercially successful, the white papers reported that DNA analysis and sequence interpretation would have to speed up by a factor of 10 and costs would have to fall between one-tenth and one-hundredth of the $100-per-test price tag in 1994. The white papers additionally revealed that the amount of technical expertise required to achieve all these technical and business goals was beyond the scope and capabilities of any one company; cooperation was essential. Government support was clearly indicated to catalyze alliance formation and technology diffusion.

As the program began to take shape, an important secondary benefit became evident. The technologies envisioned for diagnostic applications could also have a major positive effect on the time line of the Human Genome Project. As a result, the program received a high level of support from Dr. Francis Collins, head of the Human Genome Project at NIH. With his support, and the additional technical guidance from key NIH scientists, the new Tools for DNA Diagnostics program was established as a true interagency cooperative effort. Experts in DNA analysis from NIH, DOE, USDA, the National Science Foundation, and the U.S. Food and Drug Administration participated in ATP's peer-reviewed proposal selection process and provided technical advice to ATP's project managers. ATP also consulted with scientists at NIH during the monitoring of funded projects for additional expert review of progress and accomplishments.

The inaugural Tools for DNA Diagnostics focused competition was launched in 1994, with follow-up competitions in 1995 and 1998. These resulted in the funding of 26 projects (table 1), with total ATP

funds committed of approximately $99 million. In addition to the projects funded during the focused program competitions, 16 DNA technology projects were funded in ATP general/open competitions through 2002 (table 2) at a commitment level of approximately $39 million.

Table 1: Companies Funded under ATP's Tools for DNA Diagnostics Focused Program

1994 competition (13 projects)	1995 competition (7 projects)	1998 competition (6 projects)
Affymetrix, Inc./Molecular Dynamics, Inc., JV	Molecular Innovations, Inc. (formerly Immunological Associates Of Denver)	Aclara BioSciences, Inc.
Bio-Rad Laboratories	Nanogen, Inc.	PE Corporation (formerly Applied Biosystems/ PE-Biosystems), JV
Bruker Daltonics, Inc., JV	Medical Analysis Systems (formerly NAVIX, Inc.)	Caliper Technologies Corporation
Combion, Inc./Incyte Pharmaceuticals, Inc.	PE-Biosystems (formerly Perkin-Elmer Applied Biosystems) JV	Clinical MicroSensors, Division of Motorola, Inc.
CuraGen Corp./Soane JV	USB (formerly part of Amersham Pharmacia Biotech, Inc.), JV	Orchid Biosciences, Inc.
E.I. DuPont deNemours	Sangamo BioSciences, Inc.	Pharmaseq, Inc.
& Company (FQMS group)		
GeneTrace Systems, Inc.*	Vysis, Inc.	
Hyseq, Inc.		
Orchid BioSciences (formerly Molecular Tool, Inc., Alpha Center)		
Sarnoff Corporation		
Third Wave Technologies, Inc.		
JDS Uniphase (formerly Uniphase, Laser Division)		
Vysis, Inc.		

Legend: JV – joint venture.
*Company/organization no longer exists.

Table 2: DNA Diagnostic Tool Companies Funded under ATP's General/Open Competitions

Year	Company
1992	Genosensor Consortium JV*
1995	Large Scale Proteomics Corporation (formerly Large Scale Biology Corporation) Message Pharmaceuticals, Inc. (formerly Bearsden Bio/Symphony Pharmaceuticals) Moldyn, Inc. 3-Dimensional Pharmaceuticals, Inc.
1997	Curagen Corporation Large Scale Proteomics Corporation (formerly Large Scale Biology Corporation) Nanogen, Inc. Sangamo BioSciences, Inc. Third Wave Technologies, Inc.
1999	Motorola, Inc.
2001	RheoGene, LLC
2002	Gene Network Sciences, Inc. People's Genetics Ardais Corporation HandyLab, Inc.

Legend: JV – joint venture.
*Company/organization no longer exists.

