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Exemplary Science for Building Interest in STEM Careers

Edited by
Robert E. Yager

NSTA press
National Science Teachers Association

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NSTA press
National Science Teachers Association
Arlington, Virginia

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Contents

Foreword
Attracting More Students to Pursue STEM Careers vii
Robert E. Yager

Acknowledgments xi

About the Editor xiii

Chapter 1 Changes Needed in Science Education for Attracting More Students to STEM Careers 1
Bruce Alberts

Chapter 2 Designed to Invent: Camp Invention, A 21st Century Program...... 7
Maryann Wolowiec, Alaina Rutledge, and Jayme Cellitioci

Chapter 3 Science Beyond the Laboratory: The Intriguing Career Paths of 14 Scientists and Engineers 19
Melissa McCartney, Anne Poduska, Richard Weibl, and Rieko Yajima

Chapter 4 Educating Students About Careers in Science: Why It Matters ... 51
Jonathan Osborne, Stephanie Claussen, Louise Archer, Jennifer DeWitt, Justin Dillon, and Billy Wong

Chapter 5 Why STEM? Why Now? The Challenge for U.S. Education to Promote STEM Careers 63
Brenda Wojnowski, Karen Charles, and T. Georgeanne Warnock

Chapter 6 Using Inquiry-Based Teaching and Kids Inquiry Conferences to Strengthen Elementary Science Instruction and to Encourage More Students to Pursue Science Careers 81
Paula A. Magee and Ryan Flessner

Chapter 7 NSTA's Efforts to Interest More K–12 Students in Pursuing STEM Careers..................... 95
Alan J. McCormack and Francis Q. Eberle

Chapter 8 Creating a Pipeline to STEM Careers Through Service-Learning: The AFT Program 111
Anton Puvirajah, Lisa Martin-Hansen, and Geeta Verma

Chapter 9 Preparing Students for Careers That Do Not Yet Exist 129
Glenn "Max" McGee

Chapter 10 The Steppingstone Magnetic Resonance Training Center Opportunities for Students and Faculty in a True Research Laboratory Setting 145
Philip D. (Reef) Morse II, Kiyo Ann Morse, and Arthur Heiss

Chapter 11 The Promise of Service-Learning as an Instructional Approach to Motivate Interest in STEM Careers 161
Shelley H. Billig, Lyn E. Swackhamer, and Linda Fredericks

Chapter 12 Real World Externships Exposing Students to Possible Careers in STEM Disciplines 183
Jeffrey Weld, Ted Anthony Neal, Disa Lubker Cornish, and Isabel Montemayor

Chapter 13 The Talent Marketplace: Where Science Careers are Made 205
S. Anders Hedberg

Chapter 14 Scientists as Partners in K–12 Science: Engineering, Science, and Technology Careers 223
Craig Johnson

Chapter 15 Science Olympiad: Inspiring the Next Generation of Scientists.. 237
Gerard Putz and Jennifer L. Wirt

Chapter 16 Active Learning as a Way to Interest More Students in Science Careers 255
Claudia Khourey-Bowers, Tracy Saho, and Vicki McCamon

Endword
Encouraging More Students to Pursue STEM Careers: Success Stories 269
Robert E. Yager

Contributors 273

Index 277

Foreword

Attracting More Students to Pursue STEM Careers

Robert E. Yager
University of Iowa

Goal Four, which was included in the 1996 National Science Education Standards (NSES) has attracted few, if any, disagreements regarding its appropriateness. Everyone agrees that encouraging student interest in science and technology careers is a good thing. There have been no objections to its inclusion as one of the goals (reasons) for teaching school science. In fact, most K–16 science teachers endorse the current stated aim for their teaching: to attract more students to careers in science, technology, engineering, and mathematics (STEM).

Interestingly, there are but four Goals for teaching science included in the 1996 National Standards. Everyone especially liked Goal One; it calls for teachers to ensure that students "experience the richness and excitement of knowing about and understanding the natural world" (NRC 1996). Goals Two and Three focus on the importance of science being used for meeting personal and societal issues.

Goal Four calls for instruction to "increase student economic productivity through the use of the knowledge, understandings, and skills of the scientifically literate person in their careers." Interestingly, some of the authors of chapters for this monograph have even indicated that Goal Four may be the *only* important goal! Yet it is the one that seems to be most difficult to accomplish in terms of evidence for success and effectiveness over time. It is rarely included in textbooks or curriculum frameworks with specific ideas for trying and information to use in activities. Further, relatively few educators are able to discuss what they specifically do to meet the goal. Some have argued that if such a career goal were to succeed in terms of actions taken, most of our problems could be eliminated and students would use the experiences to lead them to identifying current problems and considering STEM careers for themselves.

Looking for specific features in submissions indicate exciting efforts by our Exemplary Science Programs (ESPs). The examples of success comprise the chapters of this monograph. They indicate that there are exciting ways to mentor students and to deepen their interest in pursuing STEM careers. This book is all about specific ways that are effective in increasing interest in STEM careers.

Selecting the 16 programs to highlight in these chapters was the greatest challenge, due to the dearth of responses to our call for submissions for this monograph, compared to previous titles in this series. Why? Unfortunately it has been found that student interest in science actually tends to decline each year over the K–16 interim (Ali, Yager, Haciemenoglu, and Caliskan 2011).

Research indicates that enrolling in science classes *decreases* student interest in science careers! It is interesting to note that this continues even at the college level, when a larger percentage enrolls in science by choice. These facts alone should encourage more to try and to report on successes for our ESP efforts.

The hope is that this publication will excite more teachers to try even more creative efforts to portray students as actually *doing* science rather than continuing with typical courses where teachers try to transmit the information they know directly to students and to test for their degree of success (memorization).

The real successes for stimulating more students to aim for STEM careers are eye-opening. One facet of the ESP Careers effort is the diversity of the plans offered. Many have used the help of community members, business and industry representatives, and more current views of what science is and how it indicates the importance of collaborative learning. Often this means experiences with current projects dealing with local and personal problems as well as those that affect and include students in selecting and developing their own ideas (e.g., students as part of leadership teams). Science is the act of humans trying to make sense of objects and events found in the natural world. It is exciting to engage students in resolving problems and issues using their own ideas. As noted, if science is personally experienced, it will attract many more to STEM careers! And, with more enthusiasm!

The 16 chapters that follow report on ideas and experiences representing a large number of career areas; they include scientists, engineers, inventors, and education reformers, all of whom are often aware of the importance of personal, local, and current issues as opposed to merely doing something prescribed (often from a textbook). One exciting observation is the varying forms of collaboration that have been accomplished through the efforts of the author teams. Chapter 1 starts with the inclusion of five efforts and ideas from Bruce Alberts, the editor of *Science*, the official journal of the American Association for the Advancement of Science (AAAS). Alberts's efforts in developing the National Science Education Standards add to the importance of the reforms of school science. He has also been involved with the recent development of a new framework that is to be used for guiding the 2012–13 efforts and the work on new standards that is underway. These new efforts surely are focused on STEM teaching, curricula, and careers.

Some have expressed that there would be more interest in STEM careers if students were simply not permitted to enroll in traditional science courses. But the nine statements from the 1996 Standards call for *less emphasis* on: (1) treating all students alike and responding to the group as a whole; (2) rigidly following curriculum; (3) focusing on student acquisition of information; (4) presenting scientific knowledge through lecture, text, and demonstration; (5) asking for recitation for acquired knowledge; (6) testing students for factual information at the end of the unit or chapter; (7) maintaining responsibility and authority; (8) supporting competition; and (9) working alone. Certainly the authors of the 16 chapters that follow were not doing or advocate such "typical" teaching. Instead they were aware of and interested in the nine *More Emphasis* conditions: (1) understanding and responding to individual student's interests, strengths, experiences, and needs; (2) selecting and adapting curriculum (3) focusing on student understanding and use of scientific knowledge, ideas, and inquiry processes; (4) guiding students in active and extended scientific inquiries; (5) providing opportunities for scientific discussion and debate among students; (6) continuously assessing student understanding (and involving students in the process); (7) sharing responsibility for learning with students; (8) supporting a classroom community with cooperation, shared responsibility, and respect; and (9) working with other teachers to enhance the science program.

When teachers change their teaching, student interest increases—and more students aspire to science-related careers as well. Changes in teaching must occur and typical courses must change to focus more on student efforts with projects, activities, and problem-solving. This is the best plan for getting more students interested in pursuing STEM careers after high school. Unfortunately though, typical college courses, with large enrollments in lectures and cookbook laboratories, provide poor models for K–12 teachers preparing themselves to teach. It is gratifying to see more college science teachers changing the typical mode of their college teaching. Some even label their reform teaching as to be "no lecture, no cookbook laboratories." These are exciting efforts that can result in more students wanting to spend a lifetime with STEM careers!

Reference

Ali, M., R. E. Yager, E. Haciemenoglu, and I. Caliskan. 2011. Changes in student attitudes regarding science when taught by teachers without experiences with a model professional development program. Under review.

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About the Editor

Robert E. Yager—an active contributor to the development of the National Science Education Standards—has devoted his life to teaching, writing, and advocating on behalf of science education worldwide. Having started his career as a high school science teacher, he has been a professor of science education at the University of Iowa since 1956. He has also served as president of seven national organizations, including NSTA, and has been involved in teacher education in Japan, Korea, Taiwan, Indonesia, Turkey, Egypt, and several European countries. Among his many publications are several NSTA Press books, including *Focus on Excellence* and two issues of *What Research Says to the Science Teacher*. He has authored over 700 research and policy publications as well as having served as editor for eight volumes of NSTA's Exemplary Science Programs (ESP). Yager earned a bachelor's degree in biology from the University of Northern Iowa and master's and doctoral degrees in plant physiology from the University of Iowa.

Science Beyond the Laboratory: The Intriguing Career Paths of 14 Scientists and Engineers

Melissa McCartney, Anne Poduska, Richard Weibl, and Rieko Yajima
Science *Magazine*

Setting

The American Association for the Advancement of Science (AAAS) is the world's largest general scientific society and publishes the journal *Science*, which has an estimated total readership of 1 million. Founded in 1848, the nonprofit AAAS is open to all and fulfills its mission to "advance science and serve society" through initiatives in areas such as science policy, international programs, and science education.

These vignettes exemplify the AAAS's support of the breadth of careers that use scientific skills—and AAAS's recognition that one's scientific interests can lead to pathways as diverse as research, public policy, communication, and education. Scientists and engineers working at AAAS offices in Washington, D.C., Cambridge, U.K., and Beijing, China, disseminate scientific research to technical and public audiences, build international collaborations, create curriculum and learning materials to improve science education for all, support human rights issues, and assist local and national political leaders to see the utility and value of science when addressing the critical issues facing us all.

Introduction

A planetary scientist working on human rights issues? A bird brain researcher hosting a radio show? In this chapter, we present vignettes of real scientists who found themselves traveling unique career paths that put them in jobs they didn't necessarily expect. Tracing their career aspirations from childhood through their college years and beyond, the vignettes demonstrate how our lives, educational experiences, and training teach us skills that prepare us for a career path that is uniquely suited for each person. These scientists offer advice for students who might wish to follow in their footsteps. Despite the very different life experiences of the featured scientists, they have one uniting characteristic: They all love what they are doing!

Many of these individuals grew up with a stereotypical view of science: Being a scientist means working in a laboratory, doing research at a bench filled with machines and test tubes.

However, most did not know what "doing research" really meant. After leaving high school, all of these scientists attended undergraduate college or university—typically for four years, earning a Bachelor's degree in science, engineering, or arts—where their vision of science broadened. Some learned firsthand that you can "do science" in a lab or outside of the lab, "in the field." Most learned for the first time what it meant to *do* research: A problem is identified, a solution is considered, an experiment is designed to test possible solutions, new tools and techniques are created to test more and different solutions, data collected from these tests are analyzed, and results are published to ensure that solutions are more than an accident of circumstances. Additionally, and perhaps most valuably, these aspiring scientists learned that science often deals with improving our health or developing a product that improves our everyday life or the community and world that we live in.

