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Environmental Workforce and Innovation

Supporting Education, Research and Economic Growth
Project 1.63 Synthesis Report

EPA Report Number
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Disclaimer

Foreword

Science is the foundation of the U.S. Environmental Protection Agency's (EPA) work. Charged by Congress with protecting the Nation's land, air and water resources, and under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life.

The National Center for Environmental Research (NCER) within EPA's Office of Research and Development (ORD) provides funding for high-quality research by the Nation's leading scientists and engineers in an effort to improve the scientific basis for decisions on national environmental issues. NCER supports innovative extramural research in exposure, effects, risk assessment and risk management through a suite of competitive-based research grants, fellowships, and contracts. These include EPA's Science to Achieve Results (STAR) research grants; Greater Research Opportunities (GRO) Fellowships, and the People, Prosperity and the Planet (P3), and Small Business Innovative Research (SBIR) programs.

At a time when society is experiencing an ever accelerating pace in innovation and regular explosions in new technologies reaching the marketplace, NCER programs are not only designed to support such promise, but also focus on increasing incentives for research and development that will align the protection of our environment and human health with economic opportunity and prosperity. By connecting EPA's own research program with the leading academic and private sectors, the Agency serves as a catalyst for workforce development, innovative research, and sustainable technologies. These programs are part of an overall effort to address existing environmental problems and, more importantly, to empower communities to apply more sustainable ideas, designs, and ways of living.

Name, Director

L/C/O

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Introduction

Meeting today's needs without compromising the environmental and health protection of future generations – the general concept of *sustainability* – is a critical consideration when taking action to protect our shared environment. EPA's Sustainable and Healthy Communities (SHC) research program is working to provide the knowledge, data, and tools needed to address this balance. SHC is focused on providing information and tools to EPA program and regional offices and U.S. communities to inform decisions that produce more sustainable outcomes for the environment, society, and economy.

The SHC program is organized around four research topics: (1) Decision Support and Innovation; (2) Community Well-being: Public Health and Ecosystem Goods and Services; (3) Sustainable Approaches for Contaminated Sites and Materials Management; and (4) Integrated Solutions for Sustainable Communities. Each of these topic areas include projects that are designed to effectively correspond with the objectives of the program highlighted in this report: *Supporting Education, Research and Economic Growth (SHC Project 1.63)*.

Environmental Workforce and Innovation (SHC Project 1.63)

Project 1.63 – also known as the Environmental Workforce and Innovation Project – supports environmental innovation, education, and entrepreneurship through a combination of Agency programs (People, Prosperity, and the Planet, or P3; and Small Business Innovation Research, or SBIR) and Fellowships.

Student-oriented competitions – such as the Science to Achieve Results (STAR) and Greater Research Opportunities (GRO) Fellowships and the P3 program – provide research funding to individuals and teams of students, respectively. Encouraging students to pursue an education in science, technology, engineering and mathematics (STEM) fields is vital for ensuring a future with environmental leaders who are able to implement creative ideas to protect human health and the environment. The SBIR program provides funding to small businesses developing and marketing innovative technologies aimed at solving environmental issues. In some cases, research funded through the P3 program leads an investigator to start a small business, which can be eligible for the SBIR program. The companies Lucid Design Group, Environmental Fuel Research and SimpleWater are examples of this transition from P3 student team to SBIR-contracted entrepreneur. Overall, these programs work together to foster ingenuity and collaboration among students, researchers, communities and small businesses and produce solutions to today's environmental problems.

These distinct and yet intertwined programs are part of EPA's Innovation Ecosystem – a number of independent EPA programs that are all interconnected to empower much more significant and lasting change.

Fellowships

Background

EPA recognizes that science, technology, engineering and mathematics (STEM) competence is essential to the Nation's future well-being in terms of national security and competitive economic advantage. Community health and vitality is predicated, in part, on the availability of an adequate supply of scientists, technicians, engineers and mathematicians to develop innovative technologies and solutions for community application. EPA's National Center for Environmental Research (NCER) manages the programs listed below, which are part of the national effort to help ensure that the United States meets its current and projected workforce needs in the environmental science, engineering and policy fields.

- EPA Marshall Scholarship Program, jointly funded with the Marshall Aid Commemoration Commission (MACC)
- American Association for the Advancement of Science (AAAS) Science and Technology Policy Fellowship Program
- Association of Schools and Programs of Public Health (ASPPH) Environmental Public Health Fellowship Program
- EPA Greater Research Opportunities (GRO) Undergraduate Fellowship Program
- Science to Achieve Results (STAR) Graduate Fellowship Program

These programs represent EPA's long-term investment aimed at increasing the Nation's environmental workforce, postsecondary educational opportunities, and environmental literacy. Each program is aligned with EPA's mission and statutory authorities and provides the research and training opportunities that help foster the next generation of scientific and environmental leaders. The programs are described in more detail in subsequent sections of this report, and more information is available at www.epa.gov/careers/fellowships-scholarships-and-post-doctoral-opportunities.

The GRO Undergraduate and STAR Graduate programs, initiated in 1982 and 1995 respectively, have been a cornerstone of EPA's efforts to bolster future generations of environmental professionals. These programs directly support the education and growth of STEM students as they pursue environmental and public health careers through undergraduate, graduate and advanced education programs. The GRO and STAR programs focus their efforts on building capacity at institutions of higher education that receive limited federal funding, particularly institutions with substantial minority enrollment. Since 1997, the GRO Fellowship has invested more than $14.7 million to fund 399 undergraduate fellows. The STAR Fellowship has given approximately $74 million to 1,838 graduate fellows—260 master's students and 1,578 doctoral candidates—since 1995.

EPA also supports the next generation of environmental professionals through other college and fellowship programs in partnership with the ASPPH, AAAS and the Marshall Scholarship program, such as the People, Prosperity, and the Planet (P3) Program, and small-business funding, such as the Small Business Innovation Research (SBIR) program, both of which are described in this report.

Impacts

Marshall Scholarship Program

In 2005, after recognizing the global nature of environmental challenges and the need to pool the resources of many nations to solve them, EPA established a scholarship program with the United Kingdom's Marshall Aid Commemoration Commission (MACC). The MACC has been awarding the esteemed Marshall Scholarship since 1953, and the EPA Marshall Scholarship now allows up to three college graduates with solid foundations in the environmental sciences to be selected each year to receive up to 5 years of graduate education assistance, depending on the availability of funds. The first 2 years are supported by the United Kingdom's MACC, and the scholarship recipient receives a Marshall Scholarship to a university in Great Britain. Successful candidates may be granted up to 3 additional years of support toward a doctoral degree, in either the United Kingdom or the United States.

The EPA Marshall Scholarship Program aims to raise a new generation of highly trained environmental professionals who have a global view of environmental problem solving and an improved understanding of the different cultural contexts in which environmental decisions must be made. To be eligible for the EPA Marshall Scholarship, applicants must be selected as Marshall Scholars and must be pursuing a graduate degree in one of the following areas:

- Physical, life, or systematic sciences
- Engineering and technology
- Economics
- Social and behavioral sciences
- Urban and regional planning
- Communication science

Furthermore, the proposed program of study must be demonstrably relevant to environmental protection, restoration or stewardship; environmental public health; or ecosystem health. First consideration is given to applicants working in areas that emphasize the study of global environmental problems, international collaborative approaches to environmental problem solving, technology exchange programs, or research to improve international dialog regarding the environment. Since its inception, six EPA Marshall Scholars have completed their doctoral programs, five are pursuing their doctoral programs, and two began their U.K. studies in 2014. Learn more about the traditional Marshall Scholarship or the EPA Marshall Scholarship.

American Association for the Advancement of Science (AAAS) Science and Technology Policy Fellowship Program

Since 1981, AAAS has collaborated with EPA's NCER to manage the AAAS Science and Engineering Fellowship Program. This program is designed to provide an opportunity for scientists, mathematicians and engineers with doctoral level degrees (Ph.D., Sc.D., M.D., D.V.M., etc.) to work in the fields of environmental management and administration; environmental science; and public relations and communications. The aim is to provide a firsthand opportunity to learn how scientific and technological information is used in environmental policy-making; provide a unique public policy learning experience; demonstrate the value of science, technology and economics in addressing societal problems; and make practical contributions to the more effective use of scientific and technical knowledge in the U.S. government.

Interested candidates apply to the AAAS Fellowships Energy, Environment and Agriculture Program, and accepted fellows conduct their own projects in offices throughout EPA on projects of mutual interest to both the fellows and the hosting offices. In the past 10 years, EPA has hosted about 160 participants through AAAS. For more information, go to the AAAS fellowship site: Science and Technology Policy Fellowships.

Association of Schools and Programs of Public Health (ASPPH) Environmental Public Health Fellowship Program

ASPPH is the successor to the organization formerly known as the Association of Schools of Public Health (ASPH). Through a cooperative agreement with EPA, ASPPH offers a professional development program to provide training and on-the-job experience for public health professionals who are early in their careers by enabling them to work in EPA on current and emerging environmental public health needs. The program is open to professionals who have graduated within the past 5 years from a U.S. school of public health that is an ASPPH member. The 1-year placements, which may be followed by a 1-year extension, allow the ASPPH fellows to work closely with nationally recognized experts in a number of environmental fields.

The Environmental Health Fellowship capitalizes on the important relationship between the academic public health community and EPA. Over the past 10 years, EPA has hosted about 100 ASPPH fellows. For additional information, please visit ASPPH Fellowships.

Greater Research Opportunities (GRO) Undergraduate Fellowship Program

The GRO Undergraduate Fellowship program is part of the national effort to ensure that the United States meets its current and projected workforce needs in the fields of environmental science, engineering, mathematics and technology. The GRO Fellowship program assists universities with limited funding for research by awarding fellowships to students in environmental fields entering their final 2 years of full-time study before obtaining their first bachelor's degree.

By enhancing and supporting quality environmental education for undergraduate students, the GRO Fellowship encourages promising students to pursue careers in environmental fields and to continue their education beyond the baccalaureate level. The award provides up to $50,000 in total financial support for the final 2 years of study and includes an internship at an EPA facility during the summer between their junior and senior years. The 3-month summer internship takes place at one of EPA's laboratories, regional offices or headquarters. There, the fellows work alongside agency scientists and engineers, affording them an opportunity to learn about EPA's scientific work while gaining hands-on experience. GRO Fellows reap a wide range of benefits, even beyond the monetary assistance and real-world experience. Their internships present the opportunity for travel and new experiences, program participants can make connections and network for future opportunities, and many GRO Fellows go on to win EPA STAR Fellowships as master's or doctoral students. Learn more about the GRO Fellowship Program.

The following pages showcase how the GRO Fellowship has helped young scientists guide their studies and shape their future careers.

