Research Corporation

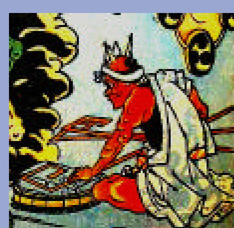
Ninety-first Annual Report, 2003

America's Private Science Foundations: Catalysts for Change

Research Corporation

ANNUAL REPORT: JANUARY 1, 2003 to DECEMBER 31, 2003

Research Corporation is a private foundation, established in 1912, that supports basic research in the physical sciences (chemistry, physics and astronomy) at U.S. and Canadian colleges and universities. As one of the country's first foundations, Research Corporation was incorporated before the term "foundation" came into popular use. Research Corporation's founder, Frederick Gardner Cottrell, was a distinguished scientist, inventor and philanthropist. He continues to serve as a model and inspiration for the scientists who receive Research Corporation awards today.



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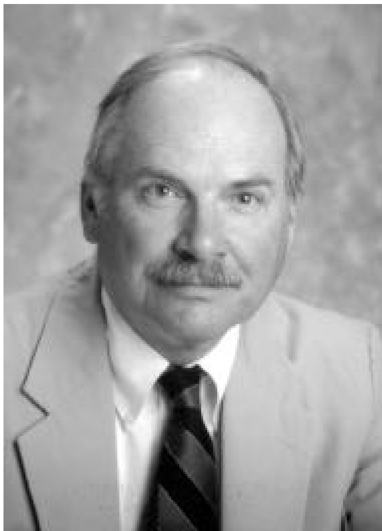
Throughout this report, images of lightning are used to represent the energy of dramatic change.



President's Message

Every day on college and university campuses, the ongoing process of research and education brings forth new ideas, technologies and understandings. Sometimes a new insight arrives in a flash. More often, innovation and learning require careful nurturing.

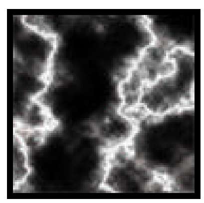
This process of growth, innovation and transformation involves a complex interplay of individuals and organizations, of personal initiative and cooperative efforts. The individuals include scholars, students, researchers, administrators and teachers. The organizations include research groups, departments, institutes, laboratories, colleges, universities, agencies and scientific societies.

Within this complex system, private science foundations and their program officers have played an important role, sometimes behind the scenes, occasionally on the main stage. The role most often undertaken by private science foundations is that of catalyst, helping other players achieve the innovation and transformation.

Since the early Twentieth Century, Research Corporation and other private science foundations have looked for ways to inspire, instill and instigate change. This annual report examines how the unique qualities and missions of private science foundations enable them to be critical participants in the higher-education and scientific communities. With the important challenges facing these same communities in the Twenty-first Century, Research Corporation and its sister philanthropic organizations must maintain and strengthen their roles as catalysts for change.

We hope that the ideas and challenges highlighted in this report will serve as catalysts themselves–inspiring all of us to innovate, to engage, and to make a difference in the world of science and higher education.

John P. Schaefer
President



Thunder is good, thunder is impressive; but it is lightning that does the work. – Mark Twain

America's Private Science Foundations: Catalysts for Change

In 1902 American scientist and inventor Frederick Gardner Cottrell received his Ph.D. in Leipzig, Germany for work with the famous German chemist, Wilhelm Ostwald. Seven years later, in 1909, Ostwald won the Nobel Prize in Chemistry "in recognition of his work on catalysis." In 1912, Cottrell established America's first foundation devoted exclusively to the advancement of science, Research Corporation.

Is it merely a coincidence that the man who had the vision to establish a philanthropic foundation for the advancement of science was also a scientist who understood catalysis?

Throughout the Twentieth Century, the foundation that Cottrell established has been a "catalyst for change" in the scientific and higher-education communities. Today, Research Corporation and other private science foundations continue to play important, catalytic roles, helping continually reshape and revitalize science.

Is there indeed a similarity between chemical catalysis and the work of private science foundations?

Any organization, of course, can call itself a "catalyst for change." A quick Google search on that well-worn slogan turns up over 73,000 websites, from a personal growth seminar in Canada to a rock-and-roll band in Cincinnati. What gives private science foundations any special claim on this phrase?

As defined in introductory chemistry textbooks, a catalyst is a substance that alters the speed of, or makes possible, a chemical or biochemical reaction but remains unchanged at the end of the reaction. By analogy, an organization that serves as a catalyst for change will alter the speed of, or make possible, transformations and changes in other institutions, while remaining itself unchanged and faithful to its original mission.

Above left: Frederick Gardner Cottrell. Right: Wilhelm Ostwald

Textbook explanations of chemical catalysts point out these additional qualities:

- Catalysts are very modest in size, compared to the large quantity of material they are able to transform.
- Catalysts can be highly targeted and exquisitely specific in how they effect chemical and biochemical change.
- Catalysts facilitate chemical reactions that would otherwise be too slow or too difficult.
- Catalysts accomplish their role by bonding temporarily with the molecules they seek to transform, creating an environment where molecular change occurs more quickly and easily, and then releasing the transformed molecules back into the wider world.

This article examines the qualities and characteristics of private science foundations–based on interviews with more than a dozen leaders from the philanthropic, scientific and higher-education communities–revealing that catalysis is indeed an apt metaphor for the role played by private science foundations. And with the set of challenges and opportunities facing today's colleges and universities, also discussed in this article, the unique role played by private science foundations will be even more important in the coming decades.

Private Science Foundations Are Small, Compared to the Federal Government

The most obvious characteristic of today's private science foundations, and the one that gives rise to many of the other characteristics, is their relatively small size. Compared to the size of the federal government's role in science (as measured in dollars), today's private science foundations are minuscule, providing only about 1.5 percent of the amount provided by the federal government for science.

Private science foundations haven't always been the "small kid on the block." When the first private foundations and research institu-

tions–Carnegie Institution of Washington (established in 1902), Carnegie Foundation for the Advancement of Teaching (established in 1905), Carnegie Corporation (established in 1911), Research Corporation (established in 1912) and Rockefeller Foundation (established in 1913)–began supporting the advancement of science and higher education, the U.S. federal government was not the major financial supporter in this arena. Early grants of Research Corporation, for example, funded pioneering work in chemistry and physics, such as Robert H. Goddard's experiments with the first liquid-fuelled rocket, Ernest O. Lawrence's development of the first large cyclotron and Robert Van de Graaff's building of the Van de Graaff generator, an early tool for nuclear research.

However, a major shift in funding occurred during and after World War II, under the leadership of Vannevar Bush. During his distinguished career, Bush, a respected engineer and science administrator, gained a sweeping overview of the scientific and technical community, including the worlds of academe, private science foundations and the federal government. He started his professional career at Massachusetts Institute of Technology (MIT) as a professor (1923-1932) and then served as vice president and dean of engineering (1932-1938). From 1938 to 1955, he was president of the Carnegie Institution of Washington. Bush also served on the board of directors of Research Corporation from 1939 to 1946.

During World War II, he became director of the Office of Scientific Research and Development, which oversaw all defense research and development, including the development of radar and the atomic bomb.

With this broad set of experiences, Bush believed that "without scientific progress no amount of achievement in other directions can insure our health, prosperity and security as a nation in the modern world." Shaping this belief into a national science policy, Bush outlined his vision in his landmark report to President Franklin Roosevelt, “Science–The Endless Frontier” (1945).

Following the path outlined by Vannevar Bush, the federal government began assuming an increasingly important role in basic scientific research. The National Science Foundation (NSF) was established in 1950. Its presence expanded rapidly, especially in the period immediately following the Soviet launch of Sputnik in late 1957. NSF's budget grew from $40 million in fiscal year 1958 to nearly $500 million in 1968. During the same period, the funding role of the National Institutes of Health (NIH) also expanded dramatically, following the establishment of the Research Grants Office in 1946. From a budget of just over $4 million in 1947, the NIH grants program grew to more than $100 million in 1957 and $1 billion in 1974.

Today, the federal government's investment in scientific research and development (R&D) dwarfs the funding available from private science foundations. For example, the non-defense portion of the federal R&D budget in 2002 (as reported by the American Association for the Advancement of Science in its annual R&D budget analysis) was approximately $51 billion. Of this amount, $23 billion was provided through the National Institutes of Health, and $28 billion flowed through other federal agencies, including the National Science Foundation, the Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA). The defense-related portion of the federal R&D budget in 2002 was approximately $55 billion, with most of those funds flowing through the Department of Defense and the Department of Energy (and, in the future, through the Department of Homeland Security).

By comparison, private foundations gave $568 million for science and technology in 2002, according to data collected by the Foundation Center. This amounts to about 2.0 percent of the $28 billion provided by non-defense, non-NIH federal science agencies. In the health field, private foundations play a larger, but still relatively small, role. In 2002, private foundations' grants in the health field were $2.9 billion, about 12.6 percent of the NIH budget. (For additional details on these data, and how they were calculated, see "The Universe of Private Science Foundations” on page fifteen.)

Can private foundations, providing funds that some might consider to be "only noise level," hope to make a difference in the scientific community? Or, phrased another way, how can private science foundations leverage their limited funds to make a significant impact?

Faced with the overarching role played by the federal government, private science foundations have taken on the characteristics of catalysts, and these strategies have enabled them to thrive and play important roles in the advancement of science.

Peter J. Bruns
Howard Hughes Medical Institute

The Howard Hughes Medical Institute (HHMI), established in 1953, is a nonprofit medical research organization that employs hundreds of leading biomedical scientists working at the forefront of their fields. In addition, through its grants program and other activities, HHMI is helping enhance science education at all levels and maintain the vigor of biomedical science worldwide. (www.hhmi.org)

Private Science Foundations Are Nimble

Peter J. Bruns, vice president for grants and special programs at the Howard Hughes Medical Institute, uses nautical analogies when discussing the roles and approaches of federal and private institutions. He portrays the federal government as a super tanker: huge, imposing and majestic, but cumbersome and slow to turn. By contrast, Bruns' analogies for private institutions are vessels with much greater speed and agility: racing boats, tugboats and pilot boats.

Although the federal government has implemented a few grants programs that allow a rapid response, such as NSF's Small Grants for Exploratory Research (SGER) program, most federal programs build up speed very gradually, like a super tanker. Arthur B. Ellis, director of NSF's Chemistry Division, says, "Private science foundations certainly have an agility that is sometimes hard for us in the federal government to match. At NSF, for example, putting out a new program announcement that has input from our community might take a year. And then it might be a couple of additional years before the program has reached a steady state."

Private science foundations, on the other hand, can establish new programs quickly and easily, without the lengthy and open process that federal agencies use. "One of the great advantages of private foundations is that they are really flexible and able to respond to perceived needs very quickly," says John P. Schaefer, president of Research Corporation.

Foundations' programs are often undertaken in the spirit of experimentation, to try out good ideas and see if they have the intended effects. According to Lawrence A. Funke, program director of the American Chemical Society's Petroleum Research Fund (PRF), for example, PRF recently launched three pilot

Arthur B. Ellis
National Science Foundation

The National Science Foundation (NSF) is an independent agency of the U.S. Government, established by the National Science Foundation Act of 1950. The Act established the NSF's mission: "To promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense." With an annual budget of approximately $4 billion, NSF's program areas include Biology; Computer/ Information Sciences; Crosscutting Programs; Education; Engineering; Geosciences; International; Math/Physical Sciences; Polar Programs and Social/Behavioral Sciences. (www.nsf.gov)

John P. Schaefer
Research Corporation

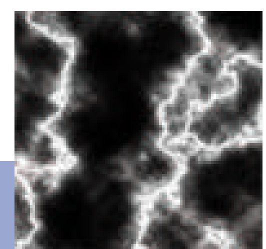
Research Corporation, established in 1912, was chartered to "make inventions and patent rights more available and effective to the useful arts and manufactures" and to devote the net earnings of the corporation to providing "means for scientific research and experimentation" at scholarly institutions. Today, its programs aid basic research in the physical sciences of chemistry, physics and astronomy. Through its grant programs, Research Corporation supports ideas independently proposed by faculty members at U.S. and Canadian colleges and universities and also carries on activities related to science advancement. (www.rescorp.org)

programs on an experimental basis. "We'll be evaluating these programs, starting next year," says Funke. "If they proceed, they will have to then come from the regular budget."

Not only can private science foundations start programs quickly, but they can also stop programs more quickly than the federal government. Lee S. Shulman, president of Carnegie Foundation for the Advancement of Teaching, says, "Foundations can be much more nimble than federal agencies. Maybe we can't quite turn on a dime, but we can turn on a quarter." If a program is not meeting its goals or a foundation sees a better use of its funds, it can simply discontinue a program. These sorts of decisions are much more difficult to make in the public and political arena in which federal agencies operate.

Every foundation has programs that have been discontinued–sometimes because the need has disappeared, sometimes because the federal government has established a similar program to meet the need, and sometimes because the program didn't work out as anticipated. At Research Corporation, for example, leaders recently suspended the Research Innovation Award (RIA) program, giving it a "sabbatical," while staff and board reassess the impact of the program. According to Schaefer, "We have a long tradition of making a big impact with programs that are targeted in a strategic way. We want to make sure the RIA program is meeting this high standard."

Along with the ability to start and stop quickly, private science foundations are considered "light on their feet" because they have great flexibility in implementing their programs. Federal agencies develop detailed written rules for programs, which must then be stringently applied on a nationwide basis. Private foundations, on the other hand, operate with more flexible guidelines and can simply "go with their gut" when an idea excites them. Mark J. Cardillo, executive director of the Camille and Henry Dreyfus Foundation, points out, "a private foundation can use its



Lawrence A. Funke
Petroleum Research Fund (PRF)

The American Chemical Society's Petroleum Research Fund (PRF), established as a trust in 1944, is dedicated to "advanced scientific education and fundamental research in the 'petroleum field,' which may include any field of pure science which . . . may afford a basis for subsequent research directly connected with the petroleum field." Grants are made to nonprofit institutions in the United States and other countries in response to proposals. Fundamental research is currently supported in chemistry, the earth sciences, chemical engineering and in related fields such as polymers and materials science. (www.chemistry.org/prf) best judgment on things that are hard to quantify." Agencies, on the other hand, often require quantifiable evidence when evaluating the success of a program.