Impacts and Direction

Impact on Genomics Technology

The Tools for DNA Diagnostics focused program met the overall technical and business goals of accelerating the commercialization of high-risk technology that would enable lower cost, more rapid DNA analysis for diagnostic purposes. It also contributed to accelerating the time line for completion of the Human Genome Project by three years. The ATP focused program helped revolutionize the field of medicine by encouraging companies to develop technologies they would probably have put on the back burner or abandoned had they not received government funding. Projects funded under this program resulted in the following accomplishments:

- Development of a "Lab-on-a-Chip" a microfluidic device that efficiently separates, purifies, and analyzes DNA samples in very small assay volumes resulting in higher throughput and reduced costs.
- Production of a new enzyme for use in DNA analyses (PCR) that enables efficient DNA sequencing and has become the "gold standard" for this technique.
- Building of a novel mass spectrometry system for rapidly sequencing DNA (this is currently undergoing early stage commercial testing).
- Demonstration of a novel method of detecting single nuclear polymorphisms (SNPs) for use in a variety of clinical applications (products based on this technology are currently on the market).
- Development of a rapid, automated DNA karyotyping system for clinical use in analyzing chromosomes for genetic disorders (a prototype system is currently undergoing early stage testing).

- Commercialization of a new diagnostic test that identifies breast cancer patients eligible for treatment with a novel anticancer drug.
- Commercialization of a portable genetic analysis system for use in molecular diagnostics.
- Development of a system that enables direct detection of bacteria or cells from blood.

Broad-Based Impact of Technical Achievements

Not only have the Tools for DNA Diagnostics projects successfully accelerated lower cost DNA diagnostic technologies toward commercialization, but many spillover benefits have also been realized. These benefits have resulted in new technical achievements as well as broader benefits to the emerging industry sector. According to Dr. Michael Knapp, CEO of Caliper Technologies, "the Tools for DNA Diagnostics program had a huge impact on the industry. It put advanced technologies for life sciences on the map." This created critical mass for the industry, which "validated genomic technologies" and set the stage for "market expansion and enhanced competitiveness," explains Dr. Robert Lipshutz, vice president of corporate development at Affymetrix. Other significant benefits of the program include the following:

- By the year 1999, the cost of performing an SNP analysis had fallen to under $1.00.[1]
- In the late 1980s, the cost of sequencing a base pair of DNA was approximately $5.00. As of November, 2002, this sequencing cost has fallen to $0.09.[2]
- Various technologies developed during ATP projects have led to the establishment of an entirely new market—the study of gene expression using DNA arrays. Project participants Affymetrix, Molecular Dynamics, and Combion all played a role in this emerging market by demonstrating the ability to perform DNA expression analysis with DNA microarrays (gene-chips), developing new methods for producing arrays, and improving data management.

[1] *Analytical Chemistry News & Features* (Oct. 1, 1999), pp. 683A–86A.

[2] *Future Pundit* (May 29, 2003).

All major pharmaceutical and biotechnology companies now use DNA microarrays as part of their drug discovery and development efforts. Insights into the mechanism of various cancers and the discovery of improved treatment regimens have resulted from the application of this technology.

Some observers credit ATP as the "godfather" of the U.S. biochip industry. Some examples supporting ATP's role in establishment of this industry include the following:[3]

- Affymetrix (Santa Clara, California) started independent operations in 1993 and received an ATP award in 1994. It had 512 employees in 1999, with sales totaling $201 million in 2000.

- PE Biosystems (Foster City, California) received ATP awards in 1994, 1995, and 1998. The company had 3,504 employees in 1999 with $1.4 billion in sales in 2000.

- Vysis (Downers Grove, Illinois) was incorporated in 1991 and received its first ATP award in 1994. By 1999, Vysis had 138 employees and in 2000 reached $21 million in sales. Notes Uwe Miller, the company's director of advanced technology, "Two-thirds of all of Vysis's current technology, and all of our future technology, can be traced back to ATP funding."

- Nanogen (San Diego, California) was founded in 1993 and received an ATP award in 1995. By 1999, the company had 142 employees; by 2000, it had reached $11 million in sales. The ATP funding award was "like a godsend" in "getting us going as a company," says James O'Connell, Nanogen's vice president of research.

- As part of a project to develop a fully integrated DNA assay system, Molecular Dynamics created a 96-array capillary electrophoresis system (a high-efficiency method to separate DNA fragments so they can be analyzed after being cut and stained). This system formed the basis for a new DNA sequencing instrument that

[3]In the following items, quotations are from *Nature Biotechnology*, Vol. 16 (December 1998), p. 1306. Company data are from Web sources.

enabled high-throughput sequencing at a significantly lower cost. Commercialization of this instrument sparked an intense competition among manufacturers that spurred the development of technological improvements and expanded the use of these instruments.