Fellowships Success Stories Table

Fellow	Fellowship Received	Degree Program	Institution	Years Awarded	Page
Cynthia Williams	GRO	Environmental Science	Alabama A&M University	2001 – 2003	6
Aiden Irish	GRO	Political Science and Environmental Ethics and Policy	University of Portland	2011 – 2013	6
Mary Beliveau	GRO	International Relations	Seton Hall University	2012 – 2014	7
Andrew Reighart	GRO	International Public Policy Studies and Political Science	St. Mary's College of Maryland	2011 – 2013	7
Annie Putman	GRO	Environmental Chemistry	Michigan Technological University	2008 – 2010	8
Ashanti Johnson	STAR	Oceanography	Texas A&M University	1997 – 2000	10
Cyrus Wadia	STAR	Energy and Resources	University of California – Berkeley	2005 – 2008	11
Caron Chess	STAR	Studies and Democratic Processes	SUNY School of Environmental Science and Forestry	1995 – 1997	12
Scott Hecht	STAR	Life Sciences	Oregon State University	1999 – 2002	13
Erika Zavaleta	STAR	Biological Sciences	Stanford University	1997 – 2000	14
Christopher Yang	STAR	Chemistry and Chemical Engineering	Princeton University	2000 – 2003	15
Andrew Maier	STAR	Molecular Toxicology	University of Cincinnati	2000 – 2003	16
Joseph Aldy	STAR	Economics	Harvard University	2000 – 2003	17
Craig Layman	STAR	Ecology and Evolutionary Biology	Texas A&M University	2000 – 2003	18
Alan Wilson	STAR	Applied Biology	Georgia Institute of Technology	2003 – 2006	19
Andréa Grottoli	STAR	Marine Biology	University of California – Irvine	1996 – 1998	20

Cynthia Williams

Cynthia Williams was awarded her GRO Fellowship in 2001 while attending Alabama A&M University to complete her B.S. in Environmental Science. Since then, she has gone on to receive both her M.S. in Environmental Management and her M.B.A. from the University of Maryland University College, and her Ph.D. in Systems Engineering from the George Washington University in 2015. While working toward her master's degrees, Cynthia served as an environmental specialist at the National Aeronautics and Space Association (NASA) Marshall Space Flight Center for 5 years before being promoted to environmental, health and safety regulatory specialist for NASA's space shuttle program. In these two positions she "was able to combine [her] passions for both the environment and space."

Currently, Cynthia is a systems engineer at the Missile Defense Agency, which is part of the U.S. Department of Defense. Her career choices may seem like a stretch for someone who studied environmental science as an undergraduate, but Cynthia claims that "thinking outside the box and learning to combine other interests with an environmental background can lead to an exciting career," and she urges current GRO Fellows to keep this in mind as they consider the future after they have earned their degrees.

Aiden Irish

Aiden Irish was granted one of the 2011 GRO Fellowships while he was pursuing his B.A. with a double major in political science and environmental ethics and policy at the University of Portland. During his studies, he spent a semester studying at Germany's Freiburg University with a focus on environmental policy and European Union politics. Freiburg is widely considered an international model for sustainable urban planning, and Aiden says, "Living in another country is a fantastic opportunity to develop a better perspective on my own country." The city's approach to urban design addresses such factors as housing, infrastructure, transportation and traffic, energy usage, and environmental protection.

The combination of classes and the experience of living in Freiburg were so influential on Aiden's interests that he went on to earn his M.S. in Regenerative Studies for Sustainable Development from California State Polytechnic University – Pomona. Aiden is currently a research consultant at Waterkeepers Chesapeake in Washington, D.C.

Mary Beliveau

Mary Beliveau, a 2012 GRO Fellow, spent time in Madagascar while working toward her B.S. in International Relations at Seton Hall University. She had the opportunity to study a policy that focuses on providing villagers with the supplies and means to grow their own eucalyptus plantations, rather than deforesting to produce charcoal. She was able to spend "two weeks living with families in two villages that have their own plantations, where [she] was informed that [she] was the only 'vazaha' – the Malagasy word for 'foreigner' – to ever stay in either village."

Mary is interested in the application of environmentally conscious techniques to sustainable development in developing nations, and her experience in Madagascar only enhanced her "desire to learn both about the policy behind conservation and the science driving the policy." Since her time in Madagascar, Mary has interned for the EPA in Corvallis, Oregon and worked for solar companies in New Jersey and South Africa. She currently serves as an English lecturer for the University of Poitiers at the Technological University of Angoulême in France.

Andrew Reighart

Andrew Reighart, a 2011 GRO Fellow, earned a B.A. in International Public Policy Studies and Political Science, with minors in Environmental Studies, Biology and French. Andrew spent a semester abroad at James Cook University in Townsville, Australia, where he was able to experience the international side of public policy studies. Andrew also challenged himself to put his French language skills to the test through a political science program in Paris. "The more you put yourself in new and uncomfortable situations, the more personal growth you will experience and the happier you will ultimately be with your experience," he says.

After obtaining his bachelor's degree, Andrew earned his Masters of Public Policy with a specialization in environmental policy, international security and economic policy, from the University of Maryland School of Public Policy. Since graduating, he has worked for the U.S. Department of the Treasury's Office of Environment and Energy and the Chesapeake Climate Action Network; he currently is an environmental protection specialist for EPA.

Annie Putman

Annie Putman, a 2008 GRO Fellow, earned her B.S. in Environmental Chemistry at Michigan Technological University, researching isotopes and how to use them as tracers in climate change studies. She enrolled in Dartmouth's Earth Sciences Department as a graduate student, continuing her work with isotopes and joining the Isotopic Investigation of Sea Ice and Precipitation in the Arctic Climate System (iiSPACS) project.

In 2012, Annie traveled to Kangerlussuaq, Greenland, where she participated in water sample collection and learned about Arctic weather patterns and the local environment firsthand. "Witnessing calving events at the edge of the Greenland ice sheet impressed upon me the scale of the ice sheet and the total mass of water stored there," she says.

Annie is an advocate for science education: She currently works with the Dartmouth chapter of Graduate Women in Science and Engineering (GWISE), a national organization that seeks to develop a community of women from scientific and engineering disciplines. "Being a GRO Fellow reinforced my scientific interest in the environment," she says. "It opened my eyes to the sorts of programs and research that are necessary to ensure that we're maintaining our natural resources for future generations."

STAR Graduate Fellowship Program

Through the Science to Achieve Results (STAR) Graduate Fellowship Program, EPA has supported approximately 1,850 students pursuing graduate degrees in disciplines related to environmental protection and restoration and improving human health and welfare. Many of those students profess that they might not have been able to pursue their graduate studies without the help of the STAR Fellowship. Others say the fellowship afforded them a degree of scientific freedom they would otherwise not have known. Through the STAR program, EPA has supported both master's students and doctoral candidates at 163 universities and has proven beneficial to both the public and private sectors by providing a steady stream of well-trained environmental specialists – including academic researchers, government scientists, science teachers and environmental engineers – trained to meet society's current environmental challenges and address future issues.

In the following pages, you will meet some alumni of the program and get a glimpse of how the STAR Fellowship was instrumental to launching their careers.

Ashanti Johnson

Dr. Ashanti Johnson, a STAR Fellow from 1997 to 2000, is dedicated to increasing diversity in science, technology, engineering and mathematics (STEM)-related fields. During her fellowship, she received her Ph.D. in Oceanography from Texas A&M University. She was the first African American student body president at Texas A&M and, at the time, also was one of the first female African American chemical oceanographers in the country. Her area of research specialization is in aquatic radiogeochemistry and focuses on the use of various biogeochemical indicators to interpret past events that have affected the marine, estuarine and freshwater environments in the Arctic and along the coastal regions of Georgia, Florida and Puerto Rico.

Dr. Johnson is currently the president of the Institute for Broadening Participation, which works to build partnerships supporting diversity in STEM research, as well as the assistant vice provost for faculty recruitment for the University of Texas at Arlington. She has been a faculty member for the Georgia Institute of Technology School of Earth and Atmospheric Sciences, the Savannah State University Marine Science Program, the University of South Florida College of Marine Science, and most recently the University of Texas at Arlington Department of Earth and Environmental Sciences.

Dr. Johnson is dedicated to the advancement and professional development of students representing diverse socioeconomic, cultural, gender, racial and academic backgrounds. She founded Minorities Striving and Pursuing Higher Degrees of Success in Earth System Science (MS PHD'S©) and has served as a member or advisor on a number of committees and subcommittees.

At the end of 2009, President Obama named her a recipient of the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring and the Presidential Award for Excellence in Mathematics and Science Teaching. Both awards recognize the crucial role that mentors and teachers play in the academic and personal development of minority students studying science and engineering.

Dr. Johnson credits her initial interest in oceans to Jacques Cousteau and says that that interest was intensified after spending a day with a female marine biology graduate student when she was in fifth grade.

Cyrus Wadia

Dr. Cyrus Wadia, a STAR Fellow in 2005, is on a mission to provide affordable solar-generated electricity to more than 7 billion people. He has an S.B. and M.S. in Chemical Engineering from the Massachusetts Institute of Technology and an M.S. and Ph.D. in Energy and Resources from the University of California, Berkeley.

While a doctoral student at the University of California, Berkeley, Dr. Wadia's research focused on the pursuit of new, highly scalable, low-cost energy technologies employing abundant natural resources. He analyzed several materials for their properties and cost-effective potential, then tested the two most promising candidates – copper sulfide and iron sulfide – and synthesized pure, more stable nanocrystals of the compounds that could be made into solar cells. Thanks to the research he conducted in solar photovoltaics during his STAR Fellowship, he was named one of *MIT Technology Review's* Innovators Under 35.

Dr. Wadia began his career by spending 7 years in Silicon Valley helping to bring new technologies to market. He first served as an engagement manager with R.B. Webber & Co., where he worked with more than 15 startups. He later became a senior product manager with AvantGo, where he launched several successful new products. Dr. Wadia then moved on to serve as guest scientist at Lawrence Berkley National Laboratory (LBNL) and later as co-director of the Clean Tech to Market Program at the University of California, Berkeley's Haas School of Business.

In 2010, the White House Office of Science and Technology Policy offered Dr. Wadia the position of Assistant Director for Clean Energy and Materials Research and Development. He spent the next 5 years supporting President Obama's mission of making solar energy economically viable on a global scale. He carried out a broad range of tasks, ensuring cross-agency coordination and conducting program management activities toward this goal.

Dr. Wadia holds two patents and more than 1,100 citations of first-author, peer-reviewed scientific articles. His goal – like others working to make solar energy a significant source of the world's electricity – is making solar energy affordable. As a senior advisor to both McKinsey & Co. and LBNL, he hopes to achieve just that.

Caron Chess

Dr. Caron Chess, a risk analyst, was one of EPA's first STAR Graduate Fellows. She completed her Ph.D. in 1997 at the State University of New York's School of Environmental Science and Forestry, and her dissertation focused on how internal organizational factors influence corporate responses to outside stakeholders. Of the STAR Fellowship, she writes, "I can say that my course work and my dissertation were critical to my development as an academic. I was able to think about both the theoretical and practical implications of my work. When I went to the STAR Fellows' meeting, I was struck by the range and importance of the research."

Dr. Chess was named Professor Emerita at Rutgers University. She was formerly the director of the Rutgers Center for Environmental Communication, president of the Society for Risk Analysis, and associate professor in the Department of Human Ecology. Her research has spanned issues from watershed management to bioterrorism, focusing on factors that affect government agencies' stakeholder involvement efforts and methods to evaluate public participation and risk communication. Her experience in government, observing how organizational problems derailed communication, prompted her to study the relationship between organizational issues and risk communication.

In addition to her many peer-reviewed publications in academic journals, Dr. Chess has written guidance materials that are used widely by government and industry practitioners, including "Communicating With the Public: Ten Questions Environmental Managers Should Ask" and a manual for the industry, both of which were highlighted as "must-reads" by the Society for Risk Analysis. Her national and international service includes appointments to four journal editorial boards, as well as more than 30 other boards, workshops and review panels – including numerous with the National Academy of Sciences. Prior to joining academia, Dr. Chess held positions in government and nonprofit environmental advocacy organizations.