Clearly, institutional flexibility is one of the keys to private science foundations' success as catalysts for change. Similarly, molecular flexibility is one of the keys to the success of chemical and biochemical catalysts. In fact, some biochemical catalysts, such as certain enzymes, can lose their ability to catalyze important biochemical reactions if they are constrained in rigid molecular structures.

Private science foundations are focused and targeted

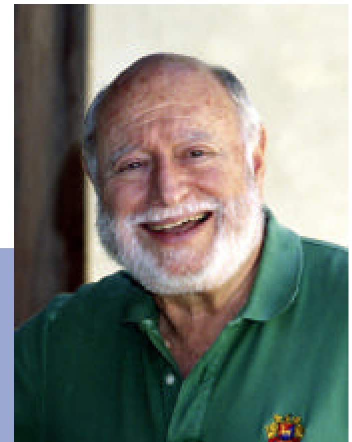
A chemical or biochemical catalyst often performs just one particular role, such as breaking or forming one particular type of chemical bond, and it performs that role very efficiently and effectively. Similarly, private science foundations often narrow the focus of their programs, performing one particular role and performing it very well.

Sometimes the focus of a foundation is based on scientific discipline. For example, the Camille and Henry Dreyfus Foundation and the Welch Foundation were established by their founders to focus on chemistry. The Petroleum Research Fund was established to support "advanced scientific education and fundamental research in the petroleum field." Research Corporation, established with a broad mission of the advancement of science, has in recent years narrowed the focus of its grants to the disciplines of chemistry, physics and astronomy.

Sometimes the focus of a foundation is based on geography. The M.J. Murdock Charitable Trust focuses its philanthropic efforts in five states of the Pacific Northwest.

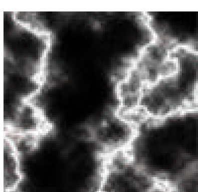
"Focus is a desirable thing," says Norman Hackerman, chairman of the Scientific Advisory Board of the Welch Foundation, which is restricted by the will of the founder to supporting chemistry in the state of Texas. "The system [for funding and doing science] is so big, it won't yield to brute force. Even though we are a little actor in a big scene, we've been able to do more than if we hadn't been restricted."

A foundation's decision to change its focus can have far-reaching impacts. For example, the F.W. Olin Foundation, established in 1938,



Lee S. Shulman
The Carnegie Foundation for the Advancement of Teaching

The Carnegie Foundation for the Advancement of Teaching, established in 1905, is an independent policy and research center whose charge is "to do and perform all things necessary to encourage, uphold, and dignify the profession of the teacher and the cause of higher education." The foundation's work is focused on four major areas of concern: undergraduate education, professional and graduate education, K-12 and teacher education, and knowledge sharing functions. (www.carnegiefoundation.org)



Mark J. Cardillo
The Camille and Henry Dreyfus Foundation, Inc.

The Camille and Henry Dreyfus Foundation, Inc., established in 1946, seeks "to advance the science of chemistry, chemical engineering and related sciences as a means of improving human relations and circumstances around the world." The foundation makes awards to academic and other eligible institutions through several awards programs. Awards are open to all academic institutions in the states, districts and territories of the United States.
(www.dreyfus.org)

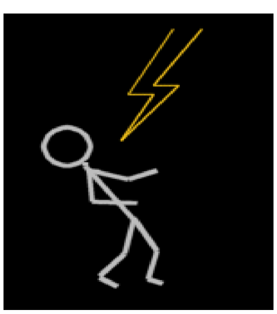
was a major funder of new buildings for more than two generations. With an emphasis on teaching and laboratory facilities for engineering and science, the foundation helped construct and fully equip seventy-two buildings on fifty-seven independent college campuses. In the 1990s, however, the foundation decided the best way to maximize its impact was to help create a college from scratch that could reform engineering education. The Franklin W. Olin College of Engineering, located in Needham, Massachusetts, officially opened in fall 2002 to its inaugural freshman class.

One of the most important tasks for new private science foundations, such as the Kavli Foundation and the Gordon and Betty Moore Foundation (both established in 2000), is to determine their specific areas of focus. The Kavli Foundation, for example, has selected three areas in which to focus its activities: cosmology, neuroscience and nanoscience. The Gordon and Betty Moore Foundation recently decided not to launch an initiative in the biomedical science area, where existing funding from other sources is already at a high level. Instead, it established a ten-year, $145-million initiative in the area of marine microbiology.

Private science foundations take risks

Leaders of private science foundations consider one of their most important roles to be as risk-takers. Research Corporation's Schaefer says, "Private foundations can take more gambles than governmental organizations. They can take on projects that are out of the mainstream–interesting ideas that don't fall within the guidelines of spelled-out programs."

Although leaders in federal agencies also talk about being risk-takers, the culture of the federal grants system presents a number of constraints and restrictions that may inhibit risk-taking. These barriers, which have evolved as part of an otherwise highly successful system of funding science, include the following:



Norman Hackerman
The Welch Foundation

The Welch Foundation supports fundamental chemical research at universities, colleges or other educational institutions within the state of Texas. Since its founding in 1954, the organization has contributed to the advancement of chemistry through research grants, departmental programs, endowed chairs, visiting lectureships and other special projects at educational institutions in Texas. (www.welch1.org)

- Agencies are accountable in a very public way to Congress, the media and taxpayers, with the implicit question being "What have you done for me lately?" Private foundations, on the other hand, are accountable primarily to the intention of their founders, with the implicit question being "Have you been true to our philanthropic mission?"
- Agencies look for results within a relatively short time horizon, with publications expected before the grant is up for renewal. Private foundations, on the other hand, are often more willing to let cutting-edge research blossom over time.

- Agencies use a formal, business-like peer review process that is inherently conservative, with favorable reviews often going to those individuals and institutions that have already established track records. One disturbing consequence of this system is that the average age of Ph.D. scientists receiving their first major NIH grant has risen from thirty-nine to forty-two over the ten-year period of 1992-2002. Some private foundations, on the other hand, make decisions in a less formal process involving peer input, where it's easier to discuss and make choices based on judgment and subjective criteria.
- Agencies, in the spirit of efficiency, often focus on larger grants, mainly to established investigators. Private foundations, on the other hand, devote some of their funds in smaller increments to projects that are still in the formative stages.

The energy required to surmount all these barriers limits the number of "risky" research projects that will be undertaken in the world of federal grants. Only a few scientists will have the energy, persistence, courage and luck to vault all these hurdles. By lowering the barriers, private foundations increase the chances that scientists will be able to move ahead. This same principle–lowering barriers to allow increased rates of success–is how chemical and biochemical catalysts work at the molecular level.

Another way that private science foundations take risks is by funding research in emerging areas, where federal programs have not yet been established. Over the years, private foundations have played major roles in the birth of fields such as radio astronomy (Research Corporation) and computational biology (W.M. Keck Foundation).

Private foundations are also able to take on certain types of projects that rarely find federal support, including bricks-and-mortar projects, "exploration-driven" research (as opposed to "hypothesis-driven" research) and the development of new types of instrumentation. Both the Keck Foundation and Research Corporation, for example, have played major roles in funding new telescopes: the Keck Observatory in Hawaii and the Large Binocular Telescope in Arizona. According to Research Corporation's Schaefer, "Those telescopes wouldn't have come into being–or would have taken many, many years–if the scientists and institutions had to go through the regular federal government funding process. A project like the Keck Telescopes, for example, would have consumed all of NSF's budget for astronomy for several years. I don't think the politics of the situation would have allowed that to happen."

Private science foundations build close relationships with scientists, institutions and scientific communities

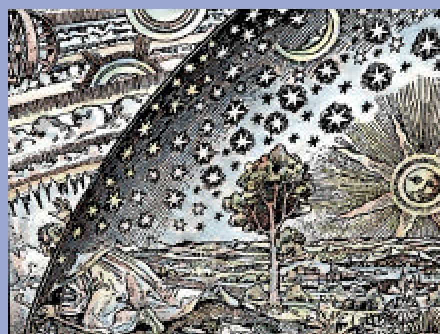
One of the most important qualities of private science foundations is that they take great care to build strong and close relationships with the institutions they serve. And because of those strong relationships, the institutions and the foundations both benefit.

Building and maintaining relationships is a labor-intensive process, and it is only possible because foundations target their programs. Neal O. Thorpe, trustee and executive director of the M.J. Murdock Charitable Trust, points out, "Compared to federal agencies, we're closer to the ground in terms of what's going on in the science divisions of the private colleges. There are only

The Universe of Private Science Foundations

The philanthropic organizations highlighted in this article represent only a sample from the broad universe of private science foundations. Within this broad universe, there is great diversity. Each philanthropic organization is unique in terms of its mission, its founding documents, its programs and its operating philosophy. Therefore, it can be challenging to collect and analyze data and information that will provide a useful and meaningful picture of the universe of private science foundations.

The data reported on page nine of this article are taken from FC Stats-The Foundation Center's Statistical Information Center (www.fdncenter.org/fc_stats). The FC Stats database contains over 2,300 data tables with valuable information categorizing foundations and grants by many different criteria.



Yet even this useful and comprehensive database is incomplete. For example, three of the philanthropic organizations interviewed for this article are not technically classified as a "foundation" for the purposes of the FC Stats database:

- The Howard Hughes Medical Institute is classified by the Internal Revenue Code as a medical research organization.
- The Carnegie Foundation for the Advancement of Teaching is classified as a private operating foundation. It uses income from an endowment to support its activities and does not award grants.
- The Petroleum Research Fund, originally established as a trust, is now an endowment administered by the American Chemical Society.

Therefore, the Foundation Center data describing the extent of private foundation funding for science and for health do not include these three organizations.

With the caveat that a rigorous analysis and comparison of philanthropic organizations is beyond the scope of this article, here are some facts that provide a brief overview of the universe of private science foundations:

The largest foundation in the United States is the Bill and Melinda Gates Foundation, with its focus on "bringing innovations in health and learning to the global community." Its endowment exceeds $25 billion. In 2002, according to FC Stats, the Gates Foundation awarded $145 million in grants for science and technology.

The Howard Hughes Medical Institute has assets of about $11 billion. In 2003, through its grants and special programs, HHMI awarded $107 million, primarily in support of science education at all levels, from pre-college science education to post-doctoral training. (In addition, HHMI, in its role as a medical research organization, disbursed nearly $500 million in support of scientific research.)

According to FC Stats, three other foundations awarded over $50 million each for grants for science and technology in 2002:

- W.M. Keck Foundation, $55 million
- The David and Lucile Packard Foundation, $52 million
- Lilly Endowment Inc., $50 million

A more complete list of private science foundations is provided by the Foundation Center in its table, "Top 50 U.S. Foundations Awarding Grants in Science and Technology, circa 2002." Within this group of 50 foundations:

- Eight foundations awarded $10 million or more for science and technology
- Sixteen foundations awarded from $5 million to $10 million for science and technology
- Twenty-six foundations awarded from $2.37 million to $5 million for science and technology

In the research areas of science, technology and health, the level of federal grant support significantly exceeds that of private science foundations. Lee Shulman points out, however, that this generalization is not true in the research fields of K-12 and higher education. Says Shulman, "there is so little federal research funding in education (in contrast to the funding of educational operations or the funding of student loans) that the funding from science foundations is actually the core of educational research support rather than a catalyst."

thirty private colleges in the five states in which we give grants. That gives us an opportunity to really get to know those institutions very well. We put a lot of energy into learning what the challenges are for science faculty and administrators, and then trying to fashion programs and responses that will meet those needs. It's easy for us to call together a group of science faculty, brainstorm with them, hear them out, and then respond. As a result, we've seen a significant change in the culture of the science divisions with respect to faculty and student research. It would have been very difficult for a large federal agency to do that."

The in-depth relationship and understanding that develop between a private science foundation and an institution it serves can lead to more effective change. Neal B. Abraham, executive vice president, vice president for academic affairs, dean of the faculty and professor of physics at DePauw University, says, "My sense is that private science foundations have been more sensitive to the ebb and flow–the pace of change–at different institutions. Some institutions adopted neuroscience or environmental science or biochemistry a decade ago, and some haven't done that yet. There's a little more faddism in the federal funding–'now is the time to do this.' The private science foundations have been more open to 'what's right for you at this point in time.' That depends on who's retiring, who's joining your faculty and whether you've just had an endowment campaign and have some money to spend. There are a lot of different things in play."

James M. Gentile, professor of biology and dean for the Natural Sciences at Hope College, points out, "In the private science foundations, the program officers play a key role in faculty development. A lot of one-on-one conversation and mentoring goes on. For the most part, you don't get that from the public sector. With private science foundations, it's a much more hands-on approach, and it really helps with

Neal O. Thorpe
M.J. Murdock Charitable Trust

The M.J. Murdock Charitable Trust, established in 1975, has a mission "to enrich the quality of life in the Pacific Northwest by providing grants to organizations that seek to strengthen the region's educational and cultural base in creative and sustainable ways." The trust has focused its grantmaking efforts in five states of the Pacific Northwest: Alaska, Idaho, Montana, Oregon and Washington. A historical emphasis in grantmaking has been in education and scientific research, and the trust has four formal grant programs with a focus on the sciences. (www.murdock-trust.org)

James M. Gentile
Hope College

Hope College, established in 1866, is a private, four-year, residential, liberal arts, undergraduate college. Located in Holland, Michigan, Hope College has an enrollment of approximately 3,000 students.
(www.hope.edu)

Neal B. Abraham
DePauw University

DePauw University, founded in 1837, is a private, selective, coeducational, residential, undergraduate liberal arts college. Located in Greencastle, Indiana, DePauw University has an enrollment of approximately 2,300 students.
(www.depauw.edu)

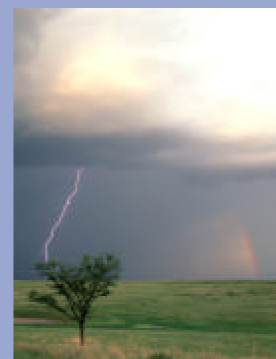
faculty development. It's almost more like classical relationship building that one finds with foundations and organizations except this is relationship building through the scientific enterprise."

In biochemistry, the classical metaphor for the way an enzyme catalyzes a chemical reaction is the lock-and-key metaphor. The enzyme provides an active site–a protected molecular environment uniquely suited to the particular molecule that will be transformed. Through a one-on-one exchange of energy and atoms that takes place in the active site, the chemical reaction is catalyzed and the target molecule transformed. Private science foundations can catalyze change in much the same way–through specially tailored, one-on-one exchanges of energy, ideas and funds.