- U.S. Biochemical (since acquired by Amersham Biosciences) received funding to develop new enzymes that operate at high temperatures. Notably, the company produced a modified DNA synthesis enzyme, or polymerase, that could be used at high temperatures making it ideally suited for use in PCR (PCR repeatedly heats and cools the DNA in order to promote gene multiplication). This enzyme became a significant success in the DNA analysis market. Soon, other researchers and manufacturers entered the field and contributed to the growth of this innovative and competitive marketplace.

The $138 million total investment by ATP on all projects supporting DNA diagnostic technologies not only spurred the development of cutting-edge biotechnology but also enabled companies to grow and contribute to sustaining this new industry sector. Thirteen of the funded companies are now public companies, adding jobs and fostering new businesses. And, further enhancing U.S. competitiveness, 179 new patents have been filed as a result of projects funded by the ATP in this area (see appendix A). One technology that was significantly advanced under the program, DNA-chips, is fast becoming a multibillion-dollar market.

Future Directions in DNA

The technical innovations funded by ATP accelerated the analysis, understanding, and application of DNA information. Industry-led research emphatically shows that there is room for further refinement and expansion of the technology in various applications such as pharmacogenomics, proteomics, and homeland security. Additionally, the evolution of the technology has created new scientific and manufacturing challenges that will require future high-risk and innovative solutions.

Summary

ATP's investment in DNA technologies, catalyzed by the creation of the Tools for DNA Diagnostics focused program, has proven to be a unique and successful industry-driven cooperative program and has had a significant impact on the Human Genome Project, the companies and industries involved in genome sequencing, and the biotechnology and diagnostics markets. It is expected that the outcome from the projects will continue to benefit U.S. society. The funding provided by ATP has allowed companies to develop high-risk technologies. New markets continue to be created, and sustainable businesses are emerging. The program's focus on a set of enabling technologies in DNA analysis provided the critical mass to overcome the challenges to raising market awareness and driving industry competitiveness. The end results of the projects funded by ATP have provided society with new ways to study and cure diseases, perform rapid tests to diagnose and manage disease, monitor the safety of food, and develop new agricultural products.

Appendix A Intellectual Property from ATP-Funded Projects on DNA Diagnostic Tools

ATP project title (project number)	Performing organization	No. of patents
Genosensor Technology Development (92-01-0044)	Genosensor Consortium (JVL) Beckman Instruments (JVP)	2 4
Hyperthermophilic Microorganisms in Molecular Biology and Biotechnology (93-01-0113)	United States Biochemical Corporation (SA)	8
Standardization of 2-D Protein Analysis Using Manufacturable Gel Media (94-01-0284)	Large Scale Proteomics Corporation (SA)	4
Molecular Recognition Technology for Precise Design of Protein-Specific Drugs (94-01-0404)	CuraGen Corporation (JVL)	17*
Compact Blue Laser for Diagnostics (94-05-0004)	Uniphase, Laser Division (JVL)	4
Development of Rapid DNA Medical Diagnostics (94-05-0006)	GeneTrace Systems, Inc. (SA)	9
Development of a Generic Technology for the Targeted Detection and Cleavage of DNA and RNA (94-05-0012)	Third Wave Technologies, Inc. (SA)	10
Miniature Integrated Nucleic Acid Diagnostic (MIND™) Development (94-05-0016)	Affymetrix (JVL) Molecular Dynamics, Inc. (JVP)	1 2
Molecular Cytogenetics Using the GeneScope: An Ultrafast, Multicolor System for Automated FISH Analysis (94-05-0017)	Bio-Rad Laboratories (SA)	1
SBH Format 3 Megabase Diagnostics Instrumentation (94-05-0018)	Hyseq, Inc. (SA)	6
DNA Diagnostic Systems Based on Novel Chem-jet Techniques (94-05-0019)	Incyte Pharmaceuticals, Inc. (SA)	5
Development and Commercial Application of Genosensor Based Comparative Genome Hybridization (94-05-0021)	Vysis, Inc. (SA)	4