Scott Hecht

Dr. Scott Hecht, a former EPA STAR Fellow, received the Best Publication Award from the European Society of Environmental Toxicology and Chemistry in Environmental Science in May 2005. He is the first American to receive this award, which is given to a student or a scientist younger than 35 for the best publication in the field of environmental sciences. According to Dr. Hecht, “This award casts a bright light on the STAR graduate program’s support of young scientists.”

Dr. Hecht conducted his research on 4-nonylphenol while he was a STAR Fellow earning his Ph.D. at Oregon State University. He considers himself fortunate to have worked with a highly skilled and interdisciplinary group of scientists from the United States, Sweden and Switzerland. His research focuses on 4-nonylphenol, which is widely used as a plastic additive and surfactant, is a chemical with endocrine-disrupting and acute narcotic properties found in many aquatic environments. This research was the first step in proving that estuarine amphipods could be “an important source of 4-nonylphenol to higher trophic levels, such as juvenile fish.” EPA is drafting water-quality guidelines for 4-nonylphenol, and Dr. Hecht’s research contributes to the literature on the effects of the compound on aquatic organisms. Today, Dr. Hecht continues his work with estuarine fish for the National Oceanic and Atmospheric Administration fisheries in Lacey, Washington, where he is the lead toxicologist for the Endangered Species Act Interagency Cooperation Division, evaluating the effects of pesticides on threatened and endangered salmonids.

Dr. Hecht and his team received a Department of Commerce Silver Medal Employee Award “for precedent-setting analysis establishing that non-lethal impacts from low concentrations of pesticides impair the recovery of endangered salmon.” The Silver Medal Employee Award is the second-highest honorary award granted by the Secretary and recognizes exceptional contributions that “have a direct and lasting impact within the Department.”

Erika Zavaleta

Dr. Erika Zavaleta, a STAR Fellow in 2001, is an ecosystem ecologist and professor at the University of California, Santa Cruz, where she manages a dynamic research program, teaches, and advises several graduate students. She completed her Ph.D. at Stanford University, and her dissertation inspired numerous articles in distinguished journals, such as *Science* and *Ecological Monographs*. She has written papers for the National Academy of Sciences and has published with internationally known ecologists.

Dr. Zavaleta is interested in the implications of interacting global and regional environmental changes, how those interactions affect biodiversity and ecosystem functioning, the stewardship of wild ecosystems, and the link between ecological condition and human well-being. Her research spans ecosystems from boreal forest to temperate grassland to subtropical islands and focuses on the cause and effect of changing biological diversity and the role of ecology in guiding effective conservation practices. Her most recent projects examine the effects of climate variability and change on biota endemic to California.

After completing her graduate degree, Dr. Zavaleta became a David H. Smith Conservation Research Fellow at the Nature Conservancy in Washington, D.C. She later served as a program ecologist for The Christensen Fund, and she received the Ecological Society of America's Sustainability Science Award. Dr. Zavaleta is known for her research on the relationship between plants and climate change. She currently serves on the boards of the David H. Smith Conservation Research Fellowship Program, the Tropical Forest Group, EcoAdapt, and the Climate Adaptation Knowledge Environment.

Regarding the benefits of the STAR Fellowship, she said, "The STAR program contributed in a huge way to launching my career. The support it provided freed me to craft my own dissertation project and pursue research and writing projects I would never have had time for without an independent fellowship. The STAR Fellows conference gave me a first, concrete glimpse of how I could apply my science to changing the world for the better. As a faculty mentor, I'm proud to have my own Ph.D. student, Kris Hulvey, supported by the STAR program."

Christopher Yang

Dr. Christopher Yang, a former STAR Fellow, earned his Ph.D. in Chemistry and Chemical Engineering from Princeton University. His work there focused on fuel-cell polymer membranes, though he also worked closely with the Center for Energy and Environmental Studies (now part of the Princeton Environmental Institute) due to his interests in renewable resources, namely H_2 production and alternatives uses. Dr. Yang credits his STAR Fellowship for enabling him to tailor his graduate work to the issues he believed were important, rather than forcing him to "go where the money was."

After graduation, Dr. Yang went to the University of California, Davis, where he is a project scientist and co-leader of the Infrastructure System Analysis research group within the Sustainable Transportation Energy Pathways (STEPS) research program at the Institute of Transportation Studies (ITS). The goal of the STEPS program is to provide timely analysis and comparisons of alternative fuel, such as hydrogen, electricity and biofuels. At the ITS, Christopher works within the Hydrogen Pathways Program to analyze the economic and environmental implications of a variety of energy pathways. He also is an advisor for two graduate students.

Dr. Yang's research focuses on three projects: (1) the evolution of the hydrogen economy on a regional and geographic context – major work includes developing simplified H_2 pathway models for hydrogen production and distribution and optimizing economics and location of production facilities and distribution networks; (2) developing the Transitional Hydrogen Economy Replacement Model (THERM) to look at simplified scenarios for the transition from distributed to centralized hydrogen production; and (3) identifying and understanding the interactions of hydrogen and electricity production in both developing and mature hydrogen economies – issues include co-production strategies, competition and coincidence in timing for primary energy feedstocks, and environmental and economic implications.

As climate change continues to be at the forefront of today's environmental discussions, the work that Dr. Yang and his colleagues are pursuing becomes ever more important. Their research on advanced vehicles and sustainable fuels will be vital in helping to reduce greenhouse gas emissions from the transportation sector.

Andrew Maier

Dr. M. Andrew Maier, former STAR Fellow, received his Ph.D. in molecular toxicology from the University of Cincinnati. After completing his education, Dr. Maier joined Toxicology Excellence for Risk Assessment (TERA), a nonprofit scientific and educational consulting company based in Cincinnati. For 2 years, he distinguished himself as a toxicologist and industrial hygienist, and he was eventually named project manager for TERA's Verifiable Estimates for Risk Assessment program. During his tenure, he has diversified and expanded the program to include emphasis on hazard screening, product safety assessment and occupational toxicology, all of which complement the comprehensive EPA assessments that are the traditional focus of the program.

Dr. Maier has authored or co-authored numerous toxicological reviews for the EPA, as well as multiple drinking water criteria documents. He is a project advisor for the U.S. Air Force Trichloroethylene Risk Assessment and is project lead for EPA's Sustainable Futures: Screening Level Assessments, which is one of EPA's Pollution Prevention initiatives. Dr. Maier also serves as the Chair of the TERA Fellows Program and the Co-Director and Chair of the Diplomate of the American Board of Toxicology.

Dr. Maier also teaches at both his undergraduate and graduate alma maters – Ball State University and the University of Cincinnati, respectively – where his active research includes methods in occupational risk assessment, including the derivation of occupational and environmental exposure limits, cumulative risk assessment, and field validation studies of exposure models. He has nearly 20 peer-reviewed articles in print and has written or contributed to numerous book chapters, and his work has garnered many awards. Andrew twice received Honorable Mention for Best Risk Assessment Poster by the Society of Toxicology Risk Assessment Specialty Section, and he has been honored with a State of West Virginia Environmental Stewardship Award.

On the benefits of the STAR Program, he writes, "I see the STAR Program as serving an important and unique role in pushing the science forward in solving contemporary applied human and ecological health problems. The STAR Fellowship Program is a unique venue for research funding that encourages scientific development targeted to making an immediate environmental health impact. [It] provides a mechanism for translating basic biology science research into enhanced risk assessment methods."

Joseph Aldy

Dr. Joseph Aldy received an EPA STAR Graduate Fellowship in 2000 to complete his Ph.D. in Economics at Harvard University, which complemented his Master of Environmental Management degree from the Duke University Nicholas School of the Environment. He says the STAR Graduate Fellowship allowed him the freedom to design an independent research project for his dissertation, instead of being forced to fit into an existing research program. Dr. Aldy's current research focuses on climate change policy, energy policy, the effectiveness of both renewable and fossil fuel subsidies, and mortality risk valuation.

Dr. Aldy served as the Special Assistant to the President for Energy and Environment from 2009 to 2010, reporting through both the National Economic Council and the Office of Energy and Climate Change at the White House. While in this position, Dr. Aldy was responsible for the White House's energy and environmental policy portfolio, the coordination of policy development and evaluation, and international energy and environmental policy in support of the National Security Council. He also has extensive international experience: He was invited to the fourth and fifth Conferences of the Parties to the U.N. Framework Convention on Climate Change, and he was the lead author for the 1998 report *The Kyoto Protocol and the President's Policies to Address Climate Change: Administration Economic Analysis.*

Dr. Aldy is now an associate professor of public policy at the John F. Kennedy School of Government at Harvard University, a visiting fellow at Resources for the Future, a faculty research fellow at the National Bureau of Economic Research, a senior adviser at the Center for Strategic and International Studies, and the faculty chair for the Regulatory Policy Program at Harvard's Mossavar-Rahmani Center for Business and Government. He has received such awards as the Switzer Foundation Environmental Fellowship and the Morris K. Udall Scholarship and Excellence in National Environmental Policy Foundation Fellowship, and he was named Stone Pre-Doctoral Fellow in Environmental and Resource Policy.

Craig Layman

Dr. Craig Layman was a STAR Fellow from 2000 to 2003, where he studied species diversity in tropical ecosystems. His dissertation was entitled, "The Role of Piscivores in a Species-Rich Tropical River," and his advisor says that it was one of the best dissertation projects he has ever mentored. After his fellowship concluded in 2003, he won a Fulbright Scholarship which he used to further his research in the Cinaruco River in Venezuela. He then finished his degree in 2004 with the help of an NSF Doctoral Dissertation Improvement Grant and a Texas A&M Agriculture and Life Sciences Graduate Research Award.

Dr. Layman states that the STAR Fellowship may have made all the difference in his graduate career. "Because of the fellowship, I could [work] full time on my research, and I could select a research site that I might not have been able to afford to work in otherwise. I absolutely know that it was a big factor in [my] winning the Fulbright [Scholarship] and in obtaining this wonderful postdoctoral position. In some very real ways, I owe my career to the fellowship."

Dr. Layman currently is an associate professor of applied ecology and a Chancellor's Faculty Excellence Fellow at North Carolina State University (NC State). His laboratory work and research focuses on food webs (exploring both top-down and bottom-up processes), consumer nutrient cycling, fish ecology, artificial reefs, lionfish invasion, urban stream ecology and conservation planning. The multidisciplinary approach that his laboratory pursues allows a broad understanding of environmental change in coastal environments. Dr. Layman likes to say that his laboratories ask "questions that span population, community, ecosystem and evolutionary sub-disciplines."

Prior to joining the faculty at NC State, Dr. Layman was a Donnelly Environmental Fellow at Yale University in the Department of Ecology and Evolutionary Biology, where he conducted research on food webs in the Cinaruco River and in the Bahamas, prey morphology (working with Brian Langerhans, another EPA STAR Fellow), and ecosystem restoration, among other projects. In addition to his research and teaching at Yale, he taught a joint field course between the College of the Bahamas and the University of Alabama, located at the Bahamas Environmental Research Center. He also spent 6 years as an assistant professor and 1 year as an associate professor at Florida International University.

Alan Wilson

Dr. Alan Wilson was an EPA STAR Fellow from 2003 to 2006, when he received his Ph.D. in Applied Biology from the Georgia Institute of Technology for his dissertation "Cyanobacteria-grazer interactions: Consequences of toxicity, morphology, and genetic diversity." This paper was the first of many for Alan, as he currently boasts a resume with over 40 peer reviewed publications to go along with numerous book chapters and other periodicals.