Some of these future scientists enjoyed doing research so much that they went on to graduate school, taking more classes and doing more research. They earned a Master's of Science (MS, which takes about two years) or a Doctor of Philosophy (PhD, which can take around 5–7 years). A few scientists did even more training and research after graduate school, either in companies or at universities as postdoctoral scholars (or postdocs), which is usually an important experience needed if you want to be a research university professor. Many also had fellowships or internships where they worked to acquire even more new skills. At each stage, these scientists learned of more ways in which they could apply their knowledge and skills in a variety of jobs. The range of experiences presented in these vignettes illustrates the limitless ways and potential educational pathways that one can be a scientist.

The vignettes are intended to be read and discussed by 9th–12th grade students, although we know others will find them useful as well. To facilitate a classroom discussion and personal reflection, we have included questions at the end of the chapter. We have also included a timeline that accompanies one vignette and highlights crucial decision-making points and events along this particular career trajectory. The following vignettes combine science with:

- Art
- Radio
- Education
- Traveling
- Journalism
- International Studies
- Editing
- Government
- Religion
- Video Games
- Test Question Evaluation
- Human Rights
- Law

Vignette 1: Combining Science and Art

Two people gifted in both science and art followed completely different paths to arrive at the same job. Chris always knew he loved science and eventually combined it with his art. Yana grew up as an artist and never considered science until she was in college. Regardless of the route they took, both Chris and Yana now agree that they were born to be medical illustrators from the start—they just didn't realize it!

Chris Bickel
Yana Hammond
Illustrators at Science *Magazine, AAAS*
Written by Melissa McCartney

Chris:
High School: Patrick Henry High School, Hanover, Virginia
Undergraduate (BA degree in medical illustration): 1 year of Illustration at Virginia Commonwealth University, Richmond, Virginia and 3 years at Rochester Institute of Technology, Rochester, New York

Yana:
High School: International High School in Israel
Undergraduate (BA degree in medical illustration): 2 years at Monroe County Community College, Rochester, New York and 2 years at Rochester Institute of Technology, Rochester, New York

A documentary on sharks is what convinced Chris Bickel that science was for him. "That documentary inspired me to be a marine biologist (someone who studies organisms in the ocean)," he says. "I was so into science that I used to wear a lab coat around for fun." Yana Hammond always thought of herself as an artist. "I wanted to be an artist since I was two years old," she says. "I always knew my path—I just didn't know what the details would be." How did two people with such different childhood ambitions end up working at the same job?

Chris has his mom to thank. "I was drawing pictures of human body organs and bones at age 4," Chris says. "My mom was an artist herself so she not only supported my drawings but helped me to learn more about medical illustration (the field of creating pictures, figures, and diagrams from scientific information) as I was growing up." Yana credits an art history professor who showed her works by Leonardo da Vinci. "da Vinci was one of the earliest medical illustrators," she says. "It was the first time I considered combining art with science."

A degree in medical illustration requires many hours of honing artistic skills, and also includes a rigorous schedule of science classes, including anatomy. "We took immunology, cell biology, and embryology with the science students," Yana says. "It was pretty much a global overview of advanced science with a concentration in anatomy." And what a concentration it was! "We took 350 hours of cadaver dissection as part of our anatomy class," Chris says. "That is twice as many hours as the medical students." The anatomy class also included time in hospital operating rooms, studying what the human body looks like in real life. "Once you train as a medical illustrator, nothing gory bothers you anymore," Chris says. Yana laughs and agrees. "When we were in school it seemed that the gorier something seemed, the cooler it was!"

At *Science* Magazine, Chris and Yana work with scientists who have authored scientific papers that will be published in the magazine. These scientific reports almost always have data accompanying them, and it is Chris's and Yana's job to bring an artistic view to this data by turning it into a scientific figure. "I love this combination of art and science," Yana says. "To me, the best part about my job is finding the perfect balance between making the data visually appealing and keeping it accurate." Chris enjoys earning the respect and appreciation of the scientists with whom he works. "It is great to realize that I have helped a scientist make their scientific paper better by turning their data into art."

While working as a medical illustrator requires a traditional art background in painting and drawing, it also requires the ability to translate this background to digital media. "As an artist, I was trained in traditional painting and drawing," Yana says. "This is still critical, even in the age of computers. An artist has the ability to see things in terms of light and shadows, and computers are not able to do that for you." Chris agrees, adding, "Computer art is still art; the computer is just another tool artists can use."

The science Chris and Yana learned in their scientific training is just as important as their training in art. "When we talk to scientists, we need to understand their research in order to turn their data into art," Yana says. "In this regard, I appreciate my classes in molecular biology." Chris is equally grateful. "In our particular jobs we interact with prominent scientists," he says. "Having a background in science helps us to communicate with them first as scientists, and we can then translate their science to art."

To aspiring medical illustrators, Chris and Yana have similar advice: Be as versatile as possible, with both your science and your art. "To be a successful medical illustrator you should not be too science-based or too art-based," Chris says. "It is important to have a sense of both and to know when to use either." Yana agrees. "I was talented in art as a kid so I geared away from science completely," she says. "I would recommend being more open-minded. Try new things and broaden your experiences as much as you can." A final piece of advice from Chris: "Concentrate on drawing still life or figure drawings because no medical illustrator program will accept you if you can only draw stick figures!"

♦ ♦ ♦

Vignette 2: Combining Science and Radio

For Kirsten "Kiki" Sanford, some unexpected personal circumstances helped her transform her passion for science into a talent for teaching others through popular media. With the help of mentors who taught her how to effectively communicate with audiences less familiar with technical scientific information, Kiki transitioned over to science journalism and now uses her science background to connect with others through her radio program This Week in Science and her online video show Dr. Kiki's Science Hour.

Kirsten "Kiki" Sanford
Host and producer for Dr. Kiki's Science Hour *and* This Week in Science
Written by Rahman A. Culver

High School: Linden High School, Linden, California
Undergraduate (BS in wildlife, fisheries and conservation biology): University of California, Davis, California
Postgraduate (PhD in molecular, cellular and integrative physiology): University of California, Davis, California

"When I was young, I aspired to be an Olympic gymnast like Mary Lou Retton. But, unfortunately, that's not really something you can have as a job," Kiki says. She also dreamed of a career in wildlife biology and saving the whales. Elementary and high school consisted of a science fair project here and there and a range of scientific subjects, including biology, physics, and chemistry.

As an undergraduate, Kiki had her first laboratory experience. She found a job working in a medical research lab taking care of sheep, and later enrolled in a summer program where she learned about research scientists who work outside of the laboratory, known as field research. The summer program encouraged her interest in birds and inspired her to pursue a job working as a student research assistant in a bird memory lab. It was in this lab that she learned many skills in cell culture, experimental design, and behavioral assessment.

Halfway through her graduate school studies, her advisor took a new job in England. Kiki found herself without a lab and no clear way to complete her research. She decided to take a leave of absence from graduate school to figure out what to do next. It was this break that really changed her career path. While in graduate school, she was doing an online radio program called *This Week in Science* (TWIS). When she left her studies, she also took a leave from the radio show. It was during this time that she realized she missed the radio show more than a collection of bird brains. This insight prompted her to return to graduate school with a new goal of using her scientific training for a future career in science media. In leaving everything behind during her time away, she was able to gain perspective and find her passion.

Kiki first started to explore a career in science communication by reaching out to science writers around the country to learn from their experience. "Their advice was invaluable to me in my decision-making process, even though most of them told me that you don't need a PhD to be a science writer," says Kiki. She explains that she was lucky to have very flexible and understanding graduate advisors. "Knowing my goals, they supported my focus on communication in addition to the research," says Kiki. "Not all advisors will back students who aren't dedicated to a career in academia."

While in graduate school, Kiki applied for and was selected to be a AAAS Mass Media Science and Engineering Fellow. Her fellowship mentor remains instrumental in teaching her how to think and write for a television news audience. She recommends the fellowship to anyone who wants to get into TV: "You learn by doing."

"My job is something that didn't exist when I started graduate school. The internet was really rather new, and online media was just getting started," explains Kiki. In the early 2000s, she and her colleagues made a website for the show (*www.twis.org*) and began posting MP3 files for listeners. That led to podcasting, which then introduced her to a whole community of people excited about this new media world. She started working in video after meeting a video podcaster.

Kiki definitely relies on the basic scientific information she learned in graduate school. And yet, because she has been covering many different subjects for the past few years, she has gained a lot of knowledge about areas she never studied in school, such as astrophysics, robotics and paleontology. Her favorite part of what she does is traveling to all sorts of places to talk to scientists, engineers, and inventors.

"To work in science media, there isn't any one scientific background that is required or that is useful," says Kiki. However, being an expert in something is helpful; it gives you credibility with other scientists and with the audience, and it gives you an insider's understanding of how science works, she adds. "Additionally, it is imperative that you are passionate about whatever you choose to do. Whether physics, biology, brains or a combination of everything, the audience will know if you are genuinely interested in it."

Kiki recommends exercising an insatiable curiosity about everything and a true enjoyment of communicating what you learn to others. Also, it doesn't hurt to learn how to write. "If you want to do things in the online space, start doing it: blog, video blog, podcast, whatever. Or, volunteer or get an internship with someone who is doing what you want to do," she says.

Finally, Kiki found combining her passion for other interests with her scientific pursuits extremely successful. "I have been known to hula hoop with fire!" says Kiki. Many scientists dabble in dancing, playing the guitar, or painting to get their creative juices flowing. Science does not exist in a bubble and is a creative process just like art and music. Her advice to others looking to combine science with other career interests is simple: "Yes, do it!"

♦ ♦ ♦

Vignette 3: Combining Science and Education

Throughout her career, Melissa McCartney has never been afraid to head in a new direction. Because she asked people for help, tried new things, and constantly thought about what she enjoys doing, Melissa was able to successfully transition from her career in neuroscience to her current position as an Editorial Fellow at *Science* magazine.

Melissa McCartney
Editorial Fellow at Science *Magazine, AAAS*
Written by Anne Poduska

High School: Kenmore East Senior High School, Buffalo, New York
Undergraduate (BS in biochemistry): State University of New York at Binghamton, Binghamton, New York
Postgraduate (PhD in neuroscience): The George Washington University, Washington, D.C.
Postdoctoral research (in neuroscience): Children's Hospital of Philadelphia, Philadelphia, Pennsylvania

As a swimmer, Melissa always wanted to grow up and become a swim coach. However, her high grades in math and science caught the attention of her teachers. "I didn't really have the greatest guidance in high school. I was told that if you were smart and got good grades you should go into science," says Melissa. "And not just any science—it had to be biology so that you could then become a doctor or a dentist. Looking back, I wish I would've had different advice, but at the time all I knew was that I liked science!" Although Melissa was most interested in chemistry, she tried to follow the advice given to her and eventually went for the best of both worlds: biochemistry, a scientific area that looks at how the chemistry of molecules can affect biological organisms.

While in college, Melissa worked with one of her chemistry professors on an independent research project. "I still remembered that I was supposed to be a doctor or a dentist, but I really loved my chemistry research. I remember one day my professor said to me, 'I don't know why the brightest minds always go to medical school when they are equally suited to becoming scientists.' It was then that it finally clicked in my head—I didn't have to be a doctor!" Melissa also spent a summer doing research at a cancer research institute where she decided to use her biochemistry background as a stepping-stone to becoming a research oncologist, someone who does research to cure cancer.

To become a research oncologist, Melissa needed to earn a PhD. Along the way, she took a course in neuroscience—the study of the nervous system, including the brain, spinal cord, and neurons throughout the body. "I found neuroscience absolutely fascinating. It was the first time that I thought of our brains as a mystery to be solved, rather than a bunch of diagrams in a textbook," says Melissa. She enjoyed neuroscience so much that she switched the concentration of her PhD to neuroscience, and continued doing neuroscience research at a hospital in Philadelphia.

Melissa was not completely satisfied being in a lab, doing the same brain research every day. She knew that she wanted to do something different—but she didn't know what. "Almost on a whim I decided to apply for a fellowship doing science policy work at the National Academies of Science," says Melissa. "It was a short fellowship and seemed like a good way to try something completely different from both neuroscience and the lab without making a huge time commitment. During this fellowship, I realized that there are so many different ways to be a scientist. I learned the importance of scientists in policy making when I went to a hearing at the U.S. House of Representatives and scientists were giving advice about how electronics, such as computers and cell phones, could be disposed of without hurting the environment. The politicians knew they had to regulate this somehow and they were relying on the scientists to give them the best advice."