Challenges and Opportunities for the Future

As discussed above, private science foundations have developed useful strategies that help them serve a catalytic role in the science and education communities. Looking ahead, the need for foundations' assistance is more important than ever, because major challenges face today's scientific and educational institutions. Here's an overview of three of those challenges.

Lightning, Legumes and Laboratories: The Role of Catalysis in Nitrogen Fixation

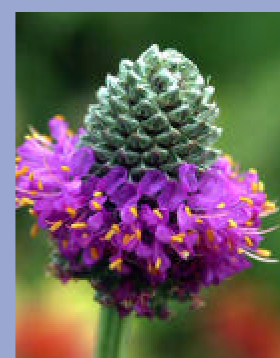


Water, water everywhere, nor any drop to drink.
- Samuel Coleridge, *The Rime of the Ancient Mariner*

If Coleridge had been a chemist, he might have chosen N_2 gas, instead of liquid H_2O, to illustrate the paradox of scarcity in the midst of apparent abundance.

Nitrogen gas, N_2, makes up 78 percent of the air we breathe. Nitrogen is also an essential component of many chemical building blocks of life, including amino acids, proteins and DNA. Yet animals and higher plants can't make use of it and convert it into these important organic molecules, because N_2 is a relatively inert substance that doesn't combine with other elements under ordinary conditions.

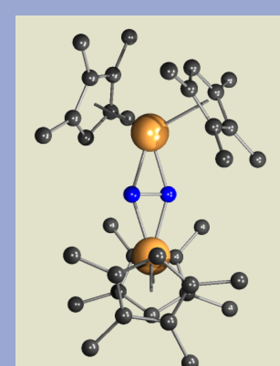
Before it can be used by most living organisms, nitrogen must first be combined with hydrogen or oxygen to form more reactive chemical compounds such as ammonia, nitrites and nitrates. Only then can most living organisms utilize the nitrogen. This process of converting nitrogen gas to a more usable form is called nitrogen fixation. It's a difficult process from a chemical perspective, with a very high activation energy barrier that must be surmounted. A recent article about biological oceanography described the problem this way: "Nitrogen, nitrogen everywhere, but not an energetically bioavailable form to drink."



Sources of Nitrogen Fixation

Several billion years ago, in earth's early days, the first conversion of nitrogen gas to nitrates and ammonia was caused by lightning, which was able to produce the extreme conditions of high temperatures and pressure required. Today, a relatively small amount of nitrogen gas is turned into nitrates and then ammonia as a result of lightning. As dramatic as lightning can be, however, it still doesn't provide enough nitrogen fixation to support abundant life on earth. Scientists estimate that only 5 to 8 percent of nitrogen fixation on earth results from lightning.

How, then, does nitrogen fixation take place?



Today, most naturally occurring nitrogen fixation takes place in a less dramatic fashion, without extreme conditions of temperature or pressure, without flashes of bright light and loud claps of thunder. It happens quietly underground and underwater. And it happens as a result of catalytic reactions in certain forms of bacteria.

These bacteria use enzymes called nitrogenases to catalyze the combination of nitrogen and hydrogen to form ammonia. These bacteria are found in the oceans, in the soil, and in symbiotic relationships that take place in root nodules of certain plants, most notably legumes such as clover, alfalfa and soybeans.

Modern Society's Reliance on Nitrogen Fixation

Materials containing fixed nitrogen, such as saltpetre (sodium nitrate), guano, manure and decaying plant material, have long been used in human agriculture as fertilizers. During the Nineteenth Century, scientists began to understand fixed nitrogen's importance to growing plants, and farmers began to incorporate the use of fertilizers into more intensive agricultural methods.

At the same time, a second use for fixed nitrogen became increasingly important–its use as a starting material for making gunpowder and explosives. By the end of the Nineteenth Century, these two competing uses started to strain the natural supplies of fixed nitrogen. Nitrogen fixation became a subject of great strategic importance, and scientists began searching for new sources of fixed nitrogen.

Early in the Twentieth Century, two German scientists, Fritz Haber and Carl Bosch, discovered and developed a catalytic process for converting nitrogen and hydrogen gas to ammonia. The process used extremely high pressures and moderately high temperatures in the presence of an active iron-based catalyst. The Haber-Bosch process quickly became one of the most important industrial chemical processes, and Haber and Bosch each received Nobel Prizes for their work. (The Haber-Bosch process, still widely used, is responsible for producing ammonia used in fertilizer that sustains roughly 40 percent of the world's population today.) As Germany began to expand its industrial production of ammonia, other countries sought to develop their own strategic capabilities in this area. In 1916, the United States established the Fixed Nitrogen Research Laboratory. A key goal of this laboratory was to develop new catalysts for nitrogen fixation.

Research Corporation's Catalytic Role in Nitrogen Fixation

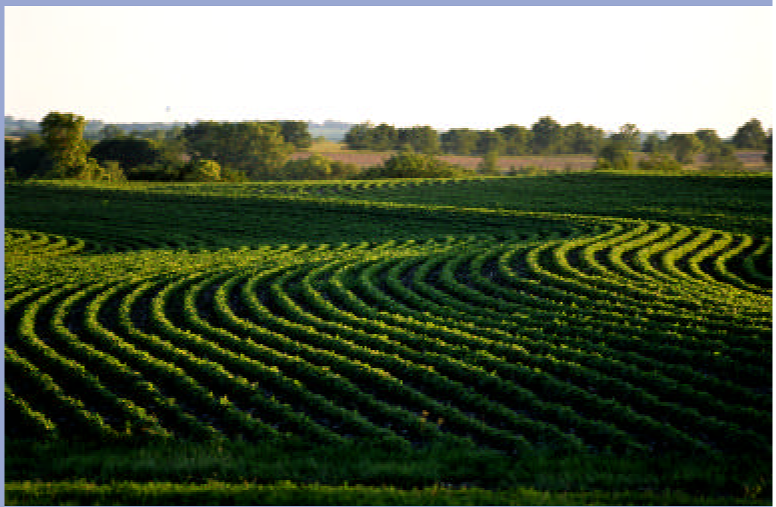
Among the many organizations and scientists that have played key roles in improving our understanding of nitrogen fixation are Research Corporation and its founder, Frederick Gardner Cottrell.

In 1922, Cottrell was appointed director of the Fixed Nitrogen Research Laboratory. During Cottrell's tenure at the laboratory, from 1922 to 1930, American scientists developed a very reactive and stable catalyst for use in the Haber-Bosch process.

Over the decades since then, scientists with Research Corporation support have continued to explore how nitrogen fixation occurs in both biological and non-biological systems. Because of its great significance, both as a field of scientific study and as a subject that promises great practical value, nitrogen fixation remains an important area of research today.

For example, among the eleven talented scholars recently selected to receive a 2004 Cottrell Scholar Award is chemist Paul Chirik. Chirik and coworkers at Cornell University, in a recent scientific paper (*Nature*, Volume 427, pages 527-530, 2004), announced the discovery of a zirconium compound that enables the production of ammonia from nitrogen and hydrogen in solution at relatively low temperatures.

Nitrogen Fixation and Symbiosis: An Inspiration for Private Science Foundations



The bacteria that toil quietly beneath the surface to transform nitrogen into ammonia play an indispensable role in the ecosystem. They use catalysis to lower the barriers to transformation, and they work closely in a symbiotic relationship with other members of the ecosystem.

The world of higher education has also been described as an ecosystem. In a chapter titled "The University as Ecosystem" (*Reinventing Undergraduate Education: A Blueprint for America's Research Universities,* 1998), the members of the Boyer Commission on Educating Undergraduates in the Research University, write:

> The ecology of the university depends on a deep and abiding understanding that inquiry, investigation and discovery are the heart of the enterprise, whether in funded research projects or undergraduate classrooms or graduate apprenticeships. Everyone at a university should be a discoverer, a learner. That shared mission binds together all that happens on a campus. The teaching responsibility of the university is to make all its students participants in the mission.

In both ecosystems–the world of plants and animals and the world of higher education–the fruits of the system would not be possible without the hidden, behind-the-scenes work of the catalysts for transformation, whether they be nitrogen-fixing bacteria or private science foundations.

Challenge # 1 : Helping scientists build and sustain their careers

The scientific and higher-education enterprise is not a well-oiled machine with easily replaced parts; it's a complex, living system comprising many individuals with unique careers, values and talents. Each of those careers is a journey, with trials and tasks, twists and turns, successes and failures. At key stages along the career path, private science foundations can play an important role in helping individuals take the next step.

One of the stages where private science foundations have been making important contributions is at the beginning of a faculty member's career. The process by which federal grants are awarded today makes it especially hard for young scientists to get started, so private science foundations have concentrated many of their programs on the needs of young faculty members. In chemistry, for example, young scientists have received valuable help early in their careers from Research Corporation, the Welch Foundation, the Arnold and Mabel Beckman Foundation, the Petroleum Research Fund and the Dreyfus Foundation.

Many scientists can point to private foundations as the first organizations to fund them and "believe in them," providing both financial and moral support at a fragile time in their careers. Carl E. Wieman, distinguished professor of physics, University of Colorado at Boulder, who received the Nobel Prize in Physics in 2001 for his work on the creation and study of Bose-Einstein condensation, describes his early career this way:

Shortly after I arrived at Michigan, I found that the research scientist position I had taken was not the research faculty position that I had expected. It had all the disadvantages of a regular postdoc, but none of the advantages in that there was not sufficient research money in the grant to cover my salary, so that I also had to teach, and I had to be responsible for much of the administration of the research group. However, I threw myself into the experiment and worked extremely hard, and my position was converted into a regular assistant professor position after a couple of years. Shortly after this, I developed a somewhat different formulation for how to describe atomic parity violation experiments. This allowed me to see clearly how to compare the sensitivities of a large variety of different experimental approaches. At that same time, I was also becoming increasingly disillusioned with the hydrogen experiment, and my new formulation made it clear to me that a quite different approach, using laser spectroscopy of cesium, would have a far better chance of success.

For a variety of reasons, I chose to pursue the cesium experiment on my own, after first receiving assurances from the department chair that this was a suitable activity. Unfortunately, my abandoning of the hydrogen experiment to pursue my own atomic parity violation experiment lead to considerable friction with senior faculty and general strife within the department. As a young assistant professor naïve in departmental politics, I was quite vulnerable, and had a difficult time during my subsequent years at Michigan. However, during that time, Sarah Gilbert and I were able to get funding from Research Corporation and then NSF and used it to thoroughly develop a novel experimental approach for measuring atomic PV in cesium . . . . By 1984 we had made sufficient progress to indicate the viability of our approach, and this attracted an offer of a faculty position at the University of Colorado in Boulder. I eagerly accepted the offer.

[from Wieman's autobiography on the Nobel Prize website (www.nobel.se)]

In a recent letter to Research Corporation, Wieman elaborated on this story, writing:

As I reflect on my career and its many successes, I remain very grateful for the help I received from Research Corporation at the most critical stage. My first grant, from Research Corporation of course, came at a terribly critical and difficult time for me. With it, I was able to demonstrate enough results to get an NSF grant and after that I was off and running. It is difficult to describe, however, how important that first Research Corporation grant was to me, and frightening to think what would have become of my career if it had not been there.

Gentile describes today's federal funding situation like this: "In the federal sector today, science is almost always done 'in arrears.' You have to prove so much of your point up front [in the grant proposal], that there's very little risk-taking involved. The entrepreneurial art of science is almost lost for the practical art of the machine-like laboratory to crank out the data and get it done. The private foundations, on the other hand, seem to be able to understand that, even while ideas aren't fully blossomed yet, they will invest in an individual or a program or a research area. They allow the people to succeed by establishing themselves. That's why private foundations oftentimes have the biggest impact on the youngest faculty."

Carl E. Wieman
University of Colorado at Boulder

The University of Colorado, Boulder, founded in 1876, is the oldest campus in the four-member University of Colorado system. It is a public university with approximately 23,500 undergraduate students and 4,500 graduate students. (www.colorado.edu)

Schaefer says, "Getting that first olive out of the jar is often very difficult for people just starting their research careers. The NSF does have programs in that area as well, but the ability to get research programs established with the help of private foundations is often a key factor in helping academic scientists launch their careers. That's going to be a continued function of science foundations."

With the recent surge in new faculty hiring to replace retiring faculty members, the need for this type of assistance is greater than ever. Funke observes, for example, that applications for PRF starter grants have increased about 30 percent in the past ten years.

Another stage in the career path where assistance is especially needed is after young faculty members receive tenure. At that point in their careers, they are expected to take on more responsibilities as college and university citizens, while continuing their commitment to teaching and maintaining an active program of scholarship in their discipline. Some administrators see this midcareer stage as a danger point, where the time crunch on faculty members can lead to burnout. Ideally, these young faculty members will learn to sustain their research over the course of their

Michael E. Nelson
University of Wisconsin, La Crosse

The University of Wisconsin-La Crosse was founded in 1909 in La Crosse, Wisconsin, as the La Crosse Normal School. Today, it is one of the thirteen four-year public campuses in the University of Wisconsin System. It has an enrollment of about 8,000 undergraduate students and 600 graduate students. (www.uwlax.edu)

careers and will develop into senior teacher-scholar-servant scientists who will serve as role models and mentors.

Michael E. Nelson, dean of the College of Science and Allied Health at the University of Wisconsin, La Crosse, speaks to this concern: "Here at La Crosse, the peak for retirements passed several years ago, and close to 70 percent of our faculty members in science have arrived in the last ten years. How will we keep this new generation of faculty members active after they have received tenure and been promoted? One of my most important tasks as a dean is to help keep faculty members intellectually active after tenure and promotion."

As the large group of young scientists who have recently joined faculties across the nation continue their growth as teacher-scholars, how can private science foundations help nurture that process?

Two new programs addressing this career stage are in the pilot stages at the Petroleum Research Fund and Research Corporation. At the Petroleum Research Fund, a pilot program to expand funding for undergraduate faculty sabbaticals has received a great deal of application interest. Research Corporation recently convened a group of senior and emerging academic leaders to explore models for academic leadership and to discuss issues related to department advancement and leadership.

Perhaps these new foundation initiatives for mid-career scientists will–just like the successful programs for starting faculty–provide an important catalytic boost at a crucial time in the careers of academic scientists.