After his postdoctoral work at the University of Michigan Cooperative Institute for Limnology and Ecosystems Research, Dr. Wilson accepted a position as an assistant professor in the School of Fisheries, Aquaculture and Aquatic Sciences at Auburn University, where he currently works. For half of his time at Auburn University he also was assistant professor in the Department of Biological Sciences. He took a year off from teaching in 2013 to work as a Global Research Institute Fellow at the University of North Carolina at Chapel Hill.

Dr. Wilson is now the program director at the National Science Foundation in the Population and Community Ecology Program, which is part of the Division of Environmental Biology. His scientific interests are broad, but as a community ecologist, he states that he is "generally interested in consumer-prey interactions and identifying the ecological and evolutionary consequences of intraspecific genetic and phenotypic variation on aquatic communities and ecosystems." His current research focuses on the ecology of cyanobacterial blooms and on learning how biotic and abiotic factors influence cyanobacterial bloom formation.

Dr. Wilson has received many grants, awards, and other forms of recognition over the years in addition to his EPA STAR Fellowship. He has various grants and awards from reputable organizations including NOAA, NSF, and Auburn University. Furthermore, his honors include Most Outstanding Biology Graduate Student Award 2004 from Georgia Tech, the 2010 Alabama Agricultural Experiment Station Director's Junior Faculty Research Award – the highest research honor available to an Assistant Professor at Alabama, and Auburn University Provost's 2014 Award for Excellence in Fostering Undergraduate Research and Creative Scholarship – the highest honor at Auburn University related to the mentoring of undergraduate students in research.

Andréa Geneviève Grottoli

Dr. Andréa Grottoli, a STAR Fellow from 1996 to 1998, gravitated toward the University of Houston's Coral Ecology Laboratory where, after her first year studying for her master's degree, she conducted graduate research in Hawaii and shifted to the doctoral program. "I was very motivated by the fact that coral reefs are these 'canary in the coal mine' ecosystems" whose condition is directly connected to human actions. Dr. Grottoli received her Ph.D. in Marine Biology in 1998 and followed that with postdoctoral studies at the University of California, Irvine (1999 – 2000). Receiving her STAR Fellowship "was amazing," Andréa says, explaining that it enabled her to focus fully on her research. That partially entailed pursuing research independent of her advisor, doing so at the Rosenstiel School of Marine and Atmospheric Science in Miami.

Dr. Grottoli's passion for reef research arose from her lifelong love of water environments, starting with the lakes and rivers of Northern Ontario, where she grew up. Currently, she is researching stresses that are affecting corals, including temperature, acidification, high nutrient levels and changes in light. In her research, Dr. Grottoli has shown that corals with a greater capacity for eating plankton or containing certain temperature-tolerant algae can possess higher resilience in response to carbon dioxide stresses. "The loss of reefs will have a dramatic ripple effect throughout human society and marine ecosystems," she cautions.

Today, Dr. Grottoli is a professor for the Ohio State University School of Earth Sciences; an affiliated professor in the Department of Ecology, Evolution, and Organismal Biology; and the head of both the Water, Climate, and the Environment Division and the Stable Isotope Biogeochemistry Laboratory. She also is a council member for the International Society for Reef Studies and served as an organizer, speaker, and presenter for the 13th International Coral Reef Symposium.

Future

In 2014, President Obama initiated a national reorganization of STEM education to consolidate programs with similar purposes, apply evidence-building strategies and build mechanisms to ensure the connection between mission agency assets and on-the-ground needs, giving programs greater reach and influence. The reorganization redirected funds to the National Science Foundation (NSF) for STEM undergraduate and graduate education and a national fellowship strategy, to the Smithsonian Institution for informal STEM engagement and to the Department of Education for K – 12 programs.

As a result of the consolidation of the funds to NSF, the federal budget for fiscal year 2016 provided no appropriation or directive language for EPA's GRO Undergraduate or STAR Graduate Fellowships. EPA is committed to programs that support the growth and development of the environmental workforce and is exploring various opportunities to continue this STEM support outside the fellowship program. One opportunity EPA is leveraging is the NSF Graduate Research Internship Program, which expands professional development opportunities for NSF Graduate Fellows with partner agencies across the federal government. EPA began a pilot program in 2015. More information EPA's support to the GRIP program is located at https://www.epa.gov/research-fellowships/graduate-research-internship-program-grip-opportunities-epa.

The AAAS, ASPPH and Marshall Scholarships Programs continue to provide opportunities for graduate students and postgraduates who have been accepted into the Marshall Scholars Program. EPA encourages students to explore all federal fellowship programs for funding and experience opportunities at www.epa.gov/careers/fellowships-scholarships-and-post-doctoral-opportunities.

People, Prosperity, and the Planet (P3)

Background

With a rapidly growing population and commensurate energy, water and natural resource consumption, this planet faces ever more severe challenges. Action must be taken to ensure a healthier environment and create a sustainable future. The U.S. EPA is one of many organizations working to achieve exactly that. Since 2004, the EPA's People, Prosperity, and the Planet (P3) Program has encouraged multidisciplinary teams of college and university students to tackle some of the most daunting obstacles facing our society. By providing funding to teams focusing on challenges facing both the developed and developing worlds, the P3 Program supports the design of tangible, innovative technologies that can solve today's problems.

The P3 Program has four primary goals: to engage and educate the next generation of scientists about sustainability; to spark innovative and sustainable technologies; to support the use of sustainable technologies around the world; and to enable the formation of enterprises rooted in sustainability. To accomplish these goals and provide the opportunity for students to create demonstrable change, the P3 Program targets a number of broader categories, including supporting the economy through small businesses and technology, laying a foundation upon which a clean energy campaign can be built, and urging students to actively create change in communities both locally and abroad.

Since the program's inception, more than 4,000 students from 226 institutions across all 50 states and Puerto Rico have been awarded 688 grants totaling more than $14.6 million. Nearly 200 publications and 15 patents have been issued, and 28 small businesses and nonprofits have been formed. Over the years, the P3 Program has yielded many striking success stories, several of which are presented here.

P3 Success Stories Table

Institution	Company	Project Area	Years Funded	Page
Harvard University	One Earth Designs	Solar Cooking	Phase I: 2009 – 2010 Phase II: 2010 – 2012	24
Cornell University	Sunn Lighting	Hybrid Lighting	Phase I: 2012 – 2013	25
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University of Virginia	The Learning Barge	Green Education	Phase I: 2006 – 2007 Phase II: 2007 – 2009	29
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Cornell University	AguaClara	Clean Drinking Water	Phase I: 2009 – 2010 Phase II: 2010 – 2012	31
University of California – Davis	Micromidas	Sustainable Plastics	Phase I: 2007 – 2008 Phase II: 2008 – 2010	32
Columbia University	Pilgrim Africa	Agriculture	Phase I: 2008 – 2009 Phase II: 2009 – 2011	33
University of Illinois	Greenlight Planet	Solar Lighting	Phase I: 2006 – 2007	34

Impacts

Harvard University

www.oneearthdesigns.com

The idea that launched One Earth Designs originated in the Himalayan mountains of western China when a Wellesley College student, Catlin Powers (Wellesley BA ’09; Harvard MS ’11, ScD’14), and an MIT student, Scot Frank (BE ’08), began working with Tibetan nomads to develop a solution to the extreme energy poverty they were facing.

It all began when a local Tibetan family asked them why scientists were studying outdoor air pollution when the real problem was the air pollution inside their homes. Catlin’s investigations revealed that the air inside the family’s home was 10 times more polluted than the air in Beijing. Each year more than 4 million people die from breathing in toxic smoke created by their cookstoves (WHO GBD 2014). Catlin and Scot’s subsequent EPA P3 project, “A Comprehensive Platform for Rural Energy Optimization in the Himalayan Region,” received both Phase I (2009 – 2010) and Phase II (2010 – 2012) awards from the EPA P3 Program.

During Phase I, the team designed, tested and improved the clean, solar-powered SolSource cooker. SolSource heats up five times faster than a charcoal grill, can reach temperatures of up to 550°F (300°C), delivers up to 1,000 watts (1kW) of power, and harnesses sunlight seven times more efficiently than an average photovoltaic solar panel. Furthermore, it captures sunlight at a 92-percent efficiency rate, protects the user’s eyes, is easily portable, and has withstood more than 10 years of accelerated weather testing.

Production increased during Phase II, and the device has been sold in more than 60 countries, received the fourth-highest global impact rating ever awarded, and has been featured on the American TV show Top Chef. Their spin-out company, One Earth Designs, has been a certified B Corporation since December 2012 and has been on the “Best for the World List” – honoring the world’s leading responsible businesses – for four years in a row (bestfortheworld.bcorporation.net). One Earth Designs has also received a number of other awards, including the *Grand Prixe du Publique* from the Geneva Inventions Competition, the St. Andrews Prize for the Environment, and the 2014 Prize for Excellence in Clean Tech Commercialization (awarded by the Prince of Monaco). One Earth Designs is now working on solar energy storage technologies that they believe have the potential revolutionize rural home energy yet again.

Cornell University

sunnlight.com

Sunn Lighting was conceived when Kelton Ray Minor found his mood dampened by Copenhagen's winters while he was studying abroad. He wished he could bring the sun down below the clouds or make it stay out longer, so when he enrolled in the graduate program at Cornell University, he and co-founder/advisor Jeremy Blum began working on Sunn Lighting.

In 2012, Minor and Blum's Cornell-based team of students received a P3 Phase I grant for 2012 – 2013 for their project "Fiber Optic Hybrid Lighting." The team achieved its goal of developing a lighting system that could collect incident sunlight on building facades, transport the focused sunlight via flexible fiber optics, and re-release the diffused sunlight deep into interior spaces through a custom-designed luminaire. They developed a control system that can tune output of a light-emitting diode (LED) to supplement natural daylight during overcast weather or in low natural-light conditions.

Sunn Lighting's energy-efficient LED light fixtures and apps mimic outdoor lighting inside. The Sunn app controls the illumination within a user's home by mimicking the sun at that location and time of day. Users also can control the amount of light Sunn Light gives. They can set their Sunn Light to tropical conditions, for example, instead of their current weather or seasonal conditions; if a user is traveling, they can set the Sunn Light to mimic their destination and help them adjust to the time difference before ever leaving. The Sunn app is compatible with existing color-tunable lights, such as the Philips Hue and LIFX.

Sunn Lighting is headquartered in Los Angeles and operates in Chicago and New York in the United States, as well as Poland and Denmark. Sunn Lighting successfully launched a Kickstarter campaign to finish iOS and Android versions on the app – both versions of which are now available.

University of Tennessee

dbei.utk.edu/projects/new-norris-house

Under the University of Tennessee's Design Build + Evaluate Initiative, a team of university students was awarded an EPA P3 grant for a project titled "The New Norris House: A Sustainable Home for the 21st Century." Through its 2008 – 2009 Phase I and 2009 – 2011 Phase II projects, a multidisciplinary team (including students from six departments) designed and constructed a sustainable home and landscape in Norris, Tennessee. This location was chosen because it is the site of a model community constructed in 1933 by the Tennessee Valley Authority as part of the Norris Dam Project, which was one of the first planned communities in the United States and consisted of a series of homes built for modern, efficient living, originally integrating new technologies such as municipal electricity and water systems.