Melissa enjoyed this three-month fellowship but did not have a clear picture of where to go next. Fortunately, her fellowship director told her that *Science* Magazine needed a summer intern to get some educational projects up and running. Melissa applied and has been working as an Editorial Fellow at *Science* Magazine ever since. She currently runs the research and development behind several educational projects implemented through the magazine. For example, she helped to design the *Science* Prize for Online Research in Education (SPORE), recognizing the best science education websites. "My science background is invaluable in this position," says Melissa. "I can understand the science on the websites and find appropriate scientists to help judge the competition. My analytical and organizational skills that I used in research have helped me design and carry out the logistics of this project."

In this job, Melissa loves the variety and the new challenges that arise every day. "Every morning when I check my e-mail, someone has sent a new idea for a possible education project, there are questions I need to answer regarding our current projects, or someone has sent an invitation to collaborate," says Melissa. "I feel more like a scientist than I ever did in the lab because I get to think about all kinds of science, whether it's the science of planets, oceans, or viruses."

In order to make this transition from science research to science education, Melissa found that a valuable perspective to have is that science is always part of a broader picture. "One of my biggest mistakes after high school was that I only took science classes: I didn't take economics, history, or a foreign language. I wish that I would have tried a variety of classes instead of just being focused on science because, in the end, it was very limiting. I think that having more variety in my undergraduate experience would have helped me to see more opportunities for my science interests earlier on," says Melissa.

If you are ever thinking of trying something new in your life, whether it's becoming a scientist or a chef, keep in mind Melissa's advice: "In reality, most people don't know what is coming next. If you feel that way too, that's normal—and you're in good company. Just make sure that you are doing something that you like and the rest will fall into place!"

♦ ♦ ♦

Vignette 4: Combining Science and Traveling

Rieko's curiosity and dedication helped shape her career to collaborate with scientists around the world, first starting with her undergraduate and PhD research in chemistry and biology, and continuing in her current position as Project Director for the Research Competitiveness Program at the AAAS.

Rieko Yajima
Project Director in the Research Competitiveness Program, AAAS
Written by Anne Poduska

High School: Saltfleet High School, Stoney Creek, Ontario, Canada
Undergraduate (Honours BS in biochemistry with a biotechnology option): University of Waterloo, Waterloo, Ontario, Canada
Postgraduate (PhD in integrative biosciences with a chemical biology option): The Pennsylvania State University, University Park, Pennsylvania

Rieko first became interested in science when she went with her mother to the makeup counter at a department store. She saw a display of sunscreen products and there were pamphlets at the counter to explain what skin cancer was and how sunscreen is important. "I was fascinated by these new products and I knew that science had to be involved somewhere to understand skin cancer," says Rieko. "It seemed like skin cancer would be a problem that wouldn't go away for a while, so I wanted to be a skin cancer researcher."

However, science classes were a struggle for Rieko at first. "I failed my first science test—it was in photosynthesis—in fifth grade because I was bad at memorizing and couldn't remember the definitions," says Rieko. With time, Rieko was able to excel at science because she took extra time to read the science textbooks and put the concepts into her own words.

Rieko started on the pathway to becoming a skin cancer researcher by earning an undergraduate biochemistry degree. "In high school I enjoyed biology and chemistry and since both subjects seemed appropriate for understanding cancer, I chose to study them both," says Rieko. "During my sophomore year I learned what biochemistry was about—and luckily it turned out to be a good decision because this scientific subject was the closest match to my interests."

Rieko also discovered that she could be a biochemist anywhere in the world. She spent one semester in Cuba interacting with other biochemists and learning Spanish. She also did research on plant proteins at a beer brewery in Japan. "This was the first experience where I learned what it was like to do research," says Rieko. "I saw that there are trial-and-error processes in science, and I learned how to design experiments carefully and to make sure you can get the same results many times. I also had really good mentors that taught me a lot about science that was not covered in textbooks."

From these international experiences, Rieko learned she was interested in helping scientists do research in developing countries, even when they might not have the money or laboratory supplies they need. She also learned that she needed more scientific training in order to be a better scientist. Moreover, she found a new area of science that she liked better than her dream of being a skin cancer researcher: she liked to study the shape of molecules and understand what the molecules do in biological systems. "I chose an interdisciplinary research program for my PhD because I wanted to know about a lot of scientific issues but still do biochemistry," says Rieko. She did her PhD in the United States, studying the hepatitis delta virus, which can cause liver damage in humans. "Up until that time, little was known about what this molecule looked like," says Rieko. "Our laboratory had good ideas to address this challenge and I received a research fellowship to examine the virus structure: the research would provide important clues as to how the virus is able to survive," says Rieko.

During her PhD studies, Rieko saw science in a new light. Once a month, scientists would visit her school, eat dinner with students, and talk about how their research can affect science policy (for example, how the government makes rules to protect the environment). Rieko became interested in science policy and was a Christine Mirzayan Science and Technology Policy Fellow at the National Academy of Sciences, where she worked with the Committee on Science, Engineering, and Public Policy and the Board on African Science Academy Development. One of her projects involved helping scientists in Africa provide advice to their governments about human health issues, such as clean water and vaccinations.

After this fellowship, Rieko realized that she would like a job in science policy but still wanted to maintain her interest in research. In her current position as Project Director for the AAAS Research Competitiveness Program, she works with universities to advance science and help states improve their economies by using science and technology. "I work with the scientific community to provide advice on how scientific research can be improved," says Rieko. "We do this with peer review, where scientists analyze the work of other scientists and then explain whether it is good and where it can be improved. Peer review can be used in all sciences and anywhere in the world."

Rieko found that it was initially difficult to look for the right science policy job. "I had to stretch beyond my biochemistry background and show how my science skills could relate to science policy," says Rieko. However, by thinking about what she is good at and how others might appreciate her skills, Rieko was able to make a successful transition from science research to science policy.

Rieko recommends the following to anyone who might be interested in science but finds some aspects challenging: "Keep in mind that science isn't about memorizing vocabulary," says Rieko. "It's really about whether you're asking the question 'Why?' and if you're curious in general—that's the start of being a scientist. Don't be afraid if you struggle with science and find it tough. Just keep in mind that you never stop learning and asking questions when you are a scientist—it's a life-long learning process."

♦ ♦ ♦

Vignette 5: Combining Science and Journalism

While navigating several career paths, Robert Frederick has always done what he was interested in. Because he was never afraid to try new things and kept in close contact with his roots as a mathematician, Robert was able to successfully transition through careers in business, publishing, and education before landing his current position as the weekly podcast host at *Science* magazine.

Robert Frederick
Podcast Host at Science *Magazine, AAAS*
Written by Melissa McCartney

High School (graduated with an IB diploma): Booker T. Washington, Tulsa, Oklahoma
Undergraduate (BA in math, statistics, and philosophy): University of Chicago, Chicago, Illinois
Graduate (MS in applied and interdisciplinary math): University of Michigan, Ann Arbor, Michigan

Robert Frederick may have been the only person disappointed when plans were announced for the International Space Station. "I really liked rockets when I was a kid," he says. "I thought people should have somewhere to go once they get to space. I was disappointed that the International Space Station was planned before I finished college because I was hoping to be the one to design it." Despite this very minor setback, Robert still made the most of his undergraduate years by receiving degrees in math, statistics, and philosophy in four years. "Thanks to the International Baccalaureate (IB) program, I was well prepared and could test out of introductory chemistry, math, physics, and a language," says Robert. "It freed up a lot of time and allowed me to try out a lot of things."

With three degrees in hand, Robert took his first job as a management consultant in an unfamiliar setting: business. "I programmed computers, but really it was an opportunity for me to check out the whole business world at once," says Robert. "What I learned was that business-world consulting was not for me—I wasn't connected enough with what was being done or made." His next job, as a mathematics textbook editor at a publishing company, brought him closer to his roots. "I was hoping to change the world one textbook at a time," he says. While working as an editor made Robert happy, he wasn't completely satisfied—"It was still too removed," says Robert, so he became a high school math teacher, which he describes as "a chance to redirect my math skills and focus on changing the world 20 students at a time instead."

Spending his days surrounded by math brought back some old memories. About eight years earlier, he was lucky enough to witness a space shuttle launch in person. "As I stood there watching the shuttle head into space, I thought about everything that had gone into this moment, all the math and engineering, and tears came to my eyes," says Robert. "Seeing my students excited about math made me think about this moment and I decided it was time to go back to graduate school."

Robert was able to leverage his teaching experience to earn a teaching fellowship that paid the tuition for his master's degree. "I was happy to be back learning math full time again, but applied math was really different from pure math," he says. (Applied math is used to solve more applied, real-world problems, whereas pure math is used to advance the field of mathematics.) "It took so much time and there were so many things that could go wrong. It was so different from my undergraduate experience." It was during his first-ever "all-nighter" working on a problem set that he saw an announcement for the AAAS Mass Media Science and Engineering Fellowship in the *Journal of the American Mathematical Society.* "I applied and before I knew it, I was working at KUNC Colorado, an NPR affiliate, telling stories about science on the radio," says Robert. "I was hooked!"

Robert found that the best part of the fellowship was "getting to study the art of storytelling like it was a type of math or science," says Robert. "I learned storytelling from my mentors at KUNC." When the fellowship ended, Robert finished his master's degree and became a science journalist. Eventually, he ended up at the NPR affiliate in St. Louis, where he helped start their science reporting and served as their first science journalist. This was the experience he needed to make his next move to podcast host at *Science*. "The favorite part of my job," says Robert, "is being able to talk to scientists about what they are truly excited about when they're the most excited about it—when they are announcing new findings to the world."

Looking back, Robert credits his love for science to his high school chemistry teacher. "He was the first person who showed me that science was not cut and dry. Sometimes things didn't turn out as expected." He also credits his ability to easily move among several professions to one of his history professors in college. "He once told me, 'Mr. Frederick, you are so well-rounded that you will roll in any direction I push you. Try something. If you don't like it, try something else,'" says Robert. "That was the best career advice I ever received, because in looking back, all of my past jobs had an aspect that I really liked, and I made sure all of my future jobs were able to include those aspects."

Science and math remain a part of everyday life for Robert. "Part of my job is to explain to my listeners how science gets done," says Robert. "To do this, I need to constantly rely on my knowledge of the scientific process. Every time I read a new study and prepare to interview another scientist, I know how to pull out the parts of their story that are part of every scientific story, and this makes it easier for me to ask the right questions."

Robert offers the same advice he was given by his history professor to any students who are considering a career in science, but adds: "Don't confuse what you are good at with what you like," says Robert. "Be careful, because this may not be what your parents or teachers want you to do based on your abilities at the time. If you like what you are doing, you are much more likely to become good at it."

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Vignette 6: Combining Science and International Studies

Throughout his career, Tom Wang wanted to balance his interests in history, political science, and the social sciences with his engineering and technology interests. He found this equilibrium by taking political science and business courses while he did engineering science research, which prepared him for his current position as the Director for International Cooperation and the Deputy Director of the Center for Science Diplomacy at the AAAS.

Tom Wang
Director for International Cooperation and the Deputy Director of the Center for Science Diplomacy, AAAS
Written by Anne Poduska

High School: Santa Monica High School, Santa Monica, California
Undergraduate (BS in chemical engineering, BA in political science): University of California, Berkeley, Berkeley, California
Postgraduate (MS in chemical engineering practice and PhD in chemical engineering): Massachusetts Institute of Technology, Cambridge, Massachussetts

As a child, Tom Wang enjoyed playing computer games and making different colored fires with his chemistry set, so he dreamed of being either a computer programmer or a chemist. However, his middle and high school history and political science classes were also interesting because his teachers transformed the textbook ideas into real-life stories. So, when Tom went to college, he studied both political science and chemical engineering. "I chose chemical engineering even though I had no idea what it was," said Tom. "I liked chemistry, I knew I wanted to build things—and since engineers build things, I thought I should be a chemical engineer!" Tom chose political science because "in history, you learn about the past," according to Tom. "In political science, you look at how the past and present can help you achieve goals."