Challenge #2: Responding to the growing interdisciplinarity of the sciences

Much of the excitement today for both research and teaching is found at the interfaces of the traditional scientific disciplines, in areas such as neuroscience, nanoscience, environmental science, computational biology and chemical genetics. But the traditional disciplines, departments, majors and introductory courses are still essential and important . . . aren't they? How are academic institutions adjusting to these emerging fields?

As young faculty members begin their academic careers at liberal arts colleges, many of them want to incorporate the frontier areas of research into the curriculum–areas such as computational biology, proteomics or the interface between astronomy and particle physics. Through these programs, young faculty members remain energized and are able to do their own research, while also introducing undergraduate students to research. However, these types of programs present a significant financial challenge, because

they often require top-end instrumentation. Unfortunately, these emerging, interdisciplinary areas often don't fit into the guidelines for particular federal programs. Private science foundations, on the other hand, have the flexibility to respond more easily and quickly to these needs and opportunities.

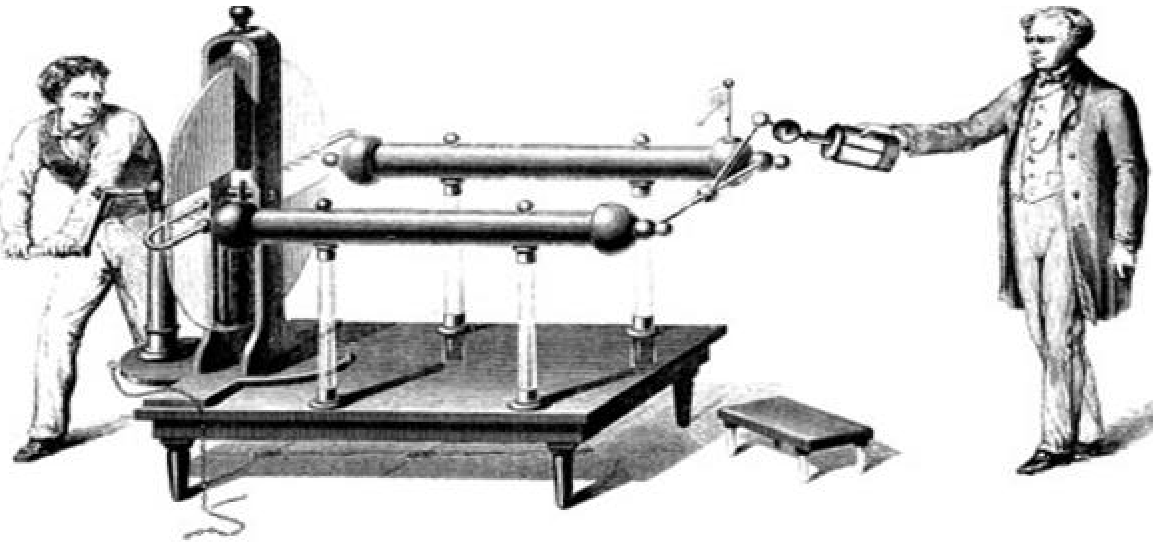
In addition to the financial challenges, the burgeoning of interdisciplinary fields provides administrative challenges and opportunities for the traditional structures of institutions.

DePauw University's Abraham says, "The interdisciplinary nature of science is a critical issue. Smaller colleges are organized around departments, and departmental structures aren't very flexible. Dealing with emerging, interdisciplinary fields and emerging subfields is a huge problem for colleges that have few people trying to cover large parts of the discipline."

When a faculty member retires, should they be replaced by someone with the same specialty? Or is this an opportunity to restructure a department by adding someone from an interdisciplinary area, even if it's outside the core discipline? If there isn't an opportunity to hire faculty members in new areas, can current faculty members be retrained in these areas? And what about the curriculum? Should new subjects be infused into the curriculum or should they simply be added as new courses to the existing curriculum? "Curriculum issues are really tough," says Abraham. "Should we preserve general chemistry as it's always been done and add yet another course in biomolecular chemistry? Or do we take a more biomolecular approach to the way we teach introductory chemistry?"

Different colleges are adopting different approaches:

- At the University of Wisconsin, La Crosse, the university established a River Studies Center, which draws on a broad range of disciplines including biology, chemistry and geography. The center includes both faculty and outside experts from governmental agencies.
- The new science building at Hope College will group faculty offices, lab space and instrumentation pods by the nature of the research rather than by academic discipline–one floor is for faculty members who investigate molecules, another floor is for those involved in environmental studies and a third floor is for those studying the human condition.
- Some colleges have added majors and new departments in areas such as biochemistry, while others keep the biochemistry program as part of a chemistry major. Other colleges add concentrations, minors or double majors.
- Some colleges are forming consortia and partnerships with sister institutions to enable them to offer more opportunities for teaching, research and collaboration in areas such as astronomy, geology and neuroscience. An early example of a successful consortium is the Five College Radio Observatory, which received initial funding from Research Corporation in 1960. The members of this consortium–Amherst College, Hampshire College,



Mount Holyoke College, Smith College and the University of Massachusetts–now offer a Five College Astronomy Department that provides a richer environment for doing astronomy than would be possible if each institution operated independently. A more recent example of a successful partnership is the Keck Geology Consortium, a collaborative effort of twelve liberal arts colleges across the nation. An example of a successful collaboration in neuroscience can be found in Philadelphia, where Bryn Mawr College and Haverford College have joined forces to offer their students an interdisciplinary concentration in Neural and Behavioral Sciences.

Each of these solutions to the challenge of increasing interdisciplinarity brings with it a different set of administrative issues related to hiring and tenure decisions, space allocation, assignment of credit hours, institutional loyalties and departmental boundaries. As institutions transform themselves in response to the changing nature of science, private science foundations can use their catalytic strengths–nimbleness, flexibility, risk-taking, focus, close involvement and familiarity–to help ease and speed the ongoing process of change.

Challenge #3: Balancing research and teaching

In recent years, a central theme for many private science foundations has been to explore ways of balancing the role of research and teaching in the various settings of higher education.

Shulman puts the problem in its historical context, looking back at the huge growth of federal science support since World War II: "The unintended consequence on undergraduate science education of this way of doing science has been to create an enormous tension within the academic institutions between research and teaching. As institutions began to elevate and honor the scholars who were most successful in attracting those government funds–far more than they honored those who did an extraordinary job in the classroom–we began to see the quality of undergraduate science education suffering. Graduate education and research took precedence, especially in the 'Research Intensive' institutions. The emphasis in doctoral education in the sciences shifted, because the preparation of the next generation of faculty was being done almost entirely within the context of big research projects. This tended to diminish the centrality of teaching in their identity as scientists."

Bruns says, "The most sweeping challenge in science education for the higher-education community is to get scientists more interested in, and rewarded for, being innovative in education. Here's my simplest assay for this:

You go up to some successful scientist and ask, 'Are you doing experiments the way you did as a graduate student?'

And they'd say, 'Of course not. Are you kidding?'

Then you ask, 'Are you teaching the way you did as a graduate student?'

And most would probably say, 'Yes.'

So there's a disconnect in the system. The burden is on both the faculty and the administration to encourage faculty to break out of the mold in education."

In the last decade, public and private science foundations have launched initiatives to redress this balance. Programs such as Research Corporation's Cottrell Scholars program, the HHMI Professors program and the NSF Director's Awards for Distinguished Teaching Scholars all seek to honor and encourage scholars who are finding innovative ways to balance research and teaching. Recent reports from the National Research Council–"Science Teaching Reconsidered" (1997), "Transforming Undergraduate Education in Science, Mathematics, Engineering, and Technology" (1999) and "Bio 2010: Undergraduate Education to Prepare Biomedical Research Scientists" (2003)–sound a clear call for reform and innovation. The Carnegie Foundation's Initiative on the Doctorate (launched in 2001) aims at enriching and invigorating the education of doctoral students, with a focus on preparing "stewards of the discipline." This initiative includes institutional partners in six academic disciplines, including chemistry, mathematics and neuroscience.

Other recent initiatives dealing with these issues include Project Kaleidoscope (launched in 1989) and the Preparing Future Faculty program (launched in 1993 by the Council of Graduate Schools and the Association of American Colleges and Universities). Both of these ongoing initiatives have benefited from strong grant support from foundations.

In the human body, catalytic enzymes play a key role in balancing all the elements of a healthy metabolism. Can private science foundations play a similar catalytic role in achieving a healthy balance between research and teaching in the higher-education community?

Metaphorical Musings on Catalysts and Private Science Foundations

Among scientific concepts that have been embraced as metaphors by modern culture and language, the metaphor of a "catalyst" ranks near the top. The notion of a substance, individual or organization that can inspire change and transformation, while remaining unchanged itself, is particularly compelling. And, in the case of private science foundations, "catalyst" proves to be a very apt metaphor.

Isaac Asimov, biochemist and prolific author, mused about metaphors and catalysts in his 1959 essay titled "Enzymes and Metaphor" [The main purpose of Asimov's essay was to suggest a variety of metaphors that could be used to introduce students to the initially mysterious concept of catalysis.]:

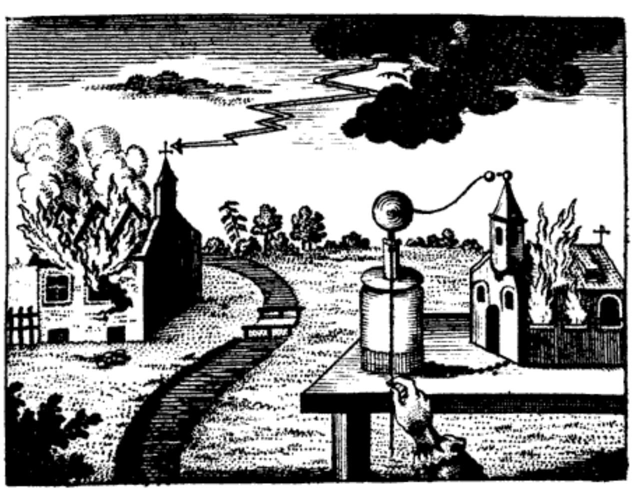
> Any unnecessary aura of mystery in science is undesirable since science is devoted to making the universe less mysterious, not more so . . . . To do away with mystery, it is only necessary to offer the students common examples of how a reaction can be hastened by mere presence of an extraneous substance; examples that, on the face of it, do not involve witchcraft. In short, a student may be unready for physical chemistry, but he is always ready for metaphor . . . . Once given the metaphor, it will, if dramatic enough, be retained.

[Asimov's metaphors include a brick and inclined plane, coated and uncoated with ice; a man stranded in the sandy desert with only a piece of paper and pencil, who is then given a writing board upon which to write; and a chair.]

> Imagine a man who is standing in a muddy field of indefinite extent who finds he must tie his shoelace . . . . An ordinary kitchen chair is quite adequate as a catalyst with which to accelerate the tying of shoelaces. But now imagine a specially designed chair with back, arm rests, and foot rests that are motorized and capable of automated motion . . . . The specially-designed chair (enzyme) is at once a more efficient and more specific enzyme than the generally-designed one (inorganic catalyst).

[In the essay's conclusion, Asimov contemplates the value of metaphors.]

> . . . the judicious use of metaphor in the introduction of new concepts, generally, is not only an aid to understanding but adds also to the interest and pleasure of the course. Naturally, we all feel that science is its own reward and requires no artificial sweetening to be stimulating and fascinating, but unaccountably, as we all know, many students fail to see this.



> Metaphor, then, by way of both reason and psychology, is itself a catalyst. By its mere presence and without actually increasing the scientific content of a course, it hastens the process of learning and is not used up thereby. [*Journal of Chemical Education*, Vol. 36, Nov. 1959, pp. 535-538]

If a metaphor "hastens the process of learning," as Asimov suggests, what more can private science foundations learn from the catalyst metaphor? What final advice can be gleaned from this metaphor as private science foundations move forward in the Twenty-first Century?

Here are three such lessons:

- Catalysts can lose their effectiveness when they become too rigid, when they lose their specificity and focus by trying to catalyze too many different types of reactions, and when they become involved with reactants that inhibit or poison the catalytic process. A catalyst is usually most effective and useful when it stays true to its original purpose and mission.
- The scientific enterprise is complex and multifaceted, like a living organism. For certain difficult chemical and biochemical reactions to take place in a living organism, catalysts are essential. For the scientific enterprise to thrive, private science foundations are also essential. Foundations must

seek out those places in the overall enterprise where they can be most useful in lowering barriers.

• Catalysts that work effectively in organisms often work as partners in inter-related reactions or metabolic cycles. When science foundations, both public and private, work together as partners, they can be especially effective and can ensure a thriving and growing scientific enterprise. Can foundations do more to coordinate their efforts in some way to further increase their effectiveness?

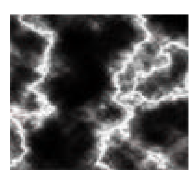
A century ago, the science of chemical catalysis and the world of private science foundations were both in their infancies. Since that time, in the hundred years known as "the American century," the United States has witnessed the growth of an unparalleled system of higher education and the creation of a scientific and technological enterprise that has vastly improved our health and quality of life. Private science foundations have played a role in this success.

Now, as we embark on another century, the future of catalysis–and private science foundations–remains bright and strong.

In the world of chemistry and biochemistry, recent advances in catalysis were honored by Nobel Prizes in 1989 and 2001. Advances in catalysis will continue to transform our understanding of nature and help us improve key areas of our lives, including health, energy and the environment.

In the world of science philanthropy, new foundations are being created, and established foundations are embarking on new programs. The leadership and support provided by private science foundations will be essential to meeting the complex challenges facing education and science in the years ahead.

If foundations can heed the lessons learned from chemical and biochemical catalysts, then foundations truly will be catalysts for change.



Program Review

Research Corporation, like other private science foundations, responds nimbly to changing needs and opportunities, while preserving a clear focus on its overall mission. That mission, as articulated by our founder Frederick Gardner Cottrell more than ninety years ago, is to provide the means for "technical and scientific investigation, research and experimentation."

In 2003, we exercised that flexibility, in order to enhance our programs, by significantly reducing our funding to one grant program while significantly increasing our funding to another. Faced with tightened budgets resulting from several years of downturn in the stock market, the board and staff of Research Corporation reviewed how well the Science Advancement Programs were meeting their original goals.