The New Norris House was built to celebrate the 75th anniversary of the Norris Project, and it attempts to reinterpret the Norris example while designing a home for the 21st century. As with the original Norris designs, the home created in this project utilized state of the art technologies and techniques while also using sustainable materials in construction. The students had to confront and resolve not only technological and scientific concerns, but also legal, social, financial and aesthetic issues that currently restrict green construction, especially in towns registered as National Historic Districts.

The project was completed in August 2011, and it hosted educational programs and a 2-year residency through 2014. Researchers measured the performance of the building and landscape systems while recording the experience of living in such a home, landscape and community. The New Norris House received a Platinum Certification from the Leadership in Energy and Environmental Design (LEED®) for Homes Program, which is the highest certification standard for homes recognized by the U.S. Green Building Council. Furthermore, it was awarded the 2012 Merit Award by the American Institute of Architects (AIA) Gulf States Design Awards, as well as the 2012 Award of Excellence from the AIA Tennessee Design Awards. In 2013, the AIA and its Committee on the Environment selected the New Norris House as one of 10 national recipients of its Top Ten Green Projects Award, and in 2014 the project was awarded a national Honor Award for Research by the American Society of Landscape Architects.

University of Tennessee

dbei.utk.edu/portfolio/green-oak-construction

The University of Tennessee's Design Build + Evaluate Initiative received an EPA P3 Award for the project "Green Oak as a Sustainable Building Material." The 2013 – 2014 Phase I and 2014 – 2016 Phase II awards help the team work with The Green Oak Initiative and the University of Tennessee Center for Renewable Carbon; the goal is to develop contemporary green (un-dried) oak construction techniques for the U.S. building market. The students also hope to develop technical documentation necessary for the construction of a demonstration project that will further acceptance of this abundant, renewable resource.

The Appalachian hardwood region is one of the most productive forests in the world, annually adding about twice the volume of timber to its reserve as is harvested, despite supporting a number of growing industries. The "heart centers" of hardwood logs, however, generally have defects that limit their usefulness for traditional dry lumber products, so this portion of the log is routinely sold green as "cants" used to manufacture shipping pallets – an extremely low-grade use.

The Green Oak Initiative will allow this wood to be used as structural members in sustainable buildings. The research will be applied to a comprehensive green demonstration project for a University of Tennessee complex located in west Tennessee. And because there is very little modern architectural or engineering knowledge in the United States about using green oak in building design and no recognition of this type of construction in building codes, this novel research could be a foundation for converting this resource to structural uses while requiring no operational changes for local saw mills.

The research team is currently conducting a variety of investigations. These include adapting European green oak grading standards to grade oak pallet cants for structural use; confirming grading standards by mechanically testing pallet cants; and examining structural bearing and spanning capabilities of pallet cants through calculation and modeling, as well as the design of composite members and trusses. The team has three home designs, which they are in the process of testing to determine the most effective option.

Embry-Riddle Aeronautical University

In January 2010, a 7.0 magnitude earthquake rocked the small island nation of Haiti, devastating an already weak infrastructure. As disaster relief poured in from around the globe, a motivated group of Embry-Riddle Aeronautical University (ERAU) students decided to make sure that next time a natural disaster occurred, the recovery process would be more manageable. They won both a 2011 – 2012 EPA P3 Phase I award and a 2012 – 2014 Phase II award for their project "Portable Solar Water Purification System for Public Use During Disaster Recovery."

Using their Phase I and II funding, the ERAU students developed a portable, solar-powered, water purification system in the form of a backpack – the Drop – capable of purifying an impressive 3 gallons of water a minute, which equates to about 4,300 gallons per day. This patented filtration technology provides up to 99.99 percent reduction of bacteria and viruses, and it filters heavy metals, chemicals, bad taste, and even smell from freshwater sources. The filtered water meets both EPA and National Science Foundation drinking water standards. By purifying water on site, plastic waste is reduced and thousands of dollars are saved in transportation, fuel and logistics.

On average, a single charge will last as long as 2 hours. The power source is a 120-watt collapsible solar panel, and the entire system weighs about 36 pounds – lighter than a 5-gallon bucket of water. Over the course of their lifetime, the filters can replace up to 105,000 liters of water, which could prevent the use of about 210,000 half-liter plastic water bottles.

AquaSolve Ventures was formed in order to expand the reach and effectiveness of the Drop. It also worked to commercialize a high-volume, solar-powered, water purification system called the Pond, which costs less than $500 per year to maintain. The Pond works much in the same way as the Drop, but on a much larger scale, and it has been installed in orphanages, missionary bases and community centers across Haiti. The systems provide enough water for these locations' daily operations, as well as surplus water to sell to the community. These micro-businesses create jobs and generate revenue to pay for system maintenance and start new programs.

AquaSolve Ventures and the work done by the ERAU students has been featured in a number of articles, and it has won the 2014 Cairns Foundation Innovation Challenge, the 2012 U.S. Army NetZero Sustainability Award for Water, and various other awards.

University of Virginia

www.elizabethriver.org/learning-barge

The Elizabeth River is one of the most contaminated tributaries of the Chesapeake Bay. More than 10 years ago, a group of University of Virginia students came up with the idea for The Learning Barge, a self-sufficient educational tool that has been dubbed "the world's first floating wetland classroom and America's greenest vessel." These students received a 2006 – 2007 EPA P3 Phase I grant for their project, as well as a 2007 – 2009 Phase II grant to expand the Learning Barge project.

The Learning Barge is completely powered by the sun and wind. It features live wetlands that filter greywater and create habitat, an enclosed classroom, composting toilets, and a rainwater filtration system. Operated by the nonprofit organization The Elizabeth River Project and its partners – which include several public school districts, the National Oceanic and Atmospheric Administration, and the Chesapeake Bay Foundation – the barge is designed to be a "steward ship," teaching the next generation of scientists who live nearby about environmental stewardship, ecology and sustainability. It travels between four major cities while monitoring and teaching about ongoing sediment remediation, pollution prevention and restoration projects. The educational spaces and interactive exhibits provide hands-on education about the tidal estuary ecology, restoration and remediation technologies, and human impact on the Elizabeth River ecosystem. Nearly 65,000 students have been educated on the barge since its 2009 launch, approximately 42,000 of whom were K – 12 students.

The Learning Barge has won a number of awards, including the 2006 American Society of Landscape Architects National Student Collaborative Design Award, the 2008 American Institute of Architects Education Award, and the 2011 Sea World & Busch Gardens Environmental Excellence Award. It also was named a Top Project in the first University of Virginia Sustainability Project Competition and recently was named one of the state's Top 10 Centers for Environmental Education Excellence by the Virginia Department of Conservation and Recreation.

Clarkson University

www.bluesphereind.com

The United Nations projects that the global population will exceed 9 billion people by the year 2050. However, the amount of arable land is decreasing because of poor management practices, and it is doubtful that enough land will be left to feed that entire population. Additionally, most areas that currently produce the majority of crops have limited fresh water, and crop yields are subject to weather conditions, which are becoming more unpredictable with increased climate change.

A student team from Clarkson University won Phase I (2009 – 2010) and Phase II (2010 – 2012) EPA P3 grants for their project "Sustainable Year-Round Food Production in Cold Climates." The team designed a high-rise farm that eventually led them to found the company Blue Sphere Industries. Because transporting produce across the country on an aging infrastructure is detrimental to the environment, this company supplies greenhouses as a way to grow local, organic food in both rural and urban cold-weather climates.

Blue Sphere Industries has developed "a sustainable, modular aeroponic growth system (a plant-cultivation technique in which the roots hang suspended in the air while nutrient solution is delivered to them in the form of a fine mist) designed for use in a controlled environment so that it can operate year-round in any climate." The roots are enclosed in a basin while a nutrient tea is mixed in a holding container. That mixture is then pumped into a pressurized tank where an automated control system periodically sprays the tea onto the root zone, purging and oxygenating it and leaving a fresh surface for water and nutrient absorption. Any of the tea not taken up by the plant falls into the basin and is returned to the holding container via a gravity siphon in order to minimize waste. This system uses 92 percent less water and 60 percent less nutrient mass per kilogram of plant yield. The system also uses light-emitting diodes (LEDs) to produce light only in the wavelengths that stimulate plant growth, another way of minimizing waste. The LEDs use approximately 200 watts to illuminate an 8-square-foot growing area. While the business model was not as successful as planned, the greenhouse is still actively being used for educational purposes.

Cornell University
www.aguaclarallc.com

aguaclara.cornell.edu

Worldwide, 1.3 billion people live with little or no access to electricity, making centralized water treatment practically impossible; 1.5 million people, mostly children, die from waterborne diseases every year from diarrhea and the resulting dehydration; and more than 800 million people living in rural communities have access to piped-in water that may be contaminated. Since 2005, students in Cornell University's AguaClara program have been perfecting gravity-powered drinking water technologies designed to be planet friendly and high performing. In 2009 – 2010, the Cornell team was awarded an EPA P3 Phase I award to improve develop a gravity powered chemical dosing system under the "Dose Controller for AguaClara Water Treatment Plants" project, which was followed by a 2010 – 2012 Phase II award.

Originally developed for low-income communities in Honduras that lacked access to both reliable electricity and clean drinking water, AguaClara currently has 12 water treatment plants in 11 Honduran communities with two more facilities under construction. These plants provide clean water to nearly 50,000 people. The gravity-powered water treatment system works in six steps: grit removal, chemical dose, hydraulic flocculation, fluidized bed flocculation, plate settlers and stacked rapid sand filtration. The AguaClara network includes a partner organization, Agua Para el Pueblo, in Honduras that provides turnkey installation and technical support for AguaClara facilities. AguaClara LLC is deploying the gravity powered chemical dosing systems for village scale water supply systems in India.

AguaClara LLC one of nearly 1,600 certified B Corporations and has been honored as one of the B Corp Best for the World (bestfortheworld.bcorporation.net), a list that recognizes companies "for overall, environmental, community and worker impact [and] for earning a score in the top 10 percent on the B Impact Assessment."

University of California, Davis

micromidas.com

One challenge to sustainable water use is the need for a method of removing carbonaceous waste from wastewater without adding hazardous chemicals. The goal is to achieve low effluent concentrations and so reduce the amount of harmful wastewater entering nearby ecosystems. A student team from the University of California, Davis was awarded an EPA P3 grant for a Phase I project (2007 – 2008), "Sustainable Biological Phosphorus Removal: A New Theory to Meet Increasingly Stringent Effluent Discharge Requirements," which grew into a Phase II project (2008 – 2010), "Production of Natural Plastics in Wastewater Treatment."

This project led to the creation of Micromidas, which was founded on the idea that genetically modified microbes could be designed to consume sewage sludge and other bio-genic waste to create biodegradable plastics – polyhydroxyalkanoates, or PHAs – that would be physically superior to current biodegradable plastic products. PHAs carry no lethal limit and decompose in just a few months, as opposed to the centuries required for petroleum-based plastics to break down. This could help ease the growing stress put on landfills and minimize the amount of plastic debris creating dead zones in the world's oceans.

In the intervening decade, in addition to developing the fermentation process, Micromidas has designed an efficient process for low-cost production of plastics. The Micromidas process is a non-fermentation, non-gasification, chemical-only process that selectively produces a furan (a heterocyclic organic compound) intermediate from any feedstock containing cellulose or hemicellulose. The company is building a chemical platform "to produce both existing aromatic and new furanic chemicals, polymers and resins using a wide variety of cellulosic biomass and carbohydrates, including wood… paper sludge, corn, corn byproducts… empty palm fruit bunches and other glucan sources." These furans are used to produce monomers, plasticizers or renewable (but chemically identical) variants of certain commodity chemicals.