While he was an undergraduate student, Tom decided to continue his studies in graduate school for several reasons. First, he liked to use his imagination to figure out something that no one else has done before, and he could do that with a graduate degree. Second, he had worked with university researchers and graduate students in laboratories during the school year and interned at engineering companies, and he learned that he enjoyed doing science research in a lab. However, Tom had to decide if he should study chemical engineering or political science; eventually, he decided to continue with science because it seemed like it offered more practical career options.

During graduate school, Tom studied the chemistry and physics of nano-thin films. These thin films can be more than 100 times thinner than the aluminum foil found in kitchens and can be put onto surfaces to change the properties. For example, the nano-thin films can be put on the surface of contact lens to make the lens feel wet in your eye while keeping your eyes healthy by allowing oxygen to reach the part of your eye under the contact lens. While Tom did his thin film research, he also pursued his interest in the social sciences by taking classes in political science, business, and management. Although Tom did continue doing science after his PhD at a company—this time doing drug delivery–related research—and gained experience in the business world, it wasn't until receiving a AAAS Science and Technology Policy Fellowship that he had a career combining his interest in science and political science.

Tom worked for the State Department in the East Asia Bureau for two years on a wide array of international issues. These projects had a scientific component and affected the United States, including disaster management after the 2004 Asian tsunami, agricultural trade issues, and health cooperation. "I found that my science background helped me in several ways," says Tom. "Having a science PhD degree helped me gain credibility when I was negotiating with people from other countries because they often value higher education and science. Getting a PhD is not just about becoming an expert in a very specific area like nano-thin films, but it is also learning how to approach complex questions and problems and finding ways to answer them. This skill can be applied in the policy world as well and I used it to understand the many international issues that I had to address."

After finishing his fellowship, Tom became the Director for International Cooperation and the Deputy Director of the Center for Science Diplomacy at the AAAS. He helps build relationships between the AAAS and organizations abroad, and he is also involved with a field called "science diplomacy," which uses scientific collaborations to promote better relationships among countries. "I enjoy this job because I can work with international organizations on problems that will benefit everyone," says Tom. "I also get to build something new—I get to help define and educate people about what is science diplomacy."

Tom did find that there were obstacles during his career change. "I found that the policy world and the science world were very different," says Tom. "In the policy world, you have to be very good at dealing with many people from many different areas and who might not speak your language. In the science world, you are in a small community and you work on narrowly focused problems." Although it was difficult at times, Tom found that he was able to make this transition because he was so interested in science and policy and had explored these new environments while in college and graduate school so that he could adapt quickly.

When preparing for a career, Tom recommends the following: "These days, you are expected to juggle many things and are pushed to be the best at everything. That's impossible and unproductive. Try your best at everything but pick a couple of things that you like and really master them. Keep in mind, though, that it takes time to develop mastery in any one thing—and it might not be possible to do both things at the same time—so you also need to have patience and perseverance."

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Vignette 7: Combining Science and Editing

Nick Wigginton has always felt connected to the environment. Throughout his career, he found many ways to explore this connection by studying geology, biology, and environmental science. Nick's diverse scientific background made him the ideal candidate for his current position as an Associate Editor of Geoscience at *Science* magazine.

Nick Wigginton
Associate Editor of Geoscience at Science *Magazine, AAAS*
Written by Melissa McCartney

High School: Holt Senior High School, Holt, Michigan
Undergraduate (BS in geology): Michigan State University, East Lansing, Michigan
Graduate (PhD in biogeochemistry): Virginia Polytechnic Institute and State University, Blacksburg, Virginia
Postdoctoral Research (in environmental microbiology): Ecole Polytechnique Federale de Lausanne, Switzerland

As a child in the early 1980s, Nick knew exactly who he wanted to be when he grew up. "Indiana Jones!" exclaims Nick. "He was always on an adventure, traveling the world, saving treasures from bad guys, and making sure the artifacts were preserved in museums." Nick had an alternate career plan, just in case. "I did also want to be a veterinarian if the adventure archaeologist plan didn't work out," he says.

In the end, the veterinary career path won out, and Nick entered college ready to take the required biology and chemistry classes. "I quickly realized this choice of a career path wasn't for me," he says. "There was too much pressure and too much emotion involved. I enjoyed the environmental side of biology. Hiking and fishing had always been a part of my childhood, but there wasn't enough of it in the biology I was taking." Nick ended up switching majors to geology: "I didn't really know much about it, but I wanted to know more," says Nick. "I also thought it would help me stay close to the environmental science that I enjoyed." This turned out to be a great decision, as he went to Brazil and studied the environmental effects of deforestation, the cutting down of trees, along the Amazon river. It wasn't quite an Indiana Jones–type adventure, but working to preserve the ecological treasures of the Amazon was pretty close!

In graduate school, Nick wanted to add more expertise to his growing background in geology and environmental science, and decided to give biology another chance. "I decided to study environmental microbiology," he says. "This allowed for me to visit the Pacific Northwest National Laboratory. It was a chance to incorporate biology with my geology to study the impact that the waste coming from nuclear plants could have on the environment."

As Nick started thinking of where to go next, he realized that he did not want to be a professor. "I found that writing about my research was more interesting to me than actually doing the research. I started asking around for advice and networking with scientists who were in non-academic careers. I found that pretty much everyone recommended I do a postdoctoral fellowship before I looked for a nonprofessorial job. So, I started looking for postdoctoral fellowships."

Fresh off a move across the Atlantic, Nick began his postdoctoral research in environmental microbiology in Switzerland. Less than a week later, the networking he had done paid off when a phone call came from *Science* Magazine offering him an interview for an open position as a geology editor. "I was scared to tell my postdoctoral advisor since I had literally just started in the lab," he says, "But she was very encouraging and didn't place any pressure on me to stay and finish the postdoc."

Nick credits his success as an editor at *Science* to his extremely broad scientific background. "I can basically cover three areas: environmental science, geology, and parts of biology," says Nick. "Because my research projects throughout my schooling were so different, it made it easy for me to transition into this position where you are constantly reading scientific studies that are outside of your immediate area of expertise." Nick says his training in several labs under several different professors was also valuable. "When journals are looking to hire new editors, they are really looking to hire good scientists. They will train you as an editor when you get here, but being exposed to a variety of science and publishing your own work in several areas makes you a very appealing candidate for the job."

Even for Nick, who knew he did not want to be a professor, making this career change was daunting. "It felt like I had decided to walk away from science as soon as I was getting good at it," says Nick. However, he soon realized that being good at science helped him do his job well. "At my job, I am constantly learning about a huge range of topics," says Nick. "Every day a paper shows up on my desk and by the time I am done reading it I have learned several new things. It may not be my own research, but it is still cutting-edge research and I am still getting to be a part of it. Plus, some days I am able to accept an author's paper [to be published], and it is such a great feeling knowing that you made their day."

For young scientists looking to follow in his footsteps, Nick does have some advice. "Take as many different classes as you can, because you may take a class you knew nothing about and it could end up becoming your passion," says Nick. "If your passion does lead you to science, make sure you take every chance you get to actually work in a lab because that is the only place to learn how science is really done."

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Vignette 8: Combining Science and Government

Jeff's interest in finding the "practical side" of science drew him to do research on computer models of dog hearts, which combined his biology, math, and physics knowledge. It was this same desire to apply scientific knowledge to everyday life that prompted Jeff to work in science policy at the U.S. Department of State, where he currently supports science education activities between African countries and the United States.

Jeff Fox
AAAS Science and Technology Policy Fellow
State Department's Bureau of African Affairs, Office of Public Diplomacy and Public Affairs
Written by Anne Poduska

High School: Theodore Roosevelt High School, Kent, Ohio
Undergraduate (BS in physics with a minor in cognitive science): The Ohio State University, Columbus, Ohio
Postgraduate (MS and PhD in physics with a minor in physiology): Cornell University, Ithaca, New York

When he was young, Jeff Fox was always interested in science. "I was curious how things worked and I liked space ships, so I wanted to become an aerospace engineer," says Jeff. In high school, Jeff enjoyed his physics courses, especially the math. His teacher showed him how the physics ideas in his textbook can be found in everyday life. "In high school, I thought that if you were good at science and math, you became an engineer," says Jeff. "However, I didn't know what it meant to be an engineer—but I also didn't know what a physicist did!" After taking both physics and engineering classes in college, Jeff realized that he preferred physics because it focused more on understanding how things worked, whereas engineering was more concerned with making ideas work in real life.

During graduate school, Jeff found a new scientific area to combine with his math and physics interests: biology. "I found that you could take physics knowledge and apply it to problems that could potentially have a really big impact on people's lives," says Jeff. He worked with his physics professor and a veterinarian professor to find out what causes dog hearts to beat irregularly, a condition that can cause a heart attack.

Jeff continued to work on this problem after he completed his PhD, working for a company on cancer and heart-related problems. It was during this time that Jeff became interested in other, more immediate ways to help society. One way he did this was as a math tutor for low-income elementary school students. While tutoring, Jeff was puzzled because he observed that some schools and students did not receive sufficient support, even though education is important for getting a good job and being a productive citizen. Jeff shifted his interest to learning more about how government makes rules and decisions, especially about science and education, and hopefully, to help it make better ones.

This interest lead him into an area called "science policy," where he could use his scientific knowledge to help the government make laws, such as ones to protect the environment or improve science education in schools. Jeff sought and earned a one-year Congressional fellowship through the American Institute of Physics and the Acoustical Society of America, which allowed him to work with a U.S. Senator on science education issues. "During this fellowship, I spent a lot of time talking to people from New Mexico to learn what was important to them, especially in the area of science education," recalls Jeff. "I found that having a science background made it easier for me to talk about science-related issues to both scientists and to people who didn't know much about science. I also found that a scientific approach to solving problems was useful and needed in science policy work."

Jeff liked his work in Washington, D.C. and was interested in working in the executive branch on international issues, so he pursued his current position as an AAAS Science and Technology Policy Fellow in the State Department's Bureau of African Affairs, Office of Public Diplomacy and Public Affairs. Jeff currently works on a number of projects, which include supporting science education collaborations between the United States and African countries, such as South Africa, Ghana, and Ethiopia. This effort promotes "science diplomacy," which uses scientific collaborations to build better relationships among countries. He also works on other nonscience projects. For example, the top priority for his office is to engage young African leaders and to support their efforts to improve their country's future.

Although Jeff enjoys his policy work, he found that the career change process was scary. "It was a big risk, a big change," says Jeff. "But I had time to think about my move from physics research to science policy, and I approached the problem in an analytical way, which made me feel less uncertain. I wrote down the list of things I might do, I investigated all of them, and at the end, I felt the most comfortable with science policy."

Jeff believes that his transition could have been easier if he had focused more on his writing and speaking skills during school. "I recommend that students take seriously those classes that involve writing and communication," says Jeff. "I wish I were better at them. In a lot of science communities, people think that communication skills are less important than scientific skills. However, if you can't communicate, you have no chance—people won't understand your ideas and you'll limit yourself tremendously."

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Vignette 9: Combining Science and Religion

One question has shaped Peyton West's career: "What would I do if I could do anything?" With some courage and hard work, Peyton discovered multiple answers to her question. Starting with an English degree and work in the publishing industry, she went on to research lion manes in Tanzania and earned a PhD in ecology. Peyton now works as Project Director for the AAAS Dialogue on Science, Ethics, and Religion where she encourages dialogue and understanding between the scientific and religious communities.

Peyton West
Project Director, Dialogue on Science, Ethics, and Religion, AAAS
Written by Anne Poduska

High School: The Brearley School, New York City, New York
Undergraduate (BA in English): Yale University, New Haven, Connecticut
Postgraduate (PhD in ecology): University of Minnesota, Minneapolis, Minnesota

When she was younger, Peyton had many career interests: She considered being a writer, astronaut, architect, and zoologist. During high school, Peyton put aside her scientific interests because she hated science. "Science was my worst subject," says Peyton. "It was too structured and I felt like it wasn't creative. It seemed like you did things to arrive at conclusions that everyone already knew. There was no real surprise at the end and it didn't feel like you learned anything."

In college, Peyton continued to avoid science because she didn't enjoy the way classes were taught, so she studied English instead. However, after finishing college and working in publishing, Peyton started to feel restless. "I worked in a few different fields, such as publishing, but wasn't passionate about any of them," says Peyton. "I went back to square one and thought, 'What would I do if I could do anything?' I knew I loved animals and figured that was a place to start."