As a result of this careful review, we determined that the Research Innovation Award (RIA) program, directed to the newest faculty, was not meeting its intended goal. Initiated in 1997, this program was heavily subscribed to from the outset. While that suggested we were meeting a need, the program also posed several problems. Among those, for example, was the very heavy burden placed on the scientific community by our need for peer review. In the judgment of the foundation, the benefits and impact of the award–although significant–were not meeting the high standards we set for our programs. Consequently, in 2003, funding for the RIA program was reduced by 24 percent and has been fully suspended for 2004 and 2005.

Also during 2003, we saw a sudden and major increase in the quality and the number of proposals submitted to the Cottrell College Science Award (CCSA) program, and we were able to respond to that development. We were pleased to award ninety-three CCSA grants in 2003, compared to an average of seventy grants annually over the previous three years. Awardees received $3,366,035, an increase of more than 31 percent over the previous year. Those funds will provide increased opportunities for research by faculty and their students at primarily undergraduate institutions across the United States and Canada.

In order to carry out the programmatic work of Research Corporation, we have a strong professional staff, a committee of distinguished science advisors and a cadre of willing expert reviewers throughout the scientific community. The hub of all this activity is our office in Tucson, Arizona, where we also made several key changes in 2003.

We added two new program officers to the Research Corporation staff. Silvia Ronco joined our staff after more than ten years at the chemistry department of University of South Dakota, where, working with undergraduates, she established a highly successful research program. Jack Pladziewicz joined the staff after a long and distinguished career in the chemistry department at University of Wisconsin, Eau Claire. The third member of our program officer team, Lee Radziemski, joined our staff in May 2002, after serving as a physicist and university administrator, most recently as dean of the College of Sciences at Washington State University.

Another significant change occurred in December 2003, when Research Corporation moved into a new office building. Our new offices, shown on page one of this report, will provide space for program expansion as needed, while also serving as a sound financial investment for the foundation.

With new staff, a new building and a clear vision of how Research Corporation programs can make a difference in the communities we serve, we look forward to meeting the new challenges and opportunities of 2004 with both forethought and flexibility.

Raymond Kellman
Vice President

Program Summary

One hundred and forty-two awards were made in support of faculty research, research-enhanced teaching and special projects in science in 2003. Funding for the foundation's programs noted below totaled $5,602,256. In addition, two other awards were made, totaling $749,000.

COTTRELL COLLEGE SCIENCE AWARDS

Cottrell College Science Awards are the foundation's largest program, supporting faculty in chemistry, physics and astronomy at primarily undergraduate institutions. The program, which encourages student research involvement, funded ninety-three out of 262 faculty applicants. Two cycles of awards are featured each year; in 2003, the foundation granted a total of $3,366,035, averaging $36,194 per award.

COTTRELL SCHOLARS AWARDS

Cottrell Scholars Awards support excellence in both research and teaching in chemistry, physics and astronomy at Ph.D.-granting institutions. Each award totals $75,000, to be used largely at the discretion of the scholar. Out of 122 requests submitted, twelve Cottrell Scholars awards were made, totaling $900,000.

RESEARCH OPPORTUNITY AWARDS

Research Opportunity Awards support midcareer faculty of demonstrated productivity who seek to explore new experimental research at Ph.D.-granting institutions. Out of six candidates nominated by their department chairs for awards in 2003, three proposals were funded for a total of $146,221.

RESEARCH INNOVATION AWARDS

Research Innovation Awards were instituted in 1997. The Research Innovation Awards program is open to beginning faculty at Ph.D.-granting institutions and encourages innovation by scientists early in their academic careers. Of 141 proposals received, thirty-four were recommended for awards which totaled $1,190,000.

OTHER AWARDS

In 2003, Louisiana State University received a Special Opportunity in Science Award of $474,000. Discretionary Awards for the year totaled $275,000.

Research Corporation
AWARDS APPROVED
January 1, 2003 to December 31, 2003

COTTRELL COLLEGE SCIENCE AWARDS

Bates College
Jennifer L. Koviach, Department of Chemistry: Synthesis of 2-deoxyglycosides by conjugate addition-$37,218

Paula Jean Schlax, Department of Chemistry: Characterization of the role of RpoS mRNA interactions with regulatory factors during osmotic induction of the rpoS gene-$24,150

Boise State University
Alex Punnoose, Department of Physics: Origin of room temperature ferromagnetism in Co doped TiO_2 thin films-$41,133

Bradley University
Kelly R. Roos, Department of Physics: Interlayer diffusion in metallic epitaxial systems-$34,144

California Polytechnic State University, San Luis Obispo
Robert Echols, Department of Physics: Exploring fundamental electrical and optical properties of heterojunction semiconducting polymer solar cells-$35,470

California State University, Chico
Christopher J. Nichols, Department of Chemistry: The synthesis of the natural product corydendramine A-$31,183

California State University, Long Beach
Christopher R. Brazier, Department of Chemistry: Jet-cooled emission spectroscopy of silicon boride-$35,382

California State University, Los Angeles
Guo-meng Zhao, Department of Physics: Oxygen-isotope effects on electrical transport and magnetic properties in single crystals and thin films of manganites-$45,803

Calvin College
Eric J. Arnoys, Department of Chemistry: Analysis of the nuclear transport of galectin-3 using fusion proteins-$33,718

Calvin College
Paul Harper, Department of Physics: Kinetics of the lamellar-hexagonal phase transition in lipid-water systems-$43,951

Central Michigan University
Minghui Chai, Department of Chemistry: Investigation of dendrimer-based self-assemblies and their encapsulation with small organic molecules in solutions-$36,224

Bradley D. Fahlman, Department of Chemistry: Supercritical fluid facilitated growth of carbon nanotube-dendrimer nanocomposite materials-$37,830

Central Washington University
Anthony L. Diaz, Department of Chemistry: Fundamental investigations of the VUV optical properties of new luminescent materials-$23,846

City University of New York, Hunter College
Gregory Foster, Department of Physics: Spin squeezing and entanglement of cold atoms for applications in precision measurement and quantum information-$35,144

Colgate University
Sara Ann Brazill, Department of Chemistry: Investigation of DNA aptamer-protein recognition utilizing electrochemical techniques: Developments toward a protein microarray-$35,910

Ephraim Woods III, Department of Chemistry: The polarity of aerosol surfaces measured using aerosol photoionization spectroscopy-$39,036

College of Charleston
Justin Wyatt, Department of Chemistry: Directed *ortho*-alkylation of chiral aromatic oxazolines (derived from chiral α, α - disubstituted amino acids)-$35,718

College of the Holy Cross
Kenneth V. Mills, Department of Chemistry: The mechanism and molecular evolution of hedgehog proteins and related auto-processing domains-$41,890

College of the Holy Cross
Kimberley Frederick, Department of Chemistry: Characterization of electroosmotic flow in fused silica capillaries and electrostatically self-assembled polyelectrolyte multilayers-$39,787

Columbia College
Frank L. Somer Jr., Department of Chemistry: Structural dynamics of liquids and glasses-$31,184

Concordia College
Drew Rutherford, Department of Chemistry: Enantioselective catalysis in “green” solvents: Recyclable catalysts for perfluorocarbon and supercritical carbon dioxide solvent systems-$29,085

DePauw University
Hilary J. Eppley, Department of Chemistry: Ionic liquid syntheses of new molecular precursors to mixed metal oxides-$44,400

East Tennessee State University
Yuriy Razskazovskiy, Department of Physics: Sequence-specific radiation targeting of DNA in hypoxic environment-$36,335

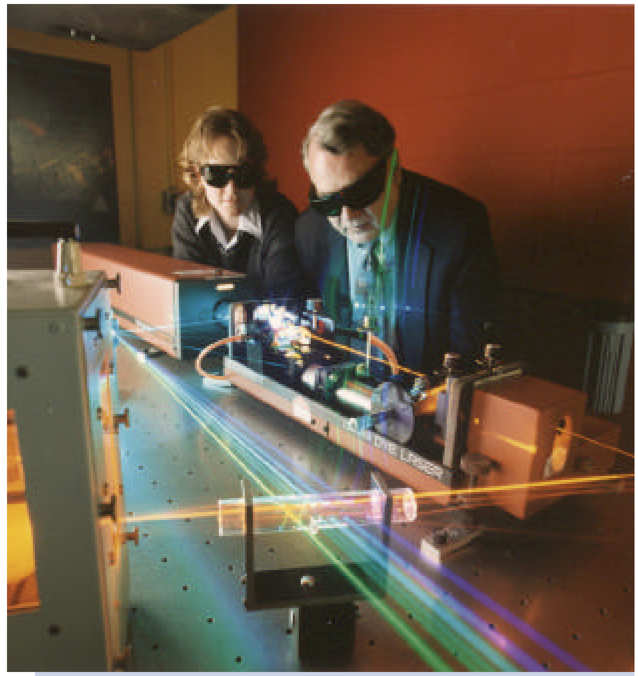
Elon University
Joel M. Karty, Department of Chemistry: Resonance and inductive contributions to fundamental chemical systems-$34,218

Fairfield University
Matthew A. Kubasik, Department of Chemistry: Studies of hydrogen/deuterium exchange kinetics in conformationally labile peptides-$36,218

Georgia Southern University
Kurt N. Wiegel, Department of Chemistry: Synthesis and characterization of photo-tunable liquid crystalline polymers with variable mesogenic structures-$43,352

Grinnell College
Charles E. Cunningham, Department of Physics: Search for an ideal 3D Ising spin glass in $Dy_xY_{(1-x)}Co_2Ge_2$ and $Nd_xLa_{(1-x)}Co_2Ge_2$ single crystals-$39,750

Hamilton College
Timothy E. Elgren, Department of Chemistry: Characterization of sol-gel encapsulated amine oxidase and chloroperoxidase-$35,220



Hamilton College
George C. Shields, Department of Chemistry: Quantum chemical investigation of the mechanism of action of the enediyne natural products-$35,000

Harvey Mudd College
Karl A. Haushalter, Department of Chemistry: The influence of chromatin structure on the repair of 8-oxoguanine DNA lesions-$34,976

Hobart and William Smith Colleges
Erin T. Pelkey, Department of Chemistry: Regiocontrolled synthesis of complex pyrrole heterocycles-$39,818

Hope College
Peter L. Gonthier, Department of Astronomy: Radio and high energy emission from neutron stars-$23,700

Mark E. Little, Department of Physics: Charge carrier transport investigations in amorphous nitride films using time-of-flight drift mobility-$46,048

William F. Polik, Department of Chemistry: Spectroscopically accurate potential energy surface calculations at high energies-$45,000

Indiana State University
Stephen F. Wolf, Department of Chemistry: Investigation of the distribution of highly volatile trace elements in chondritic meteorites-$38,860

Ithaca College
Scott M. Ulrich, Department of Chemistry: Generation of allele-specific histone deacetylase inhibitors-$38,148

James Madison University
Kevin L. Caran, Department of Chemistry: Facile synthesis and derivatization of two novel rigid trimeric scaffolds-$35,000

Kevin P. Minbiole, Department of Chemistry: A cyclopropane fragmentation approach to heterocycle assembly-$35,000

John Carroll University
Jeffrey S. Dyck, Department of Physics: Pressure tuning the ferromagnetic transition in the layered V_2-VI_3 diluted magnetic semiconductors-$35,845

Kenyon College
Frank C. Peiris, Department of Physics: Investigation of the electronic excitation structure of spintronics based diluted magnetic semiconductors using spectroscopic ellipsometry-$36,920

Lakehead University
Craig D. MacKinnon, Department of Chemistry: Engineering the structures of new oligomeric semiconductors-$32,713

Lebanon Valley College
Walter A. Patton, Department of Chemistry: Mechanism of ammonia transfer in *E. coli* GMP synthetase-$39,820

Lewis and Clark College
Louis Y. Kuo, Department of Chemistry: Aqueous investigation of molybdocene organometallic complexes-$28,684

Loyola College in Maryland
Elaine M. Shea, Department of Chemistry: Action of amide and ester conjugates of the plant hormone indole-3-acetic acid in carrot embryo initiation-$27,648

Macalester College
Paul J. Fischer, Department of Chemistry: Studies on intramolecular amine-stabilized transition-metal boryl complexes-$35,000

Marist College
Elisa M. Woolridge, Department of Chemistry: Understanding the oxidative inactivation of laccase and xylanase toward design of a simultaneous biodelignification system-$42,083

Mississippi College
G. Reid Bishop, Department of Chemistry: Structural and energetic bases of molecular recognition of amino acid analogs by DNA and RNA aptamers-$33,182

Northern Arizona University
Gus L.W. Hart, Department of Physics: A study of magnesium-based hexagonal alloys for use in light-weight applications-$29,884

Oberlin College
Stephen A. FitzGerald, Department of Physics: Quantum dynamics of gas doped fullerene systems-$37,648

Yumi Ijiri, Department of Physics: Magnetic finite size effects in iron-based nanoparticles-$44,410

Ohio Northern University
Jeffrey A. Gray, Department of Chemistry: Two-color transient absorption spectroscopy and kinetics of organic peroxy radicals in aqueous solution-$39,950

Otterbein College
David G. Robertson, Department of Physics: Studies in Coulomb gauge QCD-$34,480

Pennsylvania State University, Erie-Behrend College
Jay C. Amicangelo, Department of Chemistry: Investigations of intermediates related to silicon nitride chemical vapor deposition processes using matrix-isolation infrared spectroscopy-$39,018

Pomona College
Edward J. Crane III, Department of Chemistry: Enzymatic mechanisms of control of internal redox environment in hyperthermophiles-$39,036

Rochester Institute of Technology
Scott Victor Franklin, Department of Physics: Jamming in large aspect-ratio granular materials-$35,018

Rose-Hulman Institute of Technology
Luanne F. Tilstra, Department of Chemistry: A study of peptide aggregation that focuses on changes in particle size distribution as a function of time-$37,268

Saint Joseph's University
Thomas M. Halasinski, Department of Chemistry: Investigation of azaaromatics in the interstellar medium via matrix-isolation spectroscopy-$39,530

St. Olaf College
Jason J. Engbrecht, Department of Physics: Studies of positronium-gas interactions using an Age-Momentum Correlation spectrometer-$36,218

Seton Hall University
Daniel-Dennis McAlevy Bubb, Department of Physics: Resonant infrared pulsed laser deposition of polymer thin films-$35,000

Shippensburg University of Pennsylvania
John N. Richardson, Department of Chemistry: Application of colloidal Au nanoparticles to attenuated total reflectance spectroelectrochemical sensing-$35,563

Smith College
Kate Queeney, Department of Chemistry: Wet chemical oxidation of silicon: A microscopic and macroscopic approach-$33,410