Micromidas has raised $80 million to date. Its success has been featured in magazine, newspaper and journal articles, and its co-founder John Bissell was named to the third annual *Forbes* "30 Under 30" list in the category of Energy and Industry. The *Forbes* list highlights "founders and funders, brand builders and do-gooders who aren't waiting for a proper bump up the career ladder. Their goals are way bigger… and perfectly suited to the dynamic, entrepreneurial and impatient digital world in which they grew up."

Columbia University

www.pilgrimafrica.org/category/education/

In 2001, more than 1.5 million Ugandans were displaced by war and living in camps in the northern part of the country. A group of Ugandans founded the nonprofit organization Pilgrim Africa to help them, and today it is an international organization focused on public health and education. One of its programs works with more than 40 farmer cooperative groups for resettlement and the development of innovative agricultural techniques adapted to the region. In 2007, the Columbia University branch of Engineers Without Borders – USA began working with Pilgrim Africa to implement a Multifunction Platform (MFP) pilot. To help fund their research, the team secured EPA P3 grants for both the 2008 – 2009 Phase I cycle and the 2009 – 2011 Phase II cycle.

The MFP is a machine that mechanizes many agricultural processing activities required in rural areas: It can power several modules, such as a cereal miller and thresher, a nut grinder, an oil press, a battery charger, or an electricity generator. When fitted with certain pumps, MFPs can pump water for both irrigation and household use. MFPs are built using the Lister CS 6-1 diesel engine, which is widely available in Uganda.

Currently, hundreds of farmers are being trained to run, manage and expand the use of MFPs as a profitable, sustainable business enterprise. According to Pilgrim Africa, “this training prepares them to handle all the operational, logistical, and technical aspects of running an MFP for income generation.” The pilot program directly improves the lives of more than 800 families involved in Pilgrim Africa’s co-op partners, and it will benefit the wider villages where the co-ops are located, which is three to four times as many people.

University of Illinois at Urbana-Champaign

www.greenlightplanet.com/en

Worldwide, more than 2 billion people rely on kerosene lamps to provide light once the sun goes down. However, such lamps are highly inefficient, are expensive to maintain and refill, and release disproportionately large amounts of carbon dioxide and soot into the user's home and the environment. A team of University of Illinois students decided to develop brighter, healthier and more affordable solar-powered light-emitting diode (LED) lamps.

The Illinois team was able to design prototypes thanks in part to an EPA P3 Phase I grant (2006 – 2007). The lights were paired with a small solar panel and a battery; the battery charges during the day while the solar panel sits on the roof and provides 5 – 6 hours of light after sundown. The technology has existed for some time, but the team wanted to design a product that would be economically sustainable. The prototypes they produced cost approximately $21 and were extremely well received during the pilot phase of the project in Orissa, India.

One of the students, Patrick Walsh, teamed up with Mayank Sekhsaria and Anish Thakkar to found Greenlight Planet and produce the lamps on a larger scale. The three products currently offered by the company (Sun King Pico, Sun King Pro and Sun King Home) provide between 24 and 72 hours of light per battery charge at an intensity between 25 lumens (three times brighter than a kerosene lamp) and 200 lumens. Two of these products also come with a USB charging port for other electronic devices.

To date, more than 5 million off-grid homes and 18 million daily users in 40 countries have used Sun King products, which has offset more than 700,000 metric tons of carbon dioxide. Greenlight Planet estimates that this has resulted in a 75 percent increase in daily study time, a 25 percent increase in household income, and a 15 percent increase in monthly household savings. Furthermore, 84 percent of users reported better air quality. Greenlight Planet was named to the Fast Company Most Innovative list for 2016, and *Forbes* named Co-Founder Anish Thakkar as one of its "30 Under 30" entrepreneurs in the Energy category.

P3 Teams ⇨ SBIR Companies

Institution	Company	Project Area	P3 Years	SBIR Years	Page
Oberlin College	Lucid Connects	Energy Consumption Software	Phase I: 2004 – 2005 Phase II: 2005 – 2007	Phase I: 2014 – 2015 Phase II: 2015 – 2017	36
Drexel University	Environmental Fuel Research	Biofuels	Phase I: 2007 – 2008 Phase II: 2008 – 2010	Phase I: 2014 – 2015 Phase II: 2015 – 2017	37
University of California - Berkeley	SimpleWater	Clean Drinking Water	Phase I: 2007 – 2008 Phase II: 2008 – 2010	Phase I: 2014 – 2015	38

Oberlin College

lucidconnects.com

The built environment is responsible for two-thirds of U.S. electricity consumption and usage of more than 15 trillion gallons of water annually. On college campuses, a significant percentage of these resources are used in dormitories. A team of Oberlin College students decided to motivate building occupants to reduce their water and energy consumption with a monitoring and display system that enables real-time observation of resource use.

To fund their research, the students applied for the U.S. Environmental Protection Agency's (EPA) first annual P3 Awards and received a Phase I grant (2004 – 2005) to explore visual feedback systems. Their research was based on the premise that publicly accessible feedback on resource use in buildings would inspire students to behave in ways that minimize resource use, build knowledge and understanding, and generate both environmental and financial benefits. The team successfully demonstrated that their low-cost, wireless, resource-monitoring feedback system and web-based display system could stimulate interest and motivate college students to exhibit substantial short-term reductions in energy and water use in dormitories. This was clearly exhibited during a 2-week dorm energy competition, during which two dorms containing the resource-monitoring prototype reduced electricity use by 56 percent, while dorms without this technology reduced electricity use by an average of only 13 percent.

The Oberlin team also received a P3 Phase II award (2005 – 2007) for their project to scale up the technology and evaluate the effect of its campus-wide implementation. The Lucid Design Group was an outgrowth of this project and recently received two EPA Small Business Innovation Research (SBIR) awards, a 2014 Phase I and 2016 Phase II award.

The SBIR Phase II award supported a project developing and testing novel "building orbs" that can help monitor and reduce electricity use. This building orb technology employs off-the-shelf, multicolored, internet-connected light-emitting diodes (LEDs) – such as the Philips Hue or LIFX – combined with an existing energy data application programming interface (API) to encourage energy conservation by emitting a certain color: green if energy usage is low or red if the user is consuming more energy than usual. This simple feedback eliminates the possibility that the consumers are unaware of their energy use, which is a significant barrier to energy conservation, and keeps them from having to actively examine their usage trends.

The Phase II SBIR award is being used to develop an interactive communication tool – Storyboards – to motivate behavioral energy savings in commercial buildings. This digital signage product offers flexible, interactive ways to display building resource metrics and sustainability views.

Lucid works to "connect people to buildings, empowering organizations to make smarter decisions that reduce costs, improve occupant comfort and accelerate team productivity." Lucid currently has 65 employees, and its software is used by more than 500 customers in 13,000 buildings in such metropolitan areas as Chicago and Washington, D.C. Lucid is backed by such partners as General Electric, Google, Autodesk, the Clinton Foundation, Energy Star, Berkeley Lab, and the National Wildlife Federation. Lucid has received several awards, including the Top Product of the Year in the first annual Energy Manager Today Awards and an International Green Award, and it was named to the Global Cleantech 100 list.

Drexel University

www.envirofuelresearch.com

Drexel University student teams have received a number of EPA P3 awards, several relating to the generation and processing of biofuels. Most current biodiesel processes use refined vegetable oils, but many potential non-food sources exist.

One such source is grease-trap waste (GTW), which is an underutilized high-lipid waste stream from the wastewater management system and has vast potential for conversion into fuels. Prior research at Drexel demonstrated lipids could be separated from GTW and efficiently converted into biodiesel. Preliminary research also showed both economic feasibility and positive environmental effects of grease-to-biodiesel processes. This evidence was used as a foundation for a Phase I P3 project (2007 – 2008), "A Novel Reactor Design for Efficient Production of Biodiesel from High Free-Fatty-Acid Oils," and a subsequent Phase II project (2008 – 2010), "Novel Reactor Design for Biodiesel Production."

The Phase I project involved a feasibility study, comparing a biodiesel process using a novel reactor to traditional biodiesel, with results showing that vacuum distillation can reduce sulfur content to meet the 15 parts per million ASTM specifications, although it is challenging to meet the specifications while also obtaining high yield. In Phase II, a continuous pilot-scale version of the reactor was constructed and tested. The Bubble Column Reactor, pioneered by Dr. Richard Cairncross and student researchers at Drexel University, is a two-phase device in which methanol vapor bubbles through hot oil and the byproduct water is removed continuously as a vapor. The process is more flexible and robust for varying feed oil composition than current biodiesel reactors. This novel reactor is more effective than current reactors at using ethanol as the feed alcohol and in dealing with water impurities.

Environmental Fuel Research, LLC (EFR) was formed to commercialize the GTW-to-biodiesel process. EFR received an SBIR Phase I award (2014) to demonstrate technical feasibility of production of high-quality biodiesel, conduct an extensive study of GTW composition, determine economic feasibility and environmental effects, and prepare a commercialization plan. EFR received an SBIR Phase II award (2015) to continue development and scale up of the process for producing biodiesel from fats, oils and greases (FOG) from GTW.

A pivotal part of EFR's Phase II project entails converting FOG to biodiesel that can meet American Society for Testing and Materials (ASTM) specifications and demonstrating that the process can operate at larger scale. To accomplish this, EFR proposed a partnership with the Delaware County (Pennsylvania) Regional Water Quality Control Authority (DELCORA), a local wastewater treatment facility. DELCORA operates a grease-retrieving and concentration process that removes trash and partially dewaters GTW prior to incineration. However, the pilot process being built at DELCORA would separate between 50 and 100 gallons of FOG from 250 gallons of concentrated grease and convert it to biodiesel, rather than prepare it for incineration.

The proposed FOG biodiesel process has several environmental benefits, including reducing the amount of GTW that is incinerated or sent to landfills, reducing the management intensity of waste greases, producing a valuable fuel that can substitute for petroleum-based diesel, and reducing the life cycle emissions of greenhouse gases and other harmful pollutants.

University of California, Berkeley

www.simplewater.us

The inspiration for the research conducted at the University of California, Berkeley (UC Berkeley) came from the fact that in 2007, about 60 million Bangladeshi citizens were being slowly poisoned by the arsenic-contaminated water from their wells. Some of these wells contained up to 100 times the maximum limit set by the World Health Organization (WHO). Moreover, arsenic contamination in drinking water threatens more than 56 million people in 25 American states and more than 100 million people globally. A group of UC Berkeley students applied for and received an EPA P3 Phase I grant (2007 – 2008) for their project, "Electrochemical Arsenic Remediation in Rural Bangladesh."

Having completed preliminary background research on the subject at Lawrence Berkeley National Laboratory (LBNL) with encouraging results, the UC Berkeley student team attempted to demonstrate the ability of electrocoagulation technology to reduce the arsenic content in drinking water during their Phase I project. They began by testing electrocoagulation's effectiveness in removing high arsenic levels from Bangladeshi ground water, and the process reduced arsenic to levels lower than the limit set by the WHO. Previous arsenic removal methods had been ineffective at high concentrations, but this innovative technology overcame those obstacles and has a very low cost: $0.01 – $0.02 for 10 liters per day on a small scale.