Already thinking like the scientist she was destined to become, Peyton decided to test her idea in small steps. "I first volunteered at an animal shelter, socializing stray cats," says Peyton. "Next, I volunteered at a zoo where I helped with the rehabilitation and captive breeding of raptors. All along, I was trying to see if this was what I wanted—and I kept on telling myself that I could turn back at any point." From these experiences, Peyton realized that, if she wanted to have a career working with animals, she needed a science education. "I figured I could give it a try, even though I disliked science," says Peyton. "I took the only science class, physics, that was available at a community college nearby and to my surprise I loved it. My professor was fantastic and the course had a lot of math in it, which I enjoyed. It wasn't specifically relevant to what I wanted to do, but it gave me the confidence to move in a scientific direction."

When Peyton consulted a science professor about her potential career change, she got lucky: He offered her a research job in his microbiology lab, where she helped with basic lab tasks and eventually began a research project. At the same time, she volunteered at another zoo and took more science classes at a nearby state college. "I was required to do an internship for a class, so

I researched what diets could improve muscle growth in young cranes," says Peyton. "This was a fairly anecdotal process and I realized that I was more interested in the rigorous lab research I was doing."

Peyton decided to go to graduate school to study conservation and the preservation of endangered species. "I only had a minimal science background—two years of biology and one year of chemistry—but I applied anyway," says Peyton. "I wrote a passionate letter to an ecology professor who was doing fascinating work about my interest in working with animals but this actually had an unintended effect—he branded me as a 'bunny hugger' and disregarded my letter. Happily, another professor read it and persuaded him to take a chance on me."

Peyton's first year of graduate school was difficult. "I only got through that first year because I was so excited and I knew what I wanted to do," says Peyton. "I had to take so many classes and read journal articles, which I had never done before. I found it exhausting and stressful." Graduate school became easier with time, and Peyton spent the next six years doing research on lion manes in Tanzania, living in Africa for nine months and then studying in the United States for six months. "Nobody knew why lions have manes or why some are darker than others," says Peyton. "I was very excited to find out the answer to this very basic question."

As she was finishing her PhD, Peyton realized that she didn't want to have a career that spanned two continents, so she worked at a zoo, doing research and managing animal care and breeding. After years of observing animals in the wild, though, she found it challenging to care for animals in a captive environment. Peyton decided to leave the zoo to start a family, and after a few years, she asked herself the question again: "What would I do if I could do anything?" At the time, the debate about teaching evolution in public schools had been reinvigorated by a press to teach "intelligent design" in biology classes. Believing this practice to be inherently unscientific, Peyton decided that she wanted to help people understand evolutionary theory.

Peyton is currently the Project Director for the AAAS Dialogue on Science, Ethics, and Religion; she works to deepen societal understanding about science and values. This includes designing resources to help local school boards better understand math, science, and technology education; creating partnerships with seminaries (schools where public religious leaders are trained) to enhance the presence of science in theological education; and helping scientific and evangelical Christian communities to better appreciate each other's interests and concerns regarding science. In this position, "It helps to have both a science and English background because I can straddle both worlds, look critically at the project, and see how I might develop something that both scientists and nonscientists can use," says Peyton.

For students unsure about their interests in science, Peyton recommends that "Even if you don't enjoy taking science classes, be open to different ways you can use science. It can be found in many places, such as in novels or the Bible, and understanding science will help you understand life in general."

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Vignette 10: Combining Science and Video Games

In developing his computer programming career, Shawn found few mentors and did a great deal of learning and experimentation by himself. Because he was passionate about gaming and was willing to dive headfirst into challenges, Shawn got an early start on his career as a computer scientist and video game programmer.

Shawn Lindberg
Vehicle and Physics Video Game Programmer, Volition Inc.
Written by Heather McInnis

Undergraduate (BS in computer science): University of Illinois College of Engineering, Urbana-Champaign, Illinois

Although Shawn doesn't remember what he wanted to be when he grew up, he does have a long history of teaching himself computer skills. In middle school, he taught himself how to program video games on his graphing calculator. In high school, with quite a bit of help from books and the internet, he taught himself how to program in three different computer languages.

Fortunately, Shawn also found ways to explore his interest in computer science, both in the classroom and in extracurricular activities. For example, Sean took an independent study class in high school and wrote a 3-D graphics engine, which helps a computer display images in three dimensions. He also participated in two high school computer programming competitions held by the American Computer Science League.

When Shawn entered college, he took as many computer classes as he could and studied the psychology of vision, which is helpful to understand when you make video games. In one of his courses, he and several classmates made a 3-D Asteroids-like game. It was around this time that Shawn received a AAAS Entry Point! Internship for Students with Disabilities (*http://ehrweb.aaas.org/entrypoint/index.htm*) and worked at the Bowie State University/National Aeronautics Space Administration (NASA) Goddard Space Flight Center Summer Institute in Engineering and Computer Application, where he learned how to design software to help scientists and engineers build satellites.

Shawn's game programming and internship experiences helped him when applying for a job at Volition, Inc., a video game company, shortly after he graduated from college. In addition to his computer science knowledge, Shawn uses a lot of math, especially linear algebra and trigonometry, and physics in his programming. Shawn says,

> In video games, we don't have to exactly follow the laws of physics, but they can often be a good place to start. Sometimes we may need to bend physical laws in order to make a certain part of the game more fun to play, but often what we want is somewhat realistic. For example, I had to add airplane physics to one of our games. For our first physical model, I based it off a simplified version of what actually happens in real life. I added several

> elements to the aircraft … [and] the aircraft produced pretty believable flying physics! Of course we made plenty of modifications, but the basic idea started with real physics.

He notes that not all video game companies require programmers with physics training, but if their games feature interactive 3-D environments, chances are they have at least one specialist on the team. Shawn's favorite part of the job is "adding a new feature and seeing it in action," says Shawn. "That's one of the reasons physics programming is cool: It's visible."

Shawn says that he only learned the parts of his job that are specific to video game programming after he started working. "To be a video game programmer, a background in computer science is a huge asset," says Shawn. Today, he notes, there are many more options to learn specifically how to make games: For example, colleges are starting to offer video game courses, and "it is becoming more and more common for video game programmers to have a bachelor's degree in computer science," says Shawn.

If you are interested in combining science with other interests or passions, Shawn advises to find a balance between work and fun. "Life is not all about studying and school," says Shawn. "I think people forget to tell the super-motivated students to find a healthy balance. It catches up to you eventually." He also encourages students to "find someone interested in the same things as you, or if that fails, plow ahead solo!"

♦ ♦ ♦

Vignette 11: Combining Science and Test Question Evaluation

Cari Herrmann Abell has always had a methodical mind. While this initially drew her to math and chemistry, she explored materials science and mechanical engineering as well. Because she has a diverse background that is rooted in analysis, she has successfully moved on to a rewarding career in the development of science-based test questions and data analysis.

Cari Herrmann Abell
Research Associate at Project 2061, AAAS
Written by Melissa McCartney

High School: Madison Central High School, Old Bridge, New Jersey and Owings Mills High School, Owings Mills, Maryland
Undergraduate (BS in chemistry and math): Muhlenberg College, Allentown, Pennsylvania
Graduate (PhD in physical chemistry and materials science): University of North Carolina at Chapel Hill, Chapel Hill, North Carolina
Postdoctoral Research (in chemistry and mechanical engineering): University of Colorado at Boulder, Boulder, Colorado

Growing up, Cari wanted to go into medicine. "I alternated between wanting to be a doctor and wanting to be a veterinarian," says Cari. "I couldn't decide if I wanted to treat animals or people." It followed that math and science were her favorite subjects in high school. "I had an awesome high school chemistry teacher," she says. "He really made it fun for me, and even better, he made it formulaic. Once that happened, organic chemistry became similar to a proof in geometry: you had a product you wanted to make and you had to figure out how to make it. To me, this type of analytical thinking came easily and was something that I enjoyed."

When Cari got to college, she started taking classes needed to become a doctor. "I was still set on being a doctor," she says, "but college biology was so much memorization! It was too free-form for me, there were no set rules and everything seemed to have an exception. I really missed chemistry and thinking analytically, so, I went back to it."

In graduate school, Cari studied both chemistry and materials science. She did research with a type of microscope that lets you take images of atoms on surfaces. However, Cari wasn't happy doing this research because she wanted to do something more applicable to everyday life. She chose to do more research after graduate school, but this time in mechanical engineering. She studied microelectromechanical systems (MEMS), which are very small machines (some are as small as the width of a human hair) that can do many things, such as helping ink jet printers put ink on the paper. "My postdoctoral experience made me realize that even adding the "applied" aspect to my research wasn't enough," says Cari. "I wanted a career that I wasn't going to find in the lab."

While researching possible career alternatives to doing laboratory research, Cari saw a position opening at Project 2061, a long-term initiative of the AAAS that conducts research and develops tools and services that educators, researchers, and policy makers can use to improve the

U.S. education system. Cari's application rose to the top and she became one of a select group of Research Associates developing test questions at Project 2061.

Chemistry is still very present in Cari's daily life. "I am working on a curriculum unit to prepare students for high school biology, which targets fundamental chemistry and biochemistry concepts that students will need to understand to be successful," says Cari. In this way, her background is perfectly suited for her job. "I mostly work with middle school students," she says. "I use my chemistry background from my high school and college years all the time. In a way I have learned a new language, as now I communicate science to a younger audience instead of to experts, but the basic knowledge remains the same."

The most difficult aspect of leaving the laboratory, Cari says, is "definitely having a human audience! In the lab it was just me and the machines and I could work anytime," says Cari. "Now, dealing with teachers and students, I am tied to their classroom and school-year schedule. If I have to run a pilot test, there is a small window of time when it is possible and I have to have everything ready to go."

Cari also has not lost touch with her analytical thinking. "When you are involved in writing test questions, you end up with mountains of data from students all across the country," says Cari. "It is up to me to work through this data, to see which ideas different groups of students are struggling with—and to try to figure out why. My analytical brain enjoys every minute of it!"

To any aspiring science education hopefuls, Cari suggests having a multidisciplinary background. "This is helpful no matter what you want to do, whether or not it is in science education," says Cari. "Narrowing yourself into a specific area only limits you, while a diverse background not only gives you more skills, but it makes you unique and able to stand out. This is easily achievable as long as you keep your options open and take classes that you like and are interested in!"

♦ ♦ ♦

Vignette 12: Combining Science and Human Rights

Jonathan Drake enjoys exploring new places, which initially made him interested in planetary science and astronomy. In his position as Senior Project Coordinator for the Science and Human Rights program, he can explore the world from his desktop, using satellite pictures to help people understand where human rights are not being respected.

Jonathan Drake
Senior Project Coordinator, Science and Human Rights Program, AAAS
Written by Anne Poduska

High School: Carlisle High School, Carlisle, Pennsylvania
Undergraduate (BS in physics with a concentration in astronomy): Dickinson College, Carlisle, Pennsylvania
Graduate (MS in planetary science): Arizona State University, Phoenix, Arizona

In elementary school, Jonathan's father gave him a book with space paintings, which inspired Jonathan to want to become an astronaut. "The book showed powerful pictures of people building space stations in the future," says Jonathan. "I knew I wanted to live in those pictures—and I knew that science and engineering were necessary to make those pictures happen."

It was during his undergraduate studies in astronomy that Jonathan was first able to explore space—but with both feet on the ground. "I spent my senior year doing a research project where I took pictures of asteroids with a telescope to see how fast they were spinning," says Jonathan. Although he enjoyed doing research, Jonathan wasn't sure if he wanted to go to graduate school after college. "I really wanted to finish school first and see what the possibilities were. I knew that I could take time after my degree to think about my career, so I did." After graduating, Jonathan says, he "spent one summer doing planetary research in Hawaii. We were trying to find a way to see through all of the dust in Mars's atmosphere so we could look at its surface and see what rocks the planet is made of."

After returning from Hawaii and inspired by the experience of planetary research, Jonathan took a part-time job teaching elementary students science concepts while he applied to graduate school. He entered a PhD program in a different field—geology—in order to continue studying planetary science. However, after a year in his program, he decided a master's degree would be better for him. "It was a big change, going from physics to geology," says Jonathan. "I was learning a lot, but I wanted to see what I could do with a master's degree before committing myself to a PhD degree."