Kevin M. Shea, Department of Chemistry: A new strategy for the synthesis of tricyclic compounds using cobalt mediated reactions-$33,684

Southern Illinois University at Carbondale
Shane Stadler, Department of Physics: Half-metallic nanocomposites-$38,500

Stonehill College
Marilena Fitzsimons Hall, Department of Chemistry: Modeling the Zn^{2+} coordination site of zinc metalloenzymes using peptide phage display-$38,426

Stonehill College
Cheryl S. Schnitzer, Department of Chemistry: Developing a model of metal complexes at the gas-liquid interface using a novel bubble column-$37,025

Union College
Joanne Dora Kehlbeck, Department of Chemistry: Functional foldamers: Design, synthesis and evaluation of biomimetic heteropolymers for the recognition of the EVH1 protein domain-$37,548

Chad R. Orzel, Department of Physics: Ultra-cold ionizing collisions in metastable rare gases-$41,039

Rebecca A. Surman, Department of Physics: Heavy element synthesis in outflows from gamma-ray burst accretion disks-$20,948

Union University
Michael R. Salazar, Department of Chemistry: Theoretical investigations into the reactive collisions of closed shell positive ions with isotopic hydrogen-$32,806

University of Colorado at Colorado Springs
Radha Pyati, Department of Chemistry: New ruthenium complexes and their π-stacking interactions studied by electrochemistry, electrochemiluminescence, and photophysics-$37,310

University of Colorado at Denver
Xiaotai Wang, Department of Chemistry: Lanthanide-carboxylate coordination polymers: Syntheses, structures, and porous applications-$42,970

University of Hawaii at Hilo

Philippe Binder, Department of Physics: Determinism tests and external forcing in chaotic systems-$32,206

University of Lethbridge

Michael Gerken, Department of Chemistry: Novel molybdenum sulfide fluorides and polysulfide fluoride complexes-$28,980

University of Nevada, Las Vegas

Byron L. Bennett, Department of Chemistry: Photocatalytic reduction of carbon dioxide by Re(I) in fluorous media-$39,683

Balakrishnan Naduvalath, Department of Chemistry: Investigation of chemical reactions at ultracold temperatures-$39,500

University of North Carolina at Charlotte

Angela Davies, Department of Physics: Fundamental investigations of the phase change on reflection of light-$35,316

Thomas A. Schmedake, Department of Chemistry: Monitoring energy transfer reactions in photonic materials: Towards more efficient photocatalyst design-$33,451

University of North Carolina at Greensboro

Nadja Cech, Department of Chemistry: Indentification of immune-stimulating liver metabolites of *Echinacea*-$34,784

Edward H. Hellen, Department of Physics: Reentrant dynamics on a neural-based loop-$37,318

University of North Carolina at Wilmington

Liping Gan, Department of Physics: Precision measurements of electromagnetic properties of the light pseudoscalar mesons-$28,110

University of Portland

Ann Marie Anderssohn, Department of Chemistry: The function of myocilin as a molecular chaperone-$32,500

Tamar More, Department of Physics: Experimental observations of Stewartson layer instabilities-$43,918

University of Richmond

Samuel A. Abrash, Department of Chemistry: A study on the role of triplet states in the photochemistry of organosilanes-$40,091

University of San Diego

Leigh A. Plesniak, Department of Chemistry: Hunter-killer peptides: Structure and membrane interactions-$17,445

University of Winnipeg

Michael O. Eze, Department of Chemistry: Effects of cerulenin and nitric oxide on cell growth, fatty acid synthesis, and monooxygenase function in *Azotobacter vinelandii*-$34,072

University of Wisconsin, Eau Claire

Marcia A. Miller-Rodeberg, Department of Chemistry: The degradation of azo dyes by the catalase/peroxidase enzymes of *Brevibacterium fuscum*-$40,576

University of Wisconsin, La Crosse

Robert W. McGaff, Department of Chemistry: Solventothermal synthesis of transition metal alkoxides-$40,348

Virginia Military Institute

Daren J. Timmons, Department of Chemistry: Development of metallaligands for the synthesis and luminescence studies of mixed d- and f-block complexes-$39,755

Wellesley College

Courtney Lannert, Department of Physics: Variational wavefunction Monte Carlo analysis of cooperative ring exchange in the intermediate-U Hubbard model-$35,148

Western Kentucky University
Young-Seok Shon, Department of Chemistry: Synthesis and assembly of photoactive or electroactive dendrimer capsules-$35,000

Whittier College
B. Glenn Piner, Department of Astronomy: The maximum speed of blazar jets-$35,218

Williams College
Dwight L. Whitaker, Department of Physics: The BEC phase transition and effects of quenched disorder-$45,000

Wofford College
Ramin Radfar, Department of Chemistry: Structural analysis on the role of glycolytic enzyme enolase in interaction with cholesteryl esters and inhibition of cholesteryl ester hydrolase-$45,220

COTTRELL SCHOLARS AWARDS

California Institute of Technology
Brian M. Stoltz, Department of Chemistry: New innovations in the teaching and implementation of synthetic chemistry-$75,000

Georgetown University
David Andrew Egolf, Department of Physics: Computational science in the heart and in the classroom-$75,000

Iowa State University
Nicola L. Pohl, Department of Chemistry: Chemical biology of glycopolymer and deoxysugar biosynthesis using mass spectrometry-$75,000

Simon Fraser University
J. Steven Dodge, Department of Physics: Terahertz measurements of quasiparticle lifetimes-$75,000

Syracuse University
Mark Trodden, Department of Physics: Geometry, topology and Kaluza-Klein cosmology-$75,000

University of Arizona
Michael R. Meyer, Department of Astronomy: A whole greater than the sum of its parts: Understanding the origins of stellar masses and mentoring tomorrow's scholars-$75,000

University of Illinois at Urbana-Champaign
Taekjip Ha, Department of Physics: Structural dynamics of Holliday junction: Single molecule studies of conformer transitions and branch migration-$75,000

University of Notre Dame
Michael D. Hildreth, Department of Physics: Enhancing the potential for Higgs discovery at the Fermilab Tevatron-$75,000

University of Oregon
Richard P. Taylor, Department of Physics: Fractal conductance fluctuations in ballistic nanostructures-$75,000

University of Washington
Daniel R. Gamelin, Department of Chemistry: Synthetic, magnetic, and spectroscopic approaches to understanding and controlling the magnetism of doped inorganic nanocrystals-$75,000

Sarah L. Keller, Department of Chemistry: Specialized domains in lipid bilayers and monolayers-$75,000

Virginia Polytechnic Institute and State University
T. Daniel Crawford, Department of Chemistry: Quantum mechanical studies of chirality: Local correlation methods for optical rotation in large molecules-$75,000

RESEARCH OPPORTUNITY AWARDS

Ohio State University, Columbus
Terry Lee Gustafson, Department of Chemistry: Protein folding dynamics in quorum-sensing receptor-ligand interactions-$50,000

University of Notre Dame
Howard A. Blackstead, Department of Physics: A paradigm for the genesis of high temperature superconductor electronics-$46,584

University of Wisconsin, Milwaukee
Marija Gajdardziska-Josifovska, Department of Physics: Transmission electron microscopy study of stabilization mechanisms for polar oxide interfaces-$49,637

RESEARCH INNOVATION AWARDS

Brandeis University
Oleg V. Ozerov, Department of Chemistry: C-F bond functionalization catalyzed by three-coordinate Si compounds-$35,000

Brigham Young University
Branton J. Campbell, Department of Physics: Incident-neutron wavelength resolution with a Fourier prism-$35,000

Steven L. Castle, Department of Chemistry: A strategy for the synthesis of three contiguous quaternary centers: Application to the syntheses of acutumine and acutumidine-$35,000

Brown University
William C. Trenkle, Department of Chemistry: Catalytic stereoselective synthesis of chiral sp^3 carbon centers-$35,000

Case Western Reserve University
Jie Shan, Department of Physics: A novel approach towards high-resolution terahertz microscopy based on nonlinear optics-$35,000

Florida State University
Gregory B. Dudley, Department of Chemistry: Ring expansion strategies for preparing cyclophanes: Concise syntheses of roseophilin and floresolide A-$35,000

Georgia Institute of Technology
Alex M. Kuzmich, Department of Physics: Spin squeezing on the atomic clock transition-$35,000

Johns Hopkins University
Oleg Tchernyshyov, Department of Physics: Quantum spin liquid in frustrated magnets: A semiclassical route-$35,000

Louisiana State University
Luis Lehner, Department of Astronomy: Black string simulations: Towards understanding their final fate-$35,000

Loyola University of Chicago
Jan Florian, Department of Chemistry: Computer simulations and design of vanadium-based transition state analogs for phosphoryl transfer enzymes-$35,000

McMaster University
Paul W. Ayers, Department of Chemistry: Accurate determination of molecular electronic structure: Chasing the theoretical limit of computational efficiency-$35,000

Miami University
Hongcai Zhou, Department of Chemistry: Synthesis of novel hard-soft heterobimetallic paddlewheel complexes-$35,000

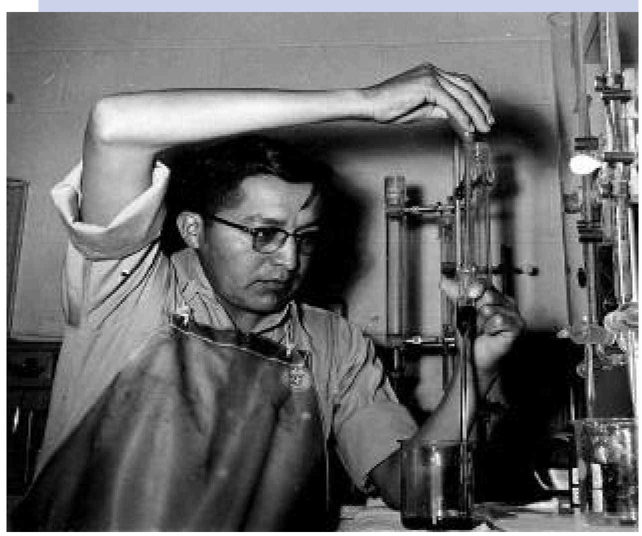
Shouzhong Zou, Department of Chemistry: Probing surface bonding, structure and reactivity on nanometer scale by tip-enhanced Raman spectroscopy-$35,000

Stanford University
David Goldhaber-Gordon, Department of Physics: Strongly-interacting electrons in a quantum point contact-$35,000

State University of New York at Albany
Igor K. Lednev, Department of Chemistry: Structural rearrangement of human S100A12 protein on metal ion binding: Real time kinetic studies-$35,000

Texas A&M University
Alexei V. Sokolov, Department of Physics: Precise control of electronic and nuclear motion by subcycle laser pulses synchronized with molecular oscillations-$35,000

Coran M.H. Watanabe, Department of Chemistry: Harnessing marine derived pharmaceuticals-$35,000



University of Arizona
Alex D. Cronin, Department of Physics: Atom wave phase shifts due to vacuum fluctuations near a surface-$35,000

University of British Columbia
Mona Berciu, Department of Physics: Spintronic nano-devices based on the giant Zeeman effect in diluted magnetic semiconductors-$35,000

University of California, Irvine
Alexander L. Chernyshev, Department of Physics: Correlated quantum phases in nanostructures-$35,000

Sergey Nizkorodov, Department of Chemistry: Development of a novel approach for studying the mechanism of ozonolysis of unsaturated fatty acids at gas-solid and gas-liquid interfaces-$35,000

University of California, Riverside
Roland Kawakami, Department of Physics: Investigating electron spin in carbon nanotubes by optical pumping techniques-$35,000

University of Chicago
Ilya A. Gruzberg, Department of Physics: Stochastic Loewner evolution, its extensions and applications-$35,000

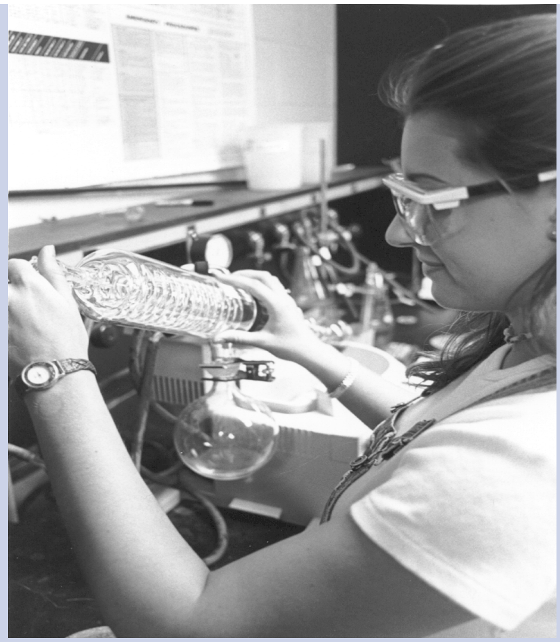
Chuan He, Department of Chemistry: Catalysis with high-valent silver species in solution-$35,000

University of Florida
Ronald K. Castellano, Department of Chemistry: Rationally designed protein polymers as biolubricants-$35,000

University of Guelph
Leonid S. Brown, Department of Physics: Investigating the light-sensitive element of a new photoreceptor in its native environment-$35,000

University of Illinois at Urbana-Champaign
Chad M. Rienstra, Department of Chemistry: Novel methods for detection of proton NMR signals in magnetically diluted solid proteins under fast magic-angle spinning-$35,000

University of Iowa
Ned Bowden, Department of Chemistry: The first controlled synthesis of hollow organic nanotubes for the templated growth of inorganic nanomaterials-$35,000



University of Minnesota, Twin Cities
Tony Gherghetta, Department of Physics: Supersymmetry and extra dimensions-$35,000

University of Ottawa
Natalie Goto, Department of Chemistry: Development of fluorinated solvents for the study of membrane protein structure by solution NMR-$35,000

University of Rochester
John C. Howell, Department of Physics: Unit quantum efficiency counting of entangled photons-$35,000

University of South Carolina-Columbia
John J. Lavigne, Department of Chemistry: Controlling molecular orientation: Directed self-assembly of functionalized oligomeric thiophenes using small molecules-$35,000

University of Toronto
Joseph H. Thywissen, Department of Physics: One-dimensional cold quantum gases-$35,000

University of Wisconsin, Madison
Gary Shiu, Department of Physics: Testing string theory from the sky: Cosmological probes of quantum gravity-$35,000

Independent Auditors' Report

Board of Directors
Research Corporation
Tucson, Arizona

We have audited the accompanying statements of financial position of Research Corporation (the "Foundation") as of December 31, 2003 and 2002, and the related statements of activity and changes in net assets and of cash flows for the years then ended. These financial statements are the responsibility of the Foundation's management. Our responsibility is to express an opinion on these financial statements based on our audits.