A year later, the UC Berkeley team received a P3 Phase II grant (2008 – 2010) to expand their project and build upon their successes, developing the ArsenicVolt. The ArsenicVolt contains reactors that control a low electric current that runs across inexpensive iron plates and separates arsenic and other contaminants from the water. It can be installed within a new or existing water treatment system and does not require pretreatment or changing the acidity of the water. Because of the success of the UC Berkeley students, SimpleWater was formed to commercialize the ArsenicVolt and expand its influence.

SimpleWater received an EPA SBIR Phase I (2014) grant to expand the affordable arsenic removal system for drinking water. The team discovered through extensive research that the technology also removes other heavy metal contaminants in addition to arsenic, and it even removes some biological pathogens.

The current maximum contaminant level (MCL) for arsenic in the United States is 10 parts per billion (ppb), which likely underestimates the health risk of human arsenic consumption. In fact, EPA and several U.S. states are advocating restricting the MCL to 5 ppb. The SimpleWater team is focused on designing a system that will be affordable even in the poorest and most supply-constrained regions of the world: Ongoing projects in Bangladesh, Cambodia and India prove that the system can reduce arsenic contamination below U.S. and WHO standards while remaining locally affordable.

Future

The future of the P3 program depends on a number of factors, including the committed team that works to keep things flowing smoothly, the federal budget, how much funding the program receives, and – perhaps most important – the motivated P3 teams themselves. The P3 program will remain dedicated to funding innovative and cutting-edge sustainability technologies, while simultaneously inspiring the next generation of environmental scientists.

Small Business Innovation Research (SBIR)

Background

While there are multiple environmental and public health issues in water quality, clean air, green manufacturing, green buildings and homeland security that need to be addressed, such challenges present immense opportunity for technological innovation. Many ideas with the potential to evolve into dynamic solutions come from entrepreneurial small businesses, which need seed funding to get these ideas off the ground. Because of this, far too many novel ideas fail to be tested through to completion. It is at this stage in the design process where the EPA Small Business Innovation Research (SBIR) program comes in.

Since 1982, the SBIR program has been a source of early-stage capital for innovative small businesses to develop and commercialize sustainable environmental technologies in such areas as water, air, manufacturing, materials and homeland security. The ultimate goal of the program is to bring the technologies to market, where they can support EPA's mission of protecting human health and the environment. In addition to supporting state-of-the-art advances in monitoring devices and pollution cleanup systems and processes, the program has focused on prevention and has made life cycle assessment a priority for all technologies funded. Since the program's inception, more than $186 million has been given to more than 600 companies through 1,782 awards. Additionally, EPA SBIR has a very broad reach and has supported companies in 46 states.

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Impacts

GVD Corporation

www.gvdcorp.com

As consumer demand for a product increases, many items are mass produced using molds, both everyday products with plastic or rubber parts – such as kitchen utensils, children's toys, shoe soles, DVDs and automotive tires – and specialized industrial and medical devices. To free the parts from those molds, manufacturers use special coatings, which can contain perfluorooctanoic acid (PFOA) and can negatively affect air quality by releasing volatile organic compounds (VOCs) during the drying process. PFOA can persist in the human body for a long time and ultimately lead to cancer, while VOCs have been linked to such health problems as eye, nose and throat irritation; headaches and nausea; loss of coordination; and damage to the liver, kidneys or central nervous system.

With support from EPA's Small Business Innovation Research (SBIR) Program, GVD Corporation created a mold-release coating made of polytetrafluoroethylene (PTFE) that uses no hazardous organic solvents or PFOA, as well as a novel vapor deposition process called initiated chemical vapor deposition (iCVD), which provides an environmentally friendly, alternative to conventional release technologies. As a result, air quality inside manufacturing facilities is vastly improved, which decreases workers' exposure to harmful substances and, in turn, causes these facilities to release fewer toxic emissions into the environment. Additionally, GVD's technology uses less energy because the coating can be applied at room temperature, the molds can be coated with a uniform and extremely thin layer (0.01 to 10 micrometers—about one-fifth the thickness of a human hair) that uses and wastes fewer raw materials, and the coating chemicals adhere to virtually any surface and wear out less quickly than conventional spray coatings.

EPA's SBIR funding has helped GVD Corporation partner with major automotive parts manufacturers that use GVD's vapor-deposited PTFE mold-release coatings to streamline tire manufacturing. Today, millions of tires produced using GVD coatings are on the road. Additional applications of GVD's coating technology can be found in the electronic, medical and semiconductor industries. GVD coatings are used for mold release, dry lubrication and custom coating solutions, and they are especially beneficial for electronics protection (e.g., printed circuit boards, radio frequency electronics, sensors and light-emitting diode boards).

The founding of GVD Corporation stemmed from research performed in the Department of Chemical Engineering at the Massachusetts Institute of Technology (MIT) in the laboratory of co-founder Dr. Karen Gleason. Along with its headquarters based in Cambridge, Massachusetts, GVD has a manufacturing facility located in Greenville, South Carolina. GVD also received a MassVentures SBIR Targeted Technologies (START) award in a competition hosted by the Commonwealth of Massachusetts.

As of 2016, GVD attributes $8.4M in revenue to technology developed through the EPA SBIR award and has added 7 employees working on its tire mold release product since the start of the Phase I. The company also was awarded the U.S. Small Business Administration's 2016 Tibbetts Award, which is bestowed upon those businesses that exemplify the promise and potential of the SBIR program.

Green Building Studio

gbs.autodesk.com/GBS

An estimated 40 percent of the world's total primary energy consumption, 30 percent of global greenhouse gas emissions, and consumption of 20 percent of the world's available water are associated with currently existing buildings. Recent concern about the effects of global climate change and dwindling resources has caused many governments to modify regulations, requiring buildings to reduce fossil fuel use and carbon dioxide emissions by 50 percent with the ultimate goal of becoming carbon neutral. Furthermore, the U.S. Green Building Council developed the Leadership in Energy and Environmental Design (LEED®) rating system to provide independent verification that a building was designed and built using strategies to conserve energy and water, be healthier and safer for occupants, and reduce harmful greenhouse gas emissions. These LEED®-certified building designs increase building value, decrease building vacancy, and improve retail sales by an estimated 40 percent.

Green Building Studio, with support from EPA's SBIR Program, developed a web-based modeling tool to streamline the design of sustainable buildings. This energy analysis software provides design alternatives so users can improve energy efficiency by analyzing water use in a building; calculating renewable energy potential at the building site, should photovoltaic panels or wind energy be utilized; summarizing natural ventilation potential by comparing the hours required to mechanically cool the building versus the hours required to use natural outdoor air to cool the building; and reporting on carbon emissions. Green Building Studio has made sustainability analysis an integral part of its building information modeling (BIM) process by providing the ENERGYSTAR® score, detailed weather data, and even the potential for achieving carbon-neutral building operations.

Green Building Studio's web service can assess a building's energy, water and carbon emission performance – which previously could take up to several weeks – in a matter of minutes and at lower cost than using today's leading BIM tools. The success of the software led Autodesk, Inc., a world leader in 3-D design, engineering and entertainment software, including AutoCAD®, to purchase the Green Building Studio web service. This move proved advantageous to both Autodesk – as it can enhance its focus on green building and LEED® certification while advancing sustainability as one of its core values – and to Green Building Studio – as it is brought to a much larger market and provided far greater visibility.

Microsoft has recognized Green Building Studio as a Gold Ingenuity Point award winner. In this global contest for independent software vendors, winners are chosen from a worldwide pool of entrants who submit solutions to address needs in education, health care and clean technology.

Bridger Photonics

www.bridgerphotonics.com

The potential impacts of climate change include an increase in average global temperatures; increased occurrences of both drought and heavy downpours with flooding; more frequent and intense heat waves and wildfires; a steeper rise in sea levels; and growing damage to water resources, agriculture, wildlife and ecosystems. The severity of the issue increases the need for accurate sensors for greenhouse gases such as carbon dioxide (CO2).

Bridger Photonics received an EPA SBIR grant in 2012 to develop a mid-infrared laser for use in a remote CO_2 sensor. Current laser sensors are difficult to use, do not provide spatial identification of the pollution source, and cannot measure or pinpoint the location of elevated CO_2 concentrations. The instrument created by Bridger Photonics has high-range resolution that will be used to spatially scan CO_2 sequestration or industrial sites for leaks, provide onsite CO_2 monitoring, and allow for precise 3-D coordinate mappings of emissions sources. The device probes plumes to measure the emitted CO_2 concentration, distance to the source, and spatial extent of the plume by sending out a pulse of light at the wavelength absorbed by CO_2. After some of that light is absorbed and the remainder comes scattering back to a receiver, the concentration of CO_2 can be calculated.

The laser system measures absorption through the atmosphere and is capable of spatially mapping atmospheric molecular concentration with better than 1 meter range resolution from more than 100 meters away and of detecting molecular concentrations of less than 100 parts per million – a vastly improved remote sensing precision. Bridger Photonics' laser has a number of other advantages over currently marketable laser systems, including its price, its compact size, the powerful pulses it produces, and an air-cooled laser system with an adjustable output energy.

Bridger Photonics has become a leader in three closely related areas of advanced laser-based technologies: precision distance measurement, remote gas sensing and 3-D imaging. It also has developed and delivered two laser prototypes for a separate application in health sciences, tissue ablation.

The September 2011 issue of *Inc. Magazine* named Bridger Photonics among its Inc. 500 list of fastest growing private companies in the United States and ranked it first in the engineering sector. The company also was awarded the U.S. Small Business Administration's 2012 Tibbetts Award, which is bestowed upon those businesses that exemplify the promise and potential of the SBIR program.

Ecovative Design

www.ecovativedesign.com

For decades businesses and consumers have relied on an array of synthetic materials in day-to-day life. Chemical-based products such as polystyrene packaging (i.e. Styrofoam™), insulation, cushioning, and particleboard are all around us. There is growing evidence and awareness that many of these synthetic products present long-term health and environmental challenges. Many are petroleum based, and are neither renewable nor biodegradable. Some – including particleboard and other engineered wood containing formaldehyde – can off-gas volatile toxic chemicals which pose serious health risks

Ecovative Design is addressing these challenges by pioneering a new materials science. Co-founders Gavin McIntyre and Eben Bayer built the company on the breakthrough idea to use the mushroom component mycelium – what they call "nature's glue" – to grow high performance products that are safe, healthy, and certified sustainable. These products are replacing such materials as plastic foam, formaldehyde-based engineered woods, and synthetic cushioning. Ecovative's business model emphasizes making quality, financially viable products that are good for the environment, and that benefit the people who produce and use them.

With early and on-going support from EPA's SBIR Program, Ecovative developed MycoFoam™ materials, a replacement for hydrocarbon-derived synthetics in packaging, insulation and structural cores. Subsequently, the firm developed MycoFoam™ insulation that now qualifies for many Leadership in Energy and Environmental Design (LEED®) credits. The packaging material Mushroom® Protective Packaging was the first Ecovative product to enter the consumer market; it is used by Fortune 500 companies and others as a replacement for polystyrene-based packaging. The company expanded its portfolio of sustainable materials with the creation of MycoBoard™ panels, now used in their manufacturing of furniture, wall tiles, and other products for the home and office. MycoFlex™ elastic foam is currently in development, with an eye toward future commercialization within seating and apparel applications.

These products are made by growing the mycelium of mushrooms on low-value agricultural byproducts, such as corn stalks or seed hulls, which are notoriously difficult to dispose of or degrade in an efficient manner. This also creates a solution to a regional agricultural waste disposal challenge. The fungi's vegetative mycelium (a web of root-like fibers that hold the hull together) self-assembles into the desired shape as it grows first in a bag and then in a product mold. Growth happens at room temperature and takes a mere 5 – 7 days. The process requires less energy while emitting less carbon dioxide than petroleum-derived equivalents such as Styrofoam™. Once the product has finished growing, the material is heated to kill the fungus and any remaining spores. The resulting material is biodegradable at the end of its useful life – decomposing in as little as 30 – 90 days – and does not off-gas.