While Jonathan wrote his master's thesis, he found a part-time job at the AAAS where he got to look at a new planet: Earth. "In my research, I had used remote sensing, which is the use of cameras to look at planets or stars," says Jonathan. "I now use remote sensing to look at Earth and document abuses of human rights—rights that everyone deserves simply by being a person."

Instead of taking pictures of Mars's surface, Jonathan now looks at satellite pictures of the Earth and finds out where human rights are being violated. For example, he identified villages being burned in Sudan, homes being bombed in Sri Lanka, and mass graveyards appearing in Afghanistan that could indicate that many people were murdered at the same time. “There are not many jobs where you can see so many different places on Earth in such detail,” says Jonathan. “You know that horrible things are going on, but it is satisfying to know that you are doing your best to stop that. By publishing these pictures and doing a scientific analysis of what we see, we hope to make a difference and help stop the abuse of human rights.”

In his work, Jonathan uses a range of scientific knowledge every day: He uses astronomy to understand the Earth’s rotation beneath the satellite, geography to know what areas the satellites will be able to photograph, physics to understand how the pictures are being made, and computer science to write computer programs to analyze the data he collects. “I believe that human rights should be respected,” says Jonathan. “Science provides powerful tools to be used for both good and bad purposes. I am proud to use them to help advance human rights and make this a better world.”

Jonathan recommends combining science with another interest: “Science is great because it touches on so many parts of the world we live in,” says Jonathan. “Pursue what interests you, because there will always be some way to connect it to science.” He also advises: “Work hard and don’t be lazy,” says Jonathan. “It’s easy to get frustrated, but the knowledge you gain in middle and high school will stay with you for the rest of your life, and the more you learn at that time, the more effective it will be later on, in college and beyond.”

♦ ♦ ♦

Vignette 13: Combining Science and Law

Unsure of where to start her career path, Anne Middaugh enrolled in a community college, which typically offers a two-year degree. This turned out to be an excellent decision, as she was able to try different things and eventually discover her passion for psychology.

Anne Middaugh
Forensic Clinical Psychologist
Written by Jen Makrides

High School: Madison High School, San Diego, California
Undergraduate (BS in psychology): Mesa Community College, San Diego, California and University of San Diego, San Diego, California
Graduate (PhD in psychology): George Washington University, Washington, D.C.

Anne is passionate about her career today, but she didn't always know she wanted to be a psychologist. "I wanted to run a surf shop," says Anne about her high school career ambitions. Despite having an average high school career, Anne was always passionate about reading and learning. A few years after graduating from high school, she enrolled at Mesa Community College in San Diego, California, where she discovered her interest in psychology. From there, a scholarship to the University of San Diego led to a PhD in psychology at George Washington University in Washington, D.C.

Since Anne is not one to avoid challenges, she is currently a forensic clinical psychologist who works in the criminal justice system and volunteers her time with asylum seekers and asylum-seeking detainees. "I've been doing this for 20 years and it's still fascinating," says Anne. "In this field, you don't get bored with your day because every case is so different."

Forensic clinical psychology bridges the legal system and mental health issues. Anne provides evaluations of alleged and convicted offenders to determine whether they can stand trial, what risk they could pose to society if released, and whether people with mental illness are criminally responsible for their actions. A typical day could involve testifying in court, meeting with patients, and interviewing police officers. Her job demands strong critical thinking and evaluation skills to ensure both the rights of people with mental illness and the safety of the larger community. In the courtroom, Anne relies on her PhD training and research to arrive at evidence-based conclusions.

In addition to her "day job," Anne volunteers her time and her training as a forensic clinical psychologist to ensure that the human rights of asylum seekers are upheld in the legal system. When Anne interviews asylum seekers, she evaluates them for Post-Traumatic Stress Disorder (PTSD), mental illness, and evidence of past torture. Anne also works with children, many of whom have fled physical or sexual abuse, or have been trafficked into the United States for forced manual labor or to work in the sex industry. Anne's work provides a scientific evaluation of the individual's claim for asylum in the United States.

Although it may seem overwhelming at times, this work is also rewarding. “I meet and learn about people from all over the world: China, India, Africa, Tibet, and South America,” says Anne. “I learn about what is going on in those countries and what happens during war and ethnic cleansing.” In some cases, Anne has evaluated individuals from opposing sides of a conflict and heard both views on what is happening in a country. Through this work, Anne is reminded that changing the world is a large task, and that “on an individual, personal level you can help one person at a time,” says Anne.

To prepare for a job like hers, Anne stresses the need to think critically and broadly. A clinical psychologist works with all kinds of people, and understanding a diverse set of ideas will enable one to connect with a diverse group of people. What about students who want to combine their love of science with other passions, like music or literature? “Do it,” says Anne. “Education is not about becoming a worker drone, it’s about learning. If you’re an artist, musician, dancer, hiker, camper—all of those things make you better at the work you do.”

For students who are interested in forensic clinical psychology, a field that usually requires a PhD, Anne recommends starting with an internship or volunteer opportunity in college or graduate school—and also to “have fun,” says Anne. “Being perfect is overrated.” She urges students to enjoy life, become well-rounded scientists, and make their work “a positive piece of the community and the world,” says Anne. “In the end, you want your work to matter to the places and the people you live with.”

♦ ♦ ♦

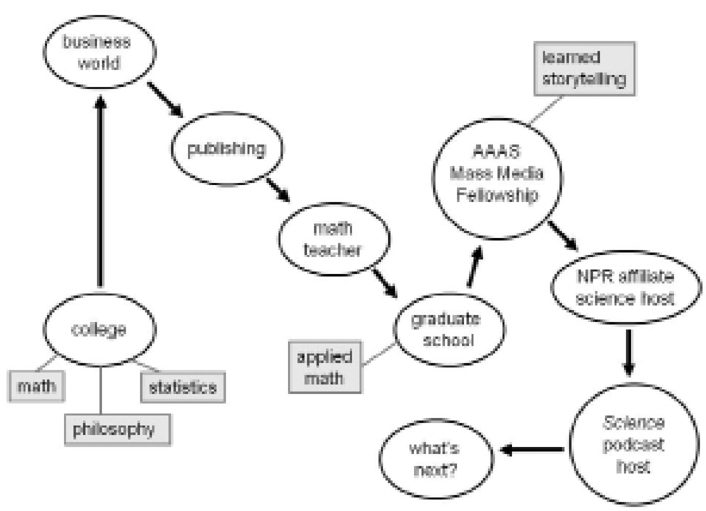
Discussion Questions

Please select one vignette and answer the following questions:

1. Pick one job described in this vignette. What does this job entail? Why did the individual accept this job and what else did it lead to?
2. What type of scientific background is described in this vignette? How does it apply to the job(s) described in this vignette?
3. When did the scientist featured in this vignette become interested in science?
4. What kind of education path is described in this vignette? Was this a straightforward path or were there twists and turns involved? This vignette ends with advice from the featured scientist. How is this advice applicable to you now? Are there ways that you can act on this advice?
5. How has this vignette helped you think about what you want to do with your future career?
6. What did you learn from reading this vignette? Please list at least three things.
7. Please identify the point(s) in this vignette where the featured scientist made a decision to try something new.

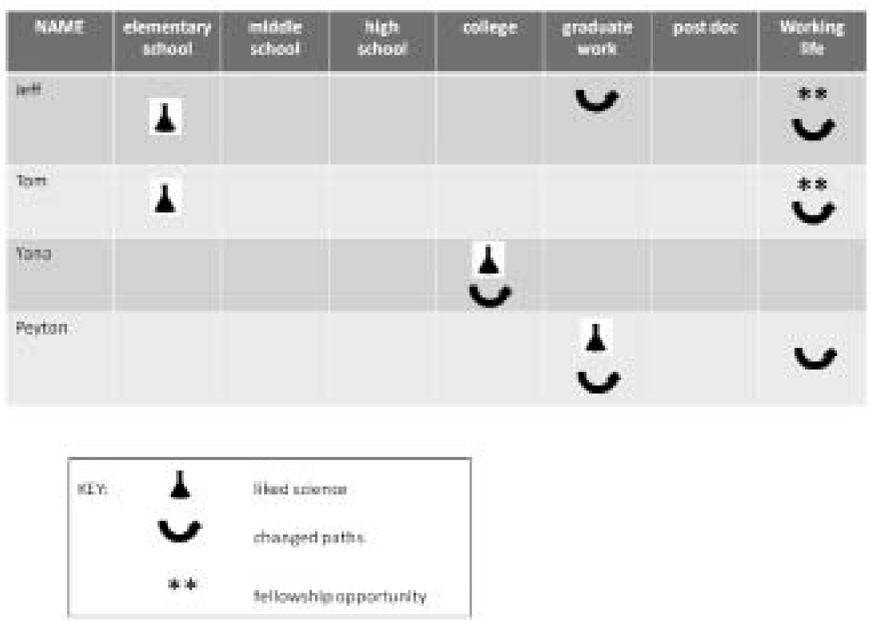
8. Please list the points(s) in this vignette where the featured scientist took specific actions that eventually led to that person's next career step or job.
9. Pick an area of science that you like and also something non-scientific (for example, cooking or dancing). Think of three ways that you could combine these in a job. Next, ask your teachers, parents, or friends if they have any ideas—and then do some research, either by the internet or by reading books, to come up with three more career ideas. List these six jobs and write a short description of what each job is.
10. Science can happen outside of your classroom. Examples include science fairs and volunteering at an animal shelter or zoo. Can you think of other places where science occurs outside of the classroom?
11. There are examples in the vignettes that show how science improves both the health and the lifestyle of a community. For example, Nick studied deforestation in order to help preserve the ecology of Brazil. Rieko was interested in the science behind sunscreen, which allows us to remain outdoors even when the sun is intense. Can you think of other examples of how scientific improvements can improve our quality of life?
12. The scientists in the vignettes were able to take their scientific skills and apply them to careers outside of the lab. Based on their experiences, can you describe the general workforce skills that they all exhibit, either as a scientist in a laboratory or in their current career?
13. Figure 3.1 outlines a career timeline for Robert Frederick, which shows his educational background and career changes. Select an individual and make a similar timeline from their vignette.

Figure 3.1. A Timeline of Robert Frederick's Career Path



14. Figure 3.2 illustrates when Jeff, Tom, Peyton, and Yana knew that they liked science (indicated by the beaker), changed career paths (indicated by the curved arrow), and had a fellowship opportunity that helped them decide what job they liked (indicated by two asterisks). Pick an adult that you know, perhaps a teacher or a parent, who has studied science or uses science in his or her job. Interview that person and make up a chart illustrating when he or she liked science, changed career paths, and did a life-changing fellowship.