ATP project title (project number)	Performing organization	No. of patents
Integrated Microfabricated DNA Analysis Device for Diagnosis of Complex Genetic Disorders (94-05-0027)	CuraGen Corporation (JVL)	7
MicroLab: A High-Throughput, Low-Cost Approach to DNA Diagnostics by Array Hybridization (94-05-0029)	Sarnoff Corporation (SA)	41
Diagnostic Laser Desorption Mass Spectrometry Detection of Multiplex Electrophore Tagged DNA (94-05-0030)	Bruker Analytical Systems, Inc. (JVL)	7
Automated DNA Amplification and Fragment Fragment Size Analysis (94-05-0033)	Qualicon (formerly DuPont, FQMS Group) (SA)	1
RNA Binding Protein Technology for Identification of Novel Therapeutics (95-01-0098)	Message Pharmaceuticals, Inc. (SA)	3
Real-Time Micro-PCR Analysis System (95-08-0006)	PE Corporation (formerly Applied BioSystems) (JVL)	2
	3M (JVP)	2
An Integrated Microelectronic DNA Diagnostic System (95-08-0009)	Nanogen, Inc. (SA)	3
Development of Bar Code Diagnostics for DNA Diagnostics (95-08-0012)	Vysis, Inc. (SA)	3
Self-Contained Cartridge Integrating Nucleic Acid Extraction, Specific Target Amplification, and "Dip Stick" Immediate Detection (95-08-0015)	Molecular Innovations (SA)	3
Generation and Development of Novel Nucleic Acid Binding Proteins and Their Use as DNA Diagnostics (95-08-0016)	Sangamo BioSciences, Inc. (SA)	2
DNA Diagnostics Using Self-Detected Target-Cycling Reaction (SD-TCR) (95-08-0017)	NAVIX, Inc. (SA)	1
Programmable Nanoscale Engines for Molecular Separation (96-01-0141)	CuraGen Corporation (SA)	3
A Portable Genetic Analysis System (96-01-0172)	Nanogen, Inc. (SA)	7
Simple, Generic, and Low-Cost Genetic-Based Tools for Disease Detection, Monitoring, and Intervention (97-01-0135)	Third Wave Technologies, Inc. (SA)	4
DNA Diagnostics for the Point of Care Using Electronic Nucleic Acid Detection (98-08-0003)	Clinical Micro Sensors, Inc. (SA)	1
Multiplex DNA Diagnostic Assay Based on Microtransponders (98-08-0020)	PharmaSeq, Inc. (SA)	2
Multiplexed Sample Preparation Microsystem for DNA Diagnostics (98-08-0029)	ACLARA Biosciences, Inc. (SA)	3
Integrated, Micro-Sample Preparation System for Genetic Analysis (98-08-0031)	3M (JVP)	7
Grand total		179

Legend: SA – single applicant; JVL – joint venture lead; JVP – joint venture participant.
*Two copyrights were realized from this project as well as the 17 patents.

About the Advanced Technology Program

The Advanced Technology Program (ATP) is a partnership between government and private industry to conduct high-risk research to develop enabling technologies that promise significant commercial payoffs and widespread benefits for the economy. ATP provides a mechanism for industry to extend its technological reach and push the envelope beyond what it otherwise would attempt.

Promising future technologies are the domain of ATP:

- Enabling technologies that are essential to the development of future new and substantially improved projects, processes, and services across diverse application areas.
- Technologies for which there are challenging technical issues standing in the way of success.
- Technologies whose development often involves complex "systems" problems requiring a collaborative effort by multiple organizations.
- Technologies that will go undeveloped and/or proceed too slowly to be competitive in global markets without ATP.

ATP funds technical research, but it does not fund product development—that is the domain of the company partners. ATP is industry driven, and that keeps it grounded in real-world needs. For-profit companies conceive, propose, co-fund, and execute all of the projects cost-shared by ATP.

Smaller firms working on single-company projects pay a minimum of all the indirect costs associated with the project. Large, "*Fortune* 500" companies participating as a single company pay at least 60 percent of total project costs. Joint ventures pay at least half of total project costs. Single-company projects can last up to three years; joint ventures can last as long as five years. Companies of all sizes participate in ATP-funded projects. To date, more than half of ATP awards have gone to individual small businesses or to joint ventures led by a small business.

Each project has specific goals, funding allocations, and completion dates established at the outset. Projects are monitored and can be terminated for cause before completion. All projects are selected in rigorous competitions that use peer review to identify those that score highest against technical and economic criteria.

Contact ATP for more information:

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