Ecovative has grown to 80+ employees, operating two manufacturing facilities in Upstate-New York, producing eco-friendly mushroom packaging, formaldehyde-free engineered wood, and fully grown furniture. Ecovative has received numerous accolades including being named a Technology Pioneer by the World Economic Forum. Customers include Steelcase, Dell, and Gunlocke Furniture.

PittMoss

pittmoss.com

It takes about 12,000 years for peatland to develop in the Northern Hemisphere, and throughout that process carbon dioxide is stored within organic material. Accounting for only 3 percent of the Earth's surface, yet sequestering nearly 33 percent of the world's stored soil carbon, peatlands store twice as much carbon dioxide as the entire planet's forest biomass (approximately 550 gigatons of carbon). Because of its unique properties, peat moss is often harvested for use in potting soils. Not only are organic materials and natural habits destroyed when peat moss is harvested, but that stored carbon is released into the atmosphere. It is estimated that the loss of just 1.5 percent of the planet's peatlands is equivalent to an entire year's release of carbon pollution. In addition to acting as carbon sinks, healthy bogs also provide a habitat for various endangered species, help purify drinking water and protect against flooding.

Mont Handley founded PittMoss to offer a sustainable, manmade product that would serve the same function as peat moss. PittMoss received a Phase I EPA SBIR grant (1996), which helped fund numerous growth trials and provided the scientific evidence and foundation for PittMoss patents. Over the next decade, PittMoss underwent a proof-of-concept phase. With a novel formula that completely replaced peat moss in many crop trials, PittMoss found seed funding through Pittsburgh's Idea Foundry.

PittMoss is a mix of patented additives and paper rescued from landfills. It contains no wetting agent, lime additive, fungicide or insecticide, and unlike traditional sphagnum peat moss, it is 100 percent environmentally sustainable. Each plant grown in PittMoss reduces the reliance on the million tons of peat moss imported to the United States each year, most of which comes from Canada. Moreover, during commercial trials PittMoss minimized environmental risk while delivering many benefits over traditional peat moss, including a lower price, decreased runoff and decreased water usage (up to 50% less). The PittMoss product has a unique fiber structure that significantly increases porousness, enabling the fiber to hold onto water and nutrients and slowly release them to plant root systems.

PittMoss is available to commercial greenhouses and nurseries, and its market will continue to expand. Mr. Handley recently appeared on the television show "Shark Tank," where he won a $600,000 investment. PittMoss recently expanded its consumer base due to the success of their product and increased demand. Previously sold primarily to commercial growers such as nurseries and greenhouses, PittMoss introduced their new line of retail products targeting the home gardener.

EP Purification

www.ep-pure.com

More than 785 million people worldwide – at least 10 % of the world's population – do not have access to clean water, and between 6 and 8 million deaths each year are the result of water-borne disease. EP Purification designs and manufactures water disinfection systems enabled by technology developed originally at the University of Illinois. Based on the production of ozone (O_3) in hundreds or thousands of microscopic channels, this technology is lighter, smaller, and more robust than conventional ozone systems, and is now in operation in more than 30 countries worldwide.

Ozone is the strongest disinfectant and oxidizer available commercially, and decades of study have shown O_3 to be more effective than chlorine in deactivating micropathogens of greatest concern, such as MRSA, *Legionella pneumophila*, and *Cryptosporidium*. Also, because ozone is short-lived in air, and any ozone remaining after the disinfection process is completed reverts back to benign, atmospheric oxygen (O_2), ozone has none of the detrimental impacts of chlorine on the environment.

EP Purification systems are designed to deliver the precise dosage of ozone required to disinfect a given amount of water. The technology is unique in building ozone systems from aluminum "chips", each of which has typically 25 microchannels and is capable of producing sufficient ozone for disinfecting 200-300 gallons of water per hour. Six to ten chips are stacked in modules, and systems having as many as 20 modules are being manufactured at present. EP Purification offers ozone systems producing up to 115 grams of ozone per hour, and 1 kg/hour (53 pounds/day) systems will be introduced in 2017. The ability to generate virtually any amount of ozone by simply installing the proper number of modules offers the versatility of applying ozone to not only disinfecting drinking water for municipalities, but also water in cooling towers, pools and saunas, food handling and processing, commercial and institutional laundries, and agriculture. Wastewater treatment and the disinfection of water in medical and dental applications are also rapidly growth areas for this technology.

Small EP Purification ozone systems (weighing only 1.1 lbs.) are supplied with a 15 Watt solar panel for "off-the grid" locations, and are currently disinfecting drinking water in more than two dozen countries, including India, the Philippines, Singapore, and Haiti. Larger systems in the U.S., Canada, and in more than 12 countries, are treating water for all of the applications mentioned earlier. EP Purification technology is supported by more than six patents, and the company's products captured the Wells Fargo Clean Energy Challenge Grand Prize for $100,000 in 2014, as well as the Entrepreneurial Excellence New Venture Award in 2015.

Providence Photonics

www.providencephotonics.com

Industrial flares are primarily safety devices that can prevent personnel injury and property damages in the event of process upset. They also minimize air pollution by combusting process vent gases to carbon dioxide and water. Thousands of flares are operating at industrial facilities across the United States. When flares are not operated properly, they emit significantly more air pollutants and greenhouse gases. Because flares combust vent gases in open air, there has been no practical technique to monitor the performance of the flares. Providence Photonics, based in Baton Rouge, Louisiana, is developing an advanced optical gas imaging technology to monitor flare combustion efficiency remotely and autonomously. The new technology is called Video Imaging Spectro-radiometry (VISR).

In 2012, Providence Photonics won an EPA SBIR Phase I award for proof of concept for this technology. After the successful completion of the Phase I work, Providence Photonics won an EPA SBIR Phase II award in 2014 to develop a commercial product based on this technology. Through this award, Providence designed a prototype flare combustion efficiency monitor, which used the VISR technology to determine the relative concentrations of carbon dioxide and unburned hydrocarbons in flare plumes, while calculating flare efficiency in real-time. This device not only measures flare efficiency, but also provides facility operators with accurate and instantaneous performance information such as whether or not the flare has visible emissions (smoke), how stable the flare is, and how much heat energy is released from the flare. With this information, facility operators can make the necessary adjustments, manually or automatically, to improve the efficiency of their flares, which improves facility operations and minimizes harmful emissions.

In January 2016, lead researchers at Providence Photonics published a paper in the peer-reviewed *Journal of the Air and Waste Management Association* about monitoring industrial flares using VISR technology. Additionally, Providence Photonics has completed the development of a commercial product based on this technology and reached a distribution agreement with a global leader in the flare manufacturing market.

GreenTechnologies

www.green-edge.com

As the human population and agricultural production both continue to grow, the demand for fertilizer, pesticides and fresh water increases. This anthropogenic change has led to an increase in both frequency and severity of eutrophication events (the state where bodies of water become rich in mineral and organic nutrients, causing certain plant life to proliferate and reduce the water's oxygen content, smothering other organisms). Nutrients constantly cycle between the environment and living organisms as a fundamental part of nature, and the human population's urban expansion has thrown many of these cycles out of balance. Nutrient runoff and leaching not only directly affect communal water bodies and the ecosystems they support, they also indirectly affect the people for whom these bodies of water provide ecosystem services.

Mimicking the basic principles of nature's nutrient cycle, GreenTechnologies, a 2015 EPA SBIR award winner, has developed GreenEdge, a slow-release fertilizer containing 100-percent organic nitrogen made from nutrient-rich byproducts. The patented nutrient recycling process converts biosolids from water treatment facilities into effective and environmentally friendly fertilizers to safely return nutrients to the soil, turning waste material into a valuable commodity. Additionally, the fertilizers are "specially formulated to eliminate the nutrient leaching and runoff that makes many synthetic fertilizers so damaging to the environment." This nutrient recycling does more than just help the surrounding ecosystems – it also helps communities become more resource efficient and reduce spending, water use and landfill space.

GreenEdge can be applied at all levels of landscaping, by homeowners, businesses or agricultural producers. Typically, the fertilizer yields visible results in as little as 3 to 5 days, and the effects can be witnessed for up to 14 weeks. GreenEdge adds organic matter to the soil and does not contain any chemical salts, decreasing the risk of foliar burning and encouraging a healthy ecosystem that boosts overall plant health. Furthermore, the slow-release mechanism not only prevents leaching and runoff, protecting local water, but it also ensures that customers use less fertilizer, helps plants grow with less water (because the water used is captured and retained more efficiently), and saves customers money.

Imaging Systems Technology, Inc.

www.teamist.com

As climate change continues and its effects on both humans and the environment grow, companies and organizations around the globe are committing themselves to finding long-term, sustainable solutions. One such company is Imaging Systems Technology, Inc. (IST), a woman-owned small business. Their novel hollow-shell technology forms the basis of a unique water purification tool.

With support from an EPA Small Business Innovation Research (SBIR) Phase I grant (2013) and Phase II grant (2014), IST is developing technologies that produce low-cost, lightweight and highly efficient water purification systems. The Phase II project involves enhancing hollow shells with titanium dioxide, a UV activated photo catalyst that breaks down contaminants in water. The innovation increases the UV activated surface area by several orders of magnitude, which potentially make this purification system significantly more powerful than any other currently on the market.

This innovation could serve a number of water purification applications, including large or industrial systems that handle vast quantities of water; small portable systems for disaster relief, humanitarian or military purposes; and industrial wastewater purification (including removing contaminants produced during oil and gas recovery). A number of organizations from each of these fields have expressed interest in the technology, which also could be expanded to purify air, food and medical instruments.

IST is moving the technology from laboratory to production under a joint development agreement with Trelleborg's offshore operation in the US. The State of Ohio also has contributed almost one million dollars to scale up effort. And investment in this project will exceed $5 million over the next two years.

Future

As the EPA SBIR Program prepares to celebrate its 35th anniversary, its main objective for the future is to continue seeking novel technology solutions to the Nation's most pressing environmental problems. The SBIR program will continue to fund a breadth of topic areas across EPA's mission and will use its modest budget to focus on increasing effective solutions in priority areas. Projects in monitoring and control technologies will be supported, and upstream prevention projects that have the potential for significant environmental benefit will be emphasized. A continued focus will be placed on the life cycle effects (including source materials, toxicity, energy and water use, end of life options) of all technologies funded.

Conclusion

Fellowships, P3 and SBIR are cornerstones of EPA's Innovation Ecosystem, each fostering creativity among students, communities and small businesses to develop tangible solutions. These programs work hand in hand to promote innovative research that supports sustainability. Fellowships allow the Agency to encourage students in STEM fields to work within their communities to solve local issues and gain practical knowledge through mentorship in a laboratory. EPA's P3 Program funds student teams with the goal of designing novel technologies aimed at solving global environmental problems. These teams are funded with the hope that they will create prototypes and start their own small businesses based on the lessons learned during their P3 projects. These small businesses can apply for SBIR contracts, allowing them to further develop their ideas and bring them to market. With this knowledge, students can become entrepreneurs and create commercial products intended to protect human health and the environment. Research, publications, and products stemming from these programs help guide EPA's mission and contribute to a healthier planet.