Figure 3.2. A Chart of Career Milestones for Four Featured Scientists



Fellowship and Career Information

Here are some of the fellowships that individuals featured in these vignettes received, which helped with their career decisions:

- AAAS Entry Point! Internship for Students with Disabilities
- AAAS Mass Media Science and Engineering Fellowship
- AAAS Science & Technology Policy Fellowship
- American Institute of Physics and the Acoustical Society of America Congressional Fellowship
- Christine Mirzayan Science and Technology Policy Fellow at the National Academy of Sciences

For additional information about science careers, fellowships, and internships, please consult:

AAAS Careers: *www.aaas.org/careercenter*
Science Careers: *http://sciencecareers.sciencemag.org*

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Index

A

A Nation at Risk, 206
AAAS. *See* American Association for the Advancement of Science
Abell, Cari Herrmann, 41–42
Academic achievement
  effect of service-learning on, 162
  of students in Illinois Mathematics and Science Academy, 138–139
  of students in STEM Academy, 73, 78
  of students in Steppingstone Magnetic Resonance Training Center, 152, 155–157
Academy for Future Teachers (AFT) program, 111–128
  curriculum of, 113–114
    daily overview for secondary science program, 116–117
    summary of activities, 115
  data sources for evaluation of, 119–120
  evaluation team for, 119
  evidence for success of, 119
  findings of evaluation of, 120–126
    choice of major in college affinity, 122, 123
    science and mathematics attitude and affinity, 121–122
    science and mathematics content understanding, 120
    student interview responses, 122–125
    teachers' experiences, 125–126
  funding for, 112, 119, 127
  model for, 113
  next steps for, 127
  NSES goals and student experiences in, 114, 118
  purpose of, 111–112
  questions raised from, 127–128
  recruitment of students into, 112–113
  scaffolding for, 111
  service-learning component of, 111, 114
  summary of, 118–119
  teaching and support staff of, 113
  tips to other specific reform efforts, 127
Achieve, Inc., 5, 212
Acoustical Society of America, 48
ACT test, 138, 186
Active learning strategies, 255–268
  alignment with National Science Education Standards, 256–257
  challenges to incorporation of, 256, 258
  definition of, 256
  evidence of effectiveness of, 265–268
    curriculum redesign, 266
    enhancement of classroom environment, 266–267
    student benefit, 265–266
    student preparation for STEM careers, 267–268
  top ten, 259–265
    create concept maps, 263–264
    demystify diagrams, 261–262
    go for the long haul, 259
    measure twice, lecture once, 262
    say it with flowers, 262–263
    talk the (STEM) talk, 265
    use discrepant events, 260
    use novel associations to explore concepts, 260
    watch your language, 259
    write to learn, 264
  in Welty Middle School's Gateway to Technology program, 257–258
Adamuti-Trache, M., 57, 58
Advanced Placement (AP) courses, 5, 58, 69, 124, 139, 142, 248
AFT. *See* Academy for Future Teachers program
AJAS (American Junior Academy of Science), 227, 228
Akcay, H., 265
Alberts, Bruce, editorials in *Science,* vii, 1–6
  An Education That Inspires, 5–6
  On Becoming a Scientist, 2–3
  Prioritizing Science Education, 3–4
  Reframing Science Standards, 4–5
  Why I Became a Scientist, 1–2
Althoff, Matthew, 244
American Association for the Advancement of Science (AAAS), viii, 1, 5, 19, 64, 206, 224, 228
  career paths of scientists and engineers at, 19–48

Center for Science Diplomacy, 31, 32
fellowship and career information, 48–49
Research Competitiveness Program of, 28
American Computer Science League, 39
American Institute of Physics, 48
American Junior Academy of Science (AJAS), 227, 228
American Management Association, 7
Andres, L., 57, 58
Andrews, S. E., 245
Angela Award, 99
Anheuser-Busch Distinguished Service Award, 100
Ankiewicz, P., 266
AP (Advanced Placement) courses, 5, 58, 69, 124, 139, 142, 248
Applied science classroom track, 215–217
Apprenticeships, 2
Art combined with science, 21–22
ASPIRES project, 51
Assessment(s), 56, 147, 269–270
ACT test, 138, 186
combining science and test question evaluation, 41–42
formative, of service-learning, 163
international, 55, 67, 206, 207, 246
National Assessment of Educational Progress, 120, 186
SAT test, 138, 242
standards for, 257
textbook-based, 270
Association for Business and Industry (Iowa), 202
Atlas for Science Literacy, 5

B

Bayer Corporation's Making Science Make Sense program, 140
Behavior management systems, 84
Bickel, Chris, 21–22
Big ideas in science, 14, 55, 60, 131
Bittick, S., 163
Bloom, Benjamin, 241
Bottge, B., 164
Bourdieu, Pierre, 52, 53, 55, 56
Briskin, Emily, 240–241
Bristol-Myers Squibb, 214–215
Bruker Bio-Spin, 145, 148
Bureau of Labor Statistics, 248
Burkhart, Debra, 257
Business Roundtable, 206, 212
Business-Higher Education Forum, 206, 212
Byars-Winston, A., 179

C

Cairns, B. D., 245, 246
Cairns, Jack, 238
Camp Invention program, 8–18
alignment with national science standards, 10–11, 15–16
background of, 7–8
evaluation of, 16–17
creativity of participants, 16
parent surveys, 17
professional growth, 17
21st-century learning, 17
key components of, 8–11
create, test, and re-create approach, 9
creativity and innovation, 9–11
immersion, 8–9
STEM, 9
team building and collaboration, 11
overview of modules of, 14
professional learning opportunities of, 14–16
sample modules of, 11–14
Game On: Power Play, 13–14
Hatched, 12
I Can Invent: Edison's Workshop, 13
Power'd, 11–12
SMArt: Science, Math, & Art, 12
support for underserved children, 17–18
Career and technical education (CTE) schools, 69
Careers in science, technology, engineering, and mathematics, vii–ix, 19–49
Academy for Future Teachers program for encouragement of, 111–128
active learning strategies for encouragement of, 255–268
attracting more minority/underrepresented students to, 17, 51, 52, 70, 111, 114, 127, 140, 141, 161, 246
barriers to interest in, 161
challenge for U.S. education to promote, 63–79
changes needed in science education to attract more students to, 1–6

combining science and art, 20–21
combining science and editing, 33–34
combining science and education, 25–26
combining science and government, 35–36
combining science and human rights, 43–44
combining science and international studies, 31–32
combining science and journalism, 29–30
combining science and law, 45–46
combining science and radio, 23–24
combining science and religion, 37–38
combining science and test question evaluation, 41–42
combining science and traveling, 27–28
combining science and video games, 39–40
curriculum focus on, 57, 58
discussion questions on, 46–48
economic value of, 53, 54, 96
employment opportunities for, 53, 54, 57, 66
family background and, 54, 57, 58, 66–67
fellowship and career information, 48–49
gap in science education about, 51–52, 53, 56
impact of Science Olympiad on choice of, 237–238, 240–241, 244, 245–247
importance of educating students about, 51–60, 66
interest in STEM vs. pursuit of, 66
key elements of programs for encouragement of, 106–109
characteristics of successful scientists, 108–109
examining historical episodes, 108
exploring the nature of science, 107–108
NSTA's efforts to promote student interest in, 95–109
oversupply in some STEM professions, 54, 59
overview of, 95–96
preparing students for careers that do not yet exist, 129–142
projected growth in, 96
real world externships to expose students to, 183–203 (*See also* Iowa Mathematics and Science Education Partnership Real World Externship program)
reasons to pursue, 96–98
sources of information about, 52, 57–59
spectrum of, 97–98
computer and mathematics careers, 98
engineering, 97
life science careers, 97
physical science careers, 97
STEM Academy focus on, 71, 72, 79
STEM workforce pipeline and Science Olympiad, 247–248
success stories of encouraging pursuit of, 269–271
talent marketplace and, 207–220
value of knowledge about, 56–58
websites about, 59
Centers for Disease Control and Prevention (CDC), 240, 241
Cerezo, N., 266–267
Challenge award program, proposal for, 5–6
Change the Equation, 212
China, 19, 46, 63–64, 134
Chui, Glenda, 131
Chung, G., 163
Clarke, B., 163
Classroom management, 84
Committee on Prospering in the Global Economy of the 21st Century, 242
Committee on Science, Engineering, and Public Policy, 161
Communication combined with science, 23–24
Competitive global economy, 7–8
Computer programming and science, 39–40
Concept maps, 263–264
Core concepts, 4, 131
learning progressions for, 5
Council of Chief State School Officers, 206
Creativity, 24, 37, 52, 55, 65, 96, 107, 109, 129, 212, 271
in Academy for Future Teachers, 116, 125
activity learning and, 264, 265, 266
in Camp Invention program, 7, 8–10, 11, 13, 14, 15, 16, 17
in Illinois Mathematics and Science Academy, 129, 132

in Iowa Mathematics and Science Education Partnership Real World Externship program, 184
in Science Olympiad, 238, 244, 245, 246
in STEM Academy, 73, 77, 78
in Steppingstone Magnetic Resonance Training Center, 154
in Toshiba ExploraVision competition, 102–103
Toyota TAPESTRY Awards for, 100
Critical thinking, 2, 3, 45, 46, 59, 103, 107, 196
in Academy for Future Teachers Program, 117, 122, 123, 125, 126
in Illinois Mathematics and Science Academy, 132, 136, 140
importance in talent marketplace, 205, 207, 214, 215, 216
in Kids Inquiry Conferences, 83, 85, 87
in Science Olympiad, 242, 247, 256
in STEM Academy, 71, 72, 77, 79
in Camp Invention, 7, 8, 9, 13, 15
CTE (career and technical education) schools, 69
Cultural capital, 52–54
acquisition of, 54
definition of, 53
vs. economic and social capital, 53
family background and, 54, 58
general scientific skills as, 55–56
institutional, 53, 57
knowledge about science careers as, 57–59
missed opportunities for enhancement of, 55, 56
scientific knowledge as, 54–55, 59
sources of, 58–59
Cultural literacy, 54–55
Curie, Marie, 108
Curiosity, 14, 24, 27, 66, 69, 79, 83, 85, 93, 96, 108, 115, 164, 260
Curriculum
of Academy for Future Teachers program, 113–117
attention to science careers in, 57, 58–60
coherence of, 5, 132
cultural capital and, 54–55
of Illinois Mathematics and Science Academy, 131–132
Project Lead the Way, in STEM Academy, 71
redesign to incorporate active learning in, 266
to support inquiry-based science education, 206

D

Damery, Krista, 249
Darling-Hammond, L., 245
Debelak, C., 245
Definition of STEM jobs, 65
Degnan, Tom, 248
Desrosiers, Arthur, III, 102–103
Detroit Science Fair, 156
Dieckman, D., 87
Differentiated instruction, 117
Discovery Channel, 100
Distinguished Informal Science Education Award, 100
"Doing" science. *See* Inquiry-based science education
Doty, Paul, 2
Doverspike, D., 267
Dr. Kiki's Science Hour, 23
Drake, Jonathan, 43–44

E

Eccles, J., 246
Economic and Statistics Administration (ESA), 65
Edison, Thomas, 13
Editing combined with science, 33–34
Education combined with science, 25–26
Education to Innovate campaign, 242
Education Week, 237
Educational Testing Service, 242
Einstein, Albert, 97
Elementary school science education, 81–93
Kids Inquiry Conference, 82, 87–93
reasons for traditional approach to, 84–85
scenarios for, 83–84
let's read the text, 83–84
meet your partner—social studies, 83
once-a-week science with the expert, 83
these kids can't do science, 84
teachers' content knowledge and, 84–85
teachers' discomfort with inquiry-based approach to, 84–85

teaching strategies to facilitate inquiry experiences in, 85–87
developing complex questions, 87
documenting and reflecting, 87
listening to children's ideas, 86
using standards as a guide, 86
using "thinking starters," 85–86
Elsom, D., 57
Employer-Teacher Work Experience Program (Vermont), 185
Ervin, Tom, 231
ESA (Economic and Statistics Administration), 65
ESPs. *See* Exemplary Science Programs
Estrada, Y., 179
Ethics, 37–38
in Illinois Mathematics and Science Academy, 136
Europe Needs More Scientists report, 56
Exemplary Science Programs (ESPs), vii, viii, xiii
active learning strategies, 255–268
Camp Invention, 7–18
career paths of 14 scientists and engineers, 19–49
challege for U.S. education to promote STEM careers, 63–79
STEM Academy, 70–78
changes needed in science education to attract more students to STEM careers, 1–6
Illinois Mathematics and Science Academy, 129–142
importance of educating students about careers in science, 51–60
inquiry-based teaching and Kids Inquiry Conferences, 81–93
Iowa Academy of Science, 223–236
Iowa Mathematics and Science Education Partnership Real World Externship program, 183–203
NSTA efforts to interest students in STEM careers, 95–108
Science Olympiad, 237–249
service-learning, 161–180
Academy for Future Teachers, 111–128
STEMester of Service, 164–179
Steppingstone Magnetic Resonance Training Center, 145–159
talent marketplace and, 205–220
ExploraVision, 100–103

F

Family/parent background and students' pursuit of STEM careers, 54, 57, 58, 66–67
Faraday Science Communicator Award, 100
Farmer, T. W., 245, 246
Fellowships, 20, 24, 26, 28, 29, 30, 32, 34, 36, 48–49, 185, 227
Firszt, Brittany, 239
Forensic clinical psychology, 45–46
Fox, Jeff, 35–36, 48
Framework for Science Education, 4–5
Frederick, Robert, 29–30
Fredricks, J., 246
Fresco, Jacques, 2
Friedman, T. L., 64

G

Galvani, Luigi, 108
Georgia State University's Academy for Future Teachers, 111–128. *See also* Academy for Future Teachers program
Gersten, R., 163
Global Learning and Observations to Benefit the Environment (GLOBE), 232–234
Goddard Space Flight Center, 39
Google International Science Fair, 104
Government combined with science, 35–36
Greenwood, C., 59
Groff, C., 163