We conducted our audits in accordance with auditing standards generally accepted in the United States of America. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audits provide a reasonable basis for our opinion.

In our opinion, such financial statements present fairly, in all material respects, the financial position of the Foundation at December 31, 2003 and 2002, and the results of its operations and its cash flows for the years then ended in conformity with accounting principles generally accepted in the United States of America.

DELOITTE & TOUCHE LLP

APRIL 19, 2004
PHOENIX, ARIZONA

Statements of Financial Position

December 31, 2003 and 2002

Assets

	2003	2002
INVESTMENTS:		
Marketable securities—at market (Note 2)	$89,488,925	$67,654,478
Other investments (Note 3)	22,647,506	21,092,312
Program-related investment in Research Corporation Technologies, Inc. (Note 4)	25,000,000	25,000,000
Other program-related investments (Note 5)	4,318,580	4,430,000
Investment in joint venture (Note 6)	1,006,500	
Total investments	142,461,511	118,176,790
Cash and cash equivalents	3,513,753	753,229
Restricted cash (Note 5)	250,000	
Accrued dividends and interest receivable	257,461	122,000
Property and equipment—net (Note 7)	255,154	36,366
Notes receivable (Note 5)	6,043,404	7,581,928
Prepaid pension cost (Note 9)	1,295,000	5,258,433
Other assets	31,712	32,816
TOTAL	$154,107,995	$131,961,562

Liabilities and Net Assets

	2003	2002
LIABILITIES:		
Grants payable	$5,098,651	$4,346,924
Line of credit (Note 8)	9,000,000	11,000,000
Notes payable (Note 5)	1,982,459	2,788,914
Other (Notes 5, 9 and 11)	2,925,762	3,103,808
Total liabilities	19,006,872	21,239,646
COMMITMENTS AND CONTINGENCIES (Notes 3, 5, 6 and 10)		
NET ASSETS:		
Unrestricted	134,851,123	110,721,916
Temporarily restricted (Note 5)	250,000	
Total net assets	135,101,123	110,721,916
TOTAL	$154,107,995	$131,961,562

See notes to financial statements.

Statements of Activity and Changes in Net Assets

Years ended December 31, 2003 and 2002

	2003	2002
REVENUE:		
Unrestricted revenues and gains:		
Interest and dividends from marketable securities	$1,799,138	$1,339,283
Interest income from program-related investment (Note 4)	1,750,000	1,750,000
Other interest income	154,567	180,747
Pension and other income (Note 9)	785,785	488,676
Total unrestricted revenues and gains	4,489,490	3,758,706
Contributions released from restrictions		26,282
Total revenue	4,489,490	3,784,988
EXPENSES:		
Grants approved (Note 5)	6,305,473	5,536,239
Science advancement	1,072,600	1,404,493
Program-related (Note 5)	1,561,330	2,874,855
Information and communications	90,619	95,930
General and administrative (Notes 9, 10 and 11)	1,355,152	3,700,105
Interest and other expense (Notes 8 and 9)	547,958	326,374
Total expenses	10,933,132	13,937,996
DECREASE IN NET ASSETS BEFORE NET LOSS ON INVESTMENTS	(6,443,642)	(10,153,008)
NET GAIN (LOSS) ON INVESTMENTS (Notes 2, 3 and 5)	30,572,849	(16,808,508)
INCREASE (DECREASE) IN UNRESTRICTED NET ASSETS	24,129,207	(26,961,516)
INCREASE IN TEMPORARILY RESTRICTED ASSETS — Contributions received for restricted purpose (Note 5)	250,000	
INCREASE (DECREASE) IN NET ASSETS	24,379,207	(26,961,516)
NET ASSETS—Beginning of year	110,721,916	137,683,432
NET ASSETS—End of year	$135,101,123	$110,721,916

See notes to financial statements.

Statements of Cash Flows

Years ended December 31, 2003 and 2002	2003	2002
CASH FLOWS FROM OPERATING ACTIVITIES:		
Increase (decrease) in net assets	24,379,207	(26,961,516)
Adjustments to reconcile increase (decrease) in net assets to net cash used in operating activities:		
Net realized losses on sales of marketable securities	415,255	5,397,648
Unrealized net (appreciation) depreciation of marketable securities	(24,249,702)	11,482,181
Noncash grants of technology investments		2,674,000
Unrealized appreciation of other investments	(6,739,000)	(72,316)
Depreciation and amortization	20,922	22,917
(Increase) decrease in accrued dividends and interest receivable	(135,461)	269,049
Increase (decrease) in prepaid pension cost	372,598	(488,676)
Decrease in other assets	1,104	10,597
Increase in grants payable	751,727	191,132
(Decrease) increase in other liabilities	(178,046)	617,021
Other	(201,264)	(225,153)
Net cash used in operating activities	(5,562,660)	(7,083,116)
CASH FLOWS FROM INVESTING ACTIVITIES:		
Purchases of marketable securities	(13,800,000)	
Proceeds from sale of marketable securities	15,800,000	2,064,401
Purchase of other investments	(350,000)	(4,500,000)
Proceeds from distribution of other investments	5,533,806	3,352,382
Investment in other program related investments	(388,580)	(1,353,500)
Proceeds from distribution of other program investments	500,000	
Contributions to joint venture	(2,006,500)	
Distributions from joint venture	1,000,000	
Proceeds received for repayments on notes receivable	1,800,000	1,300,000
Purchases of property and equipment	(239,710)	(528)
Proceeds from termination of pension plan	5,061,653	
Contribution to replacement pension plan	(1,470,818)	
Cash received for restricted purpose	(250,000)	
Net cash provided by investing activities	11,189,851	862,755
CASH FLOWS FROM FINANCING ACTIVITIES:		
Borrowings on line of credit	6,425,773	14,406,522
Repayments on line of credit	(8,425,773)	(7,551,973)
Repayments on notes payable	(866,667)	
Net cash (used in) provided by financing activities	(2,866,667)	6,854,549
NET INCREASE IN CASH AND CASH EQUIVALENTS	2,760,524	634,188
CASH AND CASH EQUIVALENTS—Beginning of year	753,229	119,041
CASH AND CASH EQUIVALENTS—End of year	$3,513,753	$753,229
SUPPLEMENTAL DISCLOSURES OF NONCASH TRANSACTIONS:		
Receipt of notes receivable in exchange for viewing rights	$	$8,281,929
Issuance of note payable in exchange for viewing rights	$	$2,789,544

See notes to financial statements.

Notes to Financial Statements

Years ended December 31, 2003 and 2002

1. SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

Research Corporation (the "Foundation") prepares its financial statements in accordance with accounting principles generally accepted in the United States of America. The following are the significant accounting policies followed by the Foundation:

a. Nature of Business-The Foundation is a New York not-for-profit corporation dedicated to the advancement of science.

b. Basis of Accounting-The financial statements are prepared on the accrual basis of accounting and are prepared in accordance with standards set forth in the Statement of Financial Accounting Standards ("SFAS") No. 117, Financial Statements of Not-for-Profit Organizations, and the American Institute of Certified Public Accountants' Audit and Accounting Guide for Audits of Not-for-Profit Organizations.

c. Securities Valuation-The Foundation carries its investments in marketable securities at fair market value (see Note 2). Realized gains and losses are computed based on the difference between the net proceeds received and cost at time of acquisition using the average cost method. Unrealized net appreciation or depreciation of investments in marketable securities represents the change in the difference between acquisition cost and current market value at the beginning of the year versus the end of the year.

d. Other investments consisting of unconsolidated limited partnership interests are recorded at estimated fair value in accordance with SFAS No. 124, Accounting for Certain Investments Held by Not-for-Profit Organizations. Investments in limited partnerships are valued at the quoted market price for securities for which market quotations are readily available or an estimate of value (fair value) as determined in good faith by the general partner. Investments without a readily determinable fair value are recorded at cost. The cost of investments sold is determined using the specific identification method. Other than temporary impairments are recognized in the period in which they occur and are included in net loss on investments.

e. Revenue and Expenses-Interest income is recorded as earned; dividends are accrued as of the ex-dividend date. Grant expense is recorded at the time the awards are approved by the board of directors.

f. Contributions-Restrictions on contributions received are generally satisfied in the year the contributions are received. The Foundation reports contributions as restricted support if they are received with donor stipulations that restrict the use of donated assets. When a donor purpose restriction is accomplished, temporarily restricted net assets are recognized as unrestricted net assets and reported as contributions released from restrictions in the statements of activity and changes in net assets.

g. Property and equipment are stated at cost. Depreciation is calculated using the straight-line method over estimated useful lives as follows:

Tenant improvements	5 years
Furniture, fixtures and equipment	5-10 years

Maintenance and repairs are charged to operations as incurred. Major renewals and betterments are capitalized.

h. Income Taxes-The Foundation qualifies as a tax-exempt private operating foundation under Internal Revenue Code Section 4940(d).

i. Statements of Cash Flows-For purposes of reporting cash flows, cash and cash equivalents include cash on hand, demand deposits, savings accounts and highly liquid debt instruments purchased with an original maturity of three months or less which are not carried in the Foundation's portfolio of marketable securities.

j. New Accounting Pronouncements-In November 2002, the Financial Accounting Standards Board ("FASB") issued Interpretation No. 45 ("FIN 45"), *Guarantor's Accounting and Disclosure Requirements for Guarantees, Including Indirect Guarantees of Indebtedness of Others*. FIN 45 addresses the disclosure requirements of a guarantor about its obligations under certain guarantees that it has issued. FIN 45 also requires a guarantor to recognize, at the inception of a guarantee, a liability for the fair value of the obligation undertaken in issuing the guarantee. The disclosure requirements of FIN 45 are effective for the Foundation for 2002. The liability recognition requirements are applicable to all guarantees issued or modified after December 31, 2002. The Foundation had no guarantees requiring recognition or disclosure at December 31, 2003, except as disclosed in Note 5.

In January 2003, the FASB issued Interpretation No. 46 ("FIN 46"), Consolidation of Variable Interest Entities, which will be effective for the Foundation as of January 1, 2005. Under FIN 46, companies are required to consolidate variable interest entities for which they are deemed to be the primary beneficiary, and disclose information about those in which they have a significant variable interest. The Foundation has no variable interest entities.

In December 2003, the FASB issued SFAS No. 132, (Revised 2003), Employers' Disclosures about Pensions and Other Postretirement Benefits, which is effective for the Foundation for the year ending December 31, 2004. SFAS No. 132 revises employers' disclosures about pension plans and other postretirement benefit plans but does not change the measurement or recognition of those plans required by FASB Statements No. 87, Employers' Accounting for Pensions, No. 88, Employers' Accounting for Settlements and Curtailments of Defined Benefit Pension Plans and for Termination Benefits, and No. 106, Employers' Accounting for Postretirement Benefits Other Than Pensions. SFAS No. 132 will result in revised disclosures for the Foundation's pension and postretirement plans in the year ending December 31, 2004. Certain provisions of the revised disclosures were implemented in the current year, as set forth in Note 9.

k. Use of Estimates-The preparation of financial statements in conformity with accounting principles generally accepted in the United States of America requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities and disclosure of contingent assets and liabilities at the date of the financial statements and the reported amounts of revenues and expenses during the reporting periods. Actual results could differ from those estimates. The Foundation utilizes various investment instruments. Investment securities, in general, are exposed to various risks, such as interest rate, credit and overall market volatility. Due to the level of risk associated with certain investment securities, it is reasonably possible that changes in the values of investment securities will occur in the near term and that such changes could materially affect the amounts reported in the statements of financial position.

2. MARKETABLE SECURITIES

Marketable securities consist of the following at December 31:

	2003		2002	
	Market Value	Cost	Market Value	Cost
Capital Guardian Trust Funds:				
Emerging Markets Growth Fund	$5,418,980	$5,557,494	$3,653,753	$5,557,494
U.S. Value Equity Fund			11,924,603	13,523,439
Washington Mutual Investors Fund	15,766,754	13,821,932		
Global Equity Fund	64,263,874	45,953,117	48,692,007	8,666,865
American High Income Fund	4,039,317	4,708,058	3,384,115	4,708,058
Total	$89,488,925	$70,040,601	$67,654,478	$72,455,856

Notes to Financial Statements

The objectives of the funds, according to each fund's prospectus, are as follows:

a. Emerging Markets Growth Fund seeks to obtain long-term growth of capital through investment in equity securities of businesses located in developing countries.

b. U.S. Value Equity Fund seeks to outperform the Russell 1000 Value Index over a full market cycle, with a similar level of risk, by investing primarily in U.S. large CAP stocks with value characteristics.

c. Washington Mutual Investors Fund seeks to provide current income and the opportunity for growth of principal consistent with sound common-stock investing.

d. Global Equity Fund seeks to achieve capital growth and future income through investments in a portfolio of securities of U.S. issuers, American depository receipts for securities of foreign issuers and securities whose principal markets are outside of the United States.

e. American High Income Fund seeks to achieve monthly income through investments primarily in bonds and also U.S. and foreign securities.

Annual activity for marketable securities consists of the following at market value for the years ended December 31:

	2003	2002
Opening Balance	$67,654,478	$86,598,708
Purchases	13,800,000	
Sales	(15,800,000)	(2,064,401)
Net appreciation (depreciation)	23,834,447	(16,879,829)
Ending balance	$89,488,925	$67,654,478

Proceeds from sale of marketable securities in 2003 and 2002 were either reinvested in other marketable securities or used to fund purchases of other investments.

Net gain (loss) on investments in marketable securities consists of the following for the years ended December 31:

	2003	2002
Net realized loss on sales of marketable securities	$ (415,255)	$ (5,397,648)
Unrealized net appreciation (depreciation) of marketable securities	24,249,702	(11,482,181)
Net gain (loss) on marketable securities	$ 23,834,447	$ (16,879,829)

3. OTHER INVESTMENTS

Other investments consist of the following at estimated fair value at December 31:

	2003	2002
Limited partnership interest (AG Super Fund L.P.)	$ 9,933,252	$ 7,111,592
Limited partnership interest (AG Realty Fund IV L.P.)	4,676,784	4,609,480
Limited partnership interest (AG Realty Fund V L.P.)	1,956,630	1,682,834
Limited partnership interest (AG Capital Recovery Fund)	2,173,607	3,998,674
Limited partnership interest (AG Capital Recovery Fund III)	3,907,233	3,689,732
Total other investments	$ 22,647,506	$21,092,312

Increase in other investments in 2003 relates to additional investment in AG Realty Fund V L.P. of $350,000. This increase was offset by distributions received from AG Capital Recovery Fund in the amount of $2,408,788, from AG Capital Recovery Fund III of $1,884,701, from AG Realty Fund IV L.P. of $400,000, and from AG Realty Fund V L.P. of $250,000. In addition, unrealized appreciation of $2,821,660, $467,306, $173,800, $583,723 and $2,102,200 was recorded in AG Super Fund L.P., AG Realty Fund IV L.P., AG Realty Fund V L.P., AG Capital Recovery Fund and AG Capital Recovery Fund III, respectively, as included in net gain (loss) on investments.

At December 31, 2003, the Foundation was committed to additional funding of $3,400,000 in the above investments and $5,000,000 in a new real estate fund, AG Core Plus.

The objective of AG Super Fund L.P. is to achieve capital appreciation through specialized investment strategies, including investing in merger arbitrage, distressed debt, special situations and convertible hedging.

The objective of the AG Realty Funds IV and V L.P. is to invest in opportunistic real estate assets, including options and mortgage loans.

The objective of the AG Capital Recovery Fund and AG Capital Recovery Fund III is to invest in the distressed credit sector of the fixed income market. Investment in these companies consists largely of commercial bank loans and publicly traded debt securities.

4. PROGRAM-RELATED INVESTMENT IN RESEARCH CORPORATION TECHNOLOGIES, INC.

On March 2, 1987, as amended on March 25, 1994, in accordance with Section 1605(c) of the Tax Reform Act of 1986, the Foundation and Research Corporation Technologies, Inc. ("RCT"), a nonprofit corporation subject to regular corporate income tax laws, entered into agreements through which RCT assumed responsibility for the Technology Transfer Program (the "Program"), which the Foundation had operated for many years. In addition to the transfer of the Program, the Foundation transferred $35,000,000 in cash and securities in exchange for a $35,000,000 fully subordinated unsecured note from RCT (the "Note") due February 28, 2017.

RCT has prepaid $10,000,000 of the Note, and the remaining $25,000,000 principal amount of the amended Note is due on February 28, 2017, subject to acceleration at the option of the Foundation after December 31, 2012, provided RCT's retained earnings exceed $100,000,000. Basic interest at the rate of 7% per annum on the outstanding principal amount is due semiannually.

To qualify as a program-related investment under Section 4944(c) of the Tax Reform Act of 1986, the terms of the loan were required to be less than prevailing terms. In addition, this investment is a vehicle for the Foundation to continue one of its charter purposes, the furthering of technology. As there are no comparable alternative program-related investments available to the Foundation, the Foundation believes it is not practicable to estimate the fair value of this investment.

Interest income on the Note for each of the years ended December 31, 2003 and 2002 was $1,750,000.

5. OTHER PROGRAM-RELATED INVESTMENTS

The Foundation has invested in and made advances to various entities that engage in the advancement of science and technology. Such investments are not readily marketable and are carried at cost.

Seaphire International, Inc.-At December 31, 2003 and 2002, the Foundation had investments in Seaphire International, Inc. ("Seaphire") totaling $4,318,580 and $4,430,000, respectively.

The largest portion of the investment in Seaphire consists of a note receivable in the amount of $3,750,000 and $4,250,000 at December 31, 2003 and 2002, respectively, bearing interest at the London Interbank Offered Rate ("LIBOR") plus 2% (3.25% at December 31, 2003). The note is payable as follows: $750,000 (2004), $750,000 (2005), $1,000,000 (2006) and $1,250,000 (2007). The Foundation received payment on notes receivable in the amount of $500,000 and $600,000 from Seaphire in 2003 and 2002, respectively, which reduced the investment balance. The remaining amounts represent advances, which are collateralized by real estate and personal guarantees.

Large Binocular Telescope Project-The Foundation is a partner with a 12.5% interest in the Large Binocular Telescope Project (the "Project"), which is building and will manage an astronomical observatory. The Foundation has sold or granted to other astronomy research institutions (the "Institutions") all of its viewing rights in the observatory along with the obligation to pay related operating costs. The Foundation remains liable for its proportionate share of observatory construction costs and at December 31, 2003, has accrued an estimate of $1,482,000 for these costs. The Foundation remains contingently liable for its proportionate share of future operating costs, to the extent the Institutions become unable to pay and forfeit their viewing rights. At December 31, 2003, the Foundation is unable to estimate what its maximum potential amount of future payments would be in the event the Institutions are unable to pay their share of the operating costs, and is also unable to estimate the amounts recoverable from any forfeited viewing rights due to the unique nature of the Project.

In 2002, the Foundation sold or granted all remaining viewing rights available under the Project to research institutions in exchange for notes receivable with original balances totaling $8,281,928 (net of original unamortized discounts of $718,072 based on an imputed interest rate of 3.375%). Remaining principal and interest amounts to be received on the notes receivable are as follows: $1,800,000 (2004), $1,800,000 (2005), $1,800,000 (2006) and $1,000,000 (2007). Included in the sales prices to these institutions was compensation for viewing rights on other University of Arizona telescopes that the Foundation purchased from the University of Arizona. These rights were purchased in exchange for a note payable with an original balance of $2,788,914 (net of original unamortized discount of $211,086 based on an imputed interest rate of 3.375%). Remaining repayments of principal and interest on the note payable are as follows: $600,000 (2004), $600,000 (2005), $600,000 (2006) and $333,333 (2007). In connection with these transactions, in 2002 the Foundation recognized a liability for future amounts payable to the Project of approximately $1,421,000, which is included in other liabilities, and recognized grants expense of approximately $2,874,000 representing a new grant of viewing rights valued at $1,750,000 on the Project, and recognized an additional grant expense of approximately $1,124,000, representing a final adjustment on viewing rights granted in prior years.

LSST Project-During 2003, the Foundation's Board of Directors approved investment of up to $10,000,000 to the LSST Corporation. At December 31, 2003, a third party had contributed $250,000 cash to the Foundation to be used for the LSST project, and the Foundation has accrued an additional $250,000 for contribution in 2004, which is included in other liabilities.

LSST Corporation was formed to build a large-aperture synoptic survey telescope. The LSST Corporation is a 501(c)(3) organization made up of universities and other not-for-profits focused on astronomy, of which the Foundation is a member.

6. INVESTMENT IN JOINT VENTURE

During 2003, the Foundation entered into a joint venture to acquire an office building (the "Venture"). Both venturers contribute equally and receive equal allocations of income and expense. A management agreement is in place with the other venturer to manage the property. During 2003, the Foundation contributed cash of $2,006,000 to the Venture, and received $1,000,000 in distributions from the Venture. The Foundation is committed to contribute to the Venture, proportionate to its share, as required, in future years.

At December 31, 2003, the Foundation occupied approximately 33% of the building under a 10-year noncancelable operating lease. The Foundation believes rent under the operating lease is at fair value and is comparable to what could be obtained with a third party. Future minimum rental payments under the lease at December 31, 2003 are as follows:

2004	$ 209,610
2005	209,610
2006	209,610
2007	209,610
2008	209,610
Thereafter	1,048,050
Total	$ 2,096,100

In March 2004, the Foundation entered into an arrangement to occupy an additional 17% of the building. It is anticipated that rent payments will commence in September 2004, and that most of the additional space will be sublet by the LSST Corporation (see Note 5).

7. PROPERTY AND EQUIPMENT

Property and equipment consist of the following at December 31:

	2003	2002
Tenant improvements	$ 145,204	$ 358,289
Furniture, fixtures and equipment	410,963	316,314
Total property and equipment	556,167	674,603
Less accumulated depreciation	301,013	638,237
Property and equipment--net	$ 255,154	$ 36,366

8. LINE OF CREDIT

The Foundation has a $20,000,000 revolving line of credit that expires April 30, 2004 and bears interest at the prime rate (4.0% at December 31, 2003) or LIBOR plus 1.25% as determined at the date of borrowing (2.50% at December 31, 2003), at the Foundation's option. Borrowings are collateralized by certain of the Foundation's investments in marketable securities. At December 31, 2003 and 2002, borrowings of $9,000,000 and $11,000,000, respectively, were outstanding under the line of credit. The Foundation recognized interest expense of $315,606 and $308,746 for the years ended December 31, 2003 and 2002, respectively, which is included in interest and other expense.

9. PENSION PLAN AND POSTRETIREMENT BENEFITS

Pension Plan-The Foundation had a noncontributory defined benefit pension plan (the "Plan") covering substantially all of its employees. The benefits provided by the Plan are generally based on years of service and employees' salary history. It is the Foundation's policy to fund pension cost accrued; however, at December 31, 2002, the Plan was in an overfunded status and no contributions were required. The measurement date for the Plan was December 31.

During 2003, the Foundation terminated the Plan, and replaced the Plan with the Research Corporation Employee's Replacement Plan (the "Replacement Plan"). Accumulated benefits totaling approximately $3,600,000 under the Plan were paid out to participants. The remaining prepaid pension cost of $5,061,653 reverted to the Foundation, of which $1,470,818 was contributed to establish the Replacement Plan. The Replacement Plan benefits are substantially the same as the benefits under the Plan. Following the initial funding, the Replacement Plan was in an overfunded status and no additional contributions were required at December 31, 2003.

The measurement date for the Replacement Plan is September 30.

A reconciliation of the funded status of the Replacement Plan (2003) and the Plan (2002) at December 31 is as follows:

	2003	2002
Projected benefit obligation	$(704,152)	$(2,987,938)
Plan assets at fair value, primarily invested in stocks and bonds	1,534,646	8,022,314
Funded status	830,494	5,034,376
Unrecognized transition net asset		(227,179)
Unrecognized net gain	(5,553)	312,418
Unrecognized prior service cost	514,013	138,818
Adjustment for net pension cost September 30-December 31	(43,954)	
Prepaid pension cost	$1,295,000	$ 5,258,433

The change in the prepaid pension cost and Plan assets for the years ended December 31, 2003 and 2002, including the effects of the curtailment and settlement due to the termination of the Plan in 2003, are as follows:

	2003	2002
Prepaid pension cost--beginning of the year	$5,258,433	$4,769,757
Curtailment gain	183,913	
Settlement loss	(380,693)	
Reversion of assets upon termination of the Plan	(5,061,653)	
Net periodic pension (cost) income	(175,818)	488,676
Employer contributions	1,470,818	
Prepaid pension cost--end of the year	$1,295,000	$5,258,433

The accumulated benefit obligation for the Replacement Plan and the Plan at December 31, 2003 and 2002 was $360,439 and $2,579,968, respectively.

The components of new periodic pension (cost) income are as follows for the years ended December 31:

	2003	2002
Service cost--benefits earned during the period	$(153,448)	$(191,380)
Interest cost on projected benefit obligations	(36,316)	(202,916)
Expected return on plan assets	45,952	727,771
Net amortization and deferral	(32,006)	155,201
Total pension (expense) income	$(175,818)	$488,676

Pension expense in 2003 is included in other expense and pension income in 2002 is included in other income.

Weighted average assumptions used to determine benefit obligations are as follows at December 31:

	2003	2002
Discount rate	6.25%	6.75%
Rate of increase in compensation levels	4.25%	4.75%
Expected long-term rate of return on assets	7.50%	7.50%

The Replacement Plan's assets at December 31, 2003 were fully invested in a balanced mutual fund. The Plan's assets at December 31, 2002 were invested in a similar investment.

During 2002, total benefits paid were $422,719. There were no benefit payments in 2003 due to the termination of the Plan. There were no other participant or employer contributions in 2003 or 2002.

Postretirement Plan-In addition to providing pension benefits, the Foundation provides certain health care benefits to retired employees and their spouses. Substantially all of the Foundation's employees may become eligible for these benefits if they reach normal retirement age while working for the Foundation.

The components of net periodic postretirement benefit cost are as follows for the years ended December 31:

	2003	2002
Service cost–benefits earned during the period	$40,299	$39,633
Interest cost on accumulated postretirement benefit obligation	77,075	76,551
Net amortization and other	55,017	44,739
Net periodic postretirement benefit cost	$172,391	$160,923

During 2003 and 2002, benefits paid were $143,508 and $81,454, respectively.

A reconciliation of the accumulated postretirement benefit obligation to the liability recognized in the statements of financial position in other liabilities is as follows at January 1:

	2003	2002
Accumulated benefit obligation	$1,336,568	$1,284,802
Unrecognized net gain subsequent to transition	363,717	462,412
Unrecognized transition obligation	(909,745)	(985,557)
Accrued postretirement benefit liability	$790,540	$761,657

The actuarial calculation assumes a health care inflation assumption of 10% in 2003, decreasing uniformly to 4.25% by 2011 and remaining level thereafter. The assumed discount rate is 6.0% and 7.25% in 2003 and 2002, respectively.

The Foundation's postretirement medical plans are not funded.

10. LITIGATION

The Foundation is subject to claims arising out of the conduct of its business. Management believes these matters are without merit and intends to contest them vigorously. These claims, when finally concluded, in the opinion of management based on information it presently possesses, will not have a material adverse effect on the Foundation's financial position, results of operations or cash flows.

During 2003 and 2002, the Foundation incurred legal fees to defend itself against certain litigation relating to the Program transferred to RCT in 1987. These costs totaled approximately $225,767 and $2,007,000 for the years ended December 31, 2003 and 2002, respectively, and are included in general and administrative costs.

The Foundation believes it may be entitled to recovery of certain legal fees paid, in whole or in part, under certain insurance and indemnity agreements. No amounts have been recognized for any possible recoveries.

11. RELATED PARTY TRANSACTIONS

The Foundation and RCT have certain agreements under which:

a. The Foundation has an office facilities lease agreement with RCT that expired July 31, 2003. Lease expense paid to RCT under this agreement for the years ended December 31, 2003 and 2002 was approximately $210,000 and $248,000, respectively.

b. At December 31, 2002, the Foundation had amounts payable to RCT of approximately $480,000 relating to expenses paid by RCT on behalf of the Foundation, included in other liabilities.

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