H

Hammond, Yana, 21–22, 48
Harrison, H., 266
Harrison, M., 59
Hawking, Stephen, 97
Heiss, Arthur, 148
Hidi, S., 164
Hirsch, E. D., 54–55
Hounsell, T. S., 243, 244
Howard, C., 179
Human rights combined with science, 43–44
Hung, Y., 164
Hunter, Madeline, 241

I

IAS. *See* Iowa Academy of Science
IB (International Baccalaureate) courses, 29, 69

IBSE. *See* Inquiry-based science education
IDED (Iowa Department of Economic Development), 202
IISME (Industry Initiative for Science and Math Education) (California), 185
IJAS. *See* Iowa Junior Academy of Science
Illinois Mathematics and Science Academy (IMSA), 129–142
Applied Engineering and IMSA Energy Center of, 135
context of, 129–130
creation of, 129–130
curriculum of, 131–132
evidence of success of, 138–
alumni longitudinal study, 139
IMSA FUSION, 140–141
Problem-Based Learning Network, 139–140
student achievement, 138–139
Teacher Candidate Institutes, 142
Golden Apple Scholars, 129
inquiry-based collaborative student instruction in, 132
instructional innovations of, 129
ISMA FUSION program of, 129, 137–138
Kids Institute and Allies programs to prepare future teachers, 135–136
leadership and ethics in, 136
Power Walkthrough model in, 132
problem-based learning approach of, 129, 130, 137, 139–140
professional development opportunities of, 136–137
self-paced physics in, 134
student population of, 130
student research in, 132–134
learning objectives for, 132–133
Methods of Scientific Inquiry, 132
publication of, 139
Student Inquiry and Research program, 132, 133–134
Teacher Candidate Institutes at, 129, 137, 138, 142
ties to standards and reform efforts, 129, 130–132
Total Applied Learning for Entrepreneurs program in, 134
IMSEP. *See* Iowa Mathematics and Science Education Partnership Real World Externship program
India, 46, 63
Industry Initiative for Science and Math Education (IISME) (California), 185
Innovation America: Building a Science, Technology, Engineering and Math Agenda, 247
Innovative Technology Experiences for Students (ITEST) grants, 187
Inquiry-based science education (IBSE), viii, 1, 4, 20, 56, 146–148, 206
active learning strategies for, 255–268
definition of, 146
elementary school teachers' discomfort with, 84–85
in elementary schools, 81, 82
in Illinois Mathematics and Science Academy, 129, 132
Kids Inquiry Conference, 82, 87–93
National Lab Network for, 104–105
professional development for support of, 206
Science Matters program, 105–106
in Science Olympiad, 243
standards supporting, 81, 146, 257
Institute of Medicine, 242
Intel International Science and Engineering Fair (Intel ISEF), 104
International assessments, 55, 67, 206, 207, 246
International Baccalaureate (IB) courses, 29, 69
International Mathematical Modeling Competition, 139
International Space Station, 29
International studies combined with science, 31–32
Internships, 20, 24, 37, 39, 46, 48–49, 71, 72, 79, 139, 184, 185, 192
Invent Now, 7–18
curriculum development by, 10, 11
development of Camp Invention by, 8–18 (*See also* Camp Invention program)
evaluation of Camp Invention, 16
founding of, 7
mission of, 11
partnering with school districts, 15
support for underserved children, 17–18
website for instructors, 14
Iowa Academy of Science (IAS), 223–236
community colleges and, 232

founding of, 224
Iowa Science Teaching Section of, 230–232
membership of, 223–224
mission of, 224
organization of, 224–225
other educational programs of, 234
partnership with GLOBE Program, 232–234
partnership with Project Wet, 232, 234
reflections on, 236
Speaker Series, 235
sponsorship of Iowa Junior Academy of Science, 223, 225–230
teaching awards presented by, 232
Visiting Scientist Program of, 230
Iowa Biotechnology Association, 202
Iowa Business Council, 202
Iowa Core Curriculum, 187, 188, 192, 194
Iowa Department of Economic Development (IDED), 202
Iowa Junior Academy of Science (IJAS), 223, 225–227
membership of, 225
objectives of, 225
Outstanding Science Student Award of, 230
programs and activities of, 225–227
scholarships awarded by, 227
student and teacher experiences with, 227–230
Iowa Mathematics and Science Education Partnership (IMSEP) Real World Externship program, 183–203
business partners of, 186, 188
challenges of, 201–202
evaluation of, 185, 192
evidence of success of, 192–200
business host findings, 192, 197–200
measurable program objectives, 192
teaching practices, 192–196
evolution of, 190–191
funding of, 187, 202
future of, 202
goals of, 184, 190
history of real world externships, 185–186
key points of, 184–185
mechanics of, 186–187
media coverage of, 203
operating costs of, 187
schedule of, 187
stipends and continuing education credits for teachers in, 187
teacher-externs in, 184, 187, 188–190
teacher-produced end products from, 187, 201
teachers' blogs during, 191
Iowa Science Teaching Section (ISTS), 230–232
Iowa Space Grant Consortium, 227
Iowa Tests of Educational Development (ITED), 192
ISTS (Iowa Science Teaching Section), 230–232
ITED (Iowa Tests of Educational Development), 192
ITEST (Innovative Technology Experiences for Students) grants, 187

J

Jackson, Shirley Ann, 64
James, Tim, 15
Jenkins, E., 53–54
Jet Propulsion Laboratory, 226
Job fairs, 209
John Glenn Center for Science Education, 95
Johnson, David, 241
Johnson, Roger, 241
Journal of College Science Teaching, 98
Journal of the American Mathematical Society, 30
Journalism combined with science, 29–30
Juliana, M., 245

K

Kids Inquiry Conference (KIC), 82, 87–93
alerting teachers and students to basics of, 90
as an annual event, 92
benefits of, 87
inquiry-based teaching coming alive through, 88–90
lessons learned from, 92–93
preparation for, 90–91
presentation of, 91–92
professional development to work toward, 87–88
student independence encouraged by, 93
Kwon, J., 164

L

Laboratory experiences, 2. *See also* Inquiry-based science education

definition of, 105
National Lab Network, 104–105
for postdoctoral training, 2–3
Steppingstone Magnetic Resonance Training Center, 145–159
Lake, C., 163
Lam, P. C., 267
Law combined with science, 45–46
Learn and Serve America programs, 167
Learning and Leading with Technology, 139
Learning disabilities, 266, 267
Learning progressions, 5
Lever, Scott, 226
Lindberg, Shawn, 39–40
Literacy skills, 3, 55
cultural literacy, 54–55
scientific literacy, vii, 1, 51, 55, 68, 81, 82, 83, 114, 116, 118, 206, 207, 243, 256
Logan, W. L., 245

M

Mahoney, J. L., 245, 246
Making Science Make Sense program, 140
Manufacturing jobs, shortage of skilled workers for, 64–65
Mars Rover Exploration Program, 226
Martin, C., 243
McCamon, Vicki, 257, 260, 265–268
McCartney, Melissa, 25
McGee-Brown, M. J., 243–244
Memorization, viii, 3, 4, 6, 27, 28, 41, 83, 92, 93, 131, 133, 206, 256
Mentors/mentoring, vii, 2, 23, 24, 27, 30, 39, 180, 219
in Academy for Future Teachers, 112, 113
in Illinois Mathematics and Science Academy, 133, 138, 139
in Iowa Junior Academy of Science, 225, 228, 230
in real world externships, 184, 185, 186–187, 188, 191
in Science Olympiad, 237, 248
in STEM Academy, 73
in Steppingstone Magnetic Resonance Training Center, 148, 149–150, 152–154, 155, 156, 158
Menzemer, C., 267
Meyer, Heidi, 233
Middaugh, Anne, 45–46
Millmeier, Cory, 229–230
Minority students, 17, 51, 52, 70, 111, 114, 127, 140, 141, 161, 246
Monsaas, J., 243
Moore, Shalia, 183
Morse, Kiyo, 148
Morse, Reef, 148, 151, 152
Motivating students, 3, 5, 10, 16, 40, 51, 52, 53, 57, 64, 66, 119, 134
active learning strategies for, 266–267
real world externships for, 186, 193–194, 195, 197, 198, 199
in Science Olympiad, 240, 241, 244–245, 248
service learning for, 161–180
Munro, M., 57

N

NAAS (National Association of Academies of Science), 227
NAEP (National Assessment of Educational Progress), 120, 186
NASA. *See* National Aeronautics and Space Administration
National Academy of Engineering, 242
National Academy of Sciences, 1, 4, 26, 28, 48, 63, 206, 236, 242
National Aeronautics and Space Administration (NASA), 6, 39, 64, 233, 242
Glenn Research Center, 185
National Space Grant College and Fellowship Program, 227
National Assessment of Educational Progress (NAEP), 120, 186
National Association of Academies of Science (NAAS), 227
National Association of Manufacturers, 64–65
National Center for the American Workforce, 65
National Center on Education and the Economy, 246
National Defense Education Act (NDEA), 242
National Governors Association, 206, 237, 247
National Institutes of Health, 158
National Inventors Hall of Fame, 7, 8, 11
National Lab Network, 104–105
National Oceanic and Atmospheric Administration (NOAA), 233
National Research Council (NRC), 81, 83, 93, 206

Committee on Highly Successful Schools or Programs for K–12 STEM Education, 67–68
report on successful STEM education, 67–69
National Science Board, 65
National Science Education Standards (NSES), vii, viii, xiii, 1, 4, 51, 81, 269, 270, 271
alignment of active learning strategies with, 256–257
alignment of Camp Invention curriculum with, 10–11, 15–16
alignment of Illinois Mathematics and Science Academy with, 129
alignment of Science Olympiad with, 239, 251–254
qualities defining scientific literacy, 243
and student experiences in Academy for Future Teachers program, 114, 118
supporting inquiry, 81, 146, 257
National Science Fair, 104
National Science Foundation (NSF), 67, 99, 112, 127, 158, 161, 185, 187, 202, 206, 233, 243, 270
National Science Resources Center (NSRC), 206, 214–215
National Science Teachers Association (NSTA), 95–108, 206, 238
awards given by, 99–103
Angela Award, 99
Anheuser-Busch Distinguished Service Award, 100
Distinguished Informal Science Education Award, 100
Faraday Science Communicator Award, 100
Toshiba/NSTA ExploraVision competition, 100–103
Toyota TAPESTRY Awards, 100
conferences for science educators, 99
founding of, 95, 98
journals and books published by, 98
Learning Center of, 99
membership of, 98, 147
National Lab Network, 104–105
partnering with Science and Engineering Festivals, 103–104
Professional Development Institutes of, 99
Science Education for Middle Level Students, 8
support for science fairs, 104
National Wildlife Federation, 165
National Youth Science Camp, 226
Nature, 139
Nature of science, exploration of, 54, 104, 106–108, 257
in Academy for Future Teachers, 112, 115, 116, 117
active learning strategies for, 265
in Camp Invention, 10
in Illinois Mathematics and Science Academy, 132
in Research Experiences for Teachers, 185
in Science Olympiad, 240
NDEA (National Defense Education Act), 242
Neuroscience Research Communications, 139
Neutze, D., 87
No Child Left Behind Act, 56
NOAA (National Oceanic and Atmospheric Administration), 233
NRC. *See* National Research Council
NSES. *See* National Science Education Standards
NSF (National Science Foundation), 67, 99, 112, 127, 158, 161, 185, 187, 202, 206, 233, 243, 270
NSRC (National Science Resources Center), 206, 214–215
NSTA. *See* National Science Teachers Association

O

Obama, Barack, 242
Office of Special Assistant to the President for Science and Technology, 242
Ozturk, M., 245

P

Panec, Kelen, 228
Parent/family background and students' pursuit of STEM careers, 54, 57, 58, 66–67
Partnership for 21st-Century Skills, 217
PAST Foundation, 72
Pasteur, Louis, 108
Patel, P. J., 133
PBL. *See* Problem-based learning
Pearce, C., 87
Peltz, Tova, 237–238

Peterson, R., 266
Physical activity and creativity, 13–14
PISA (Programme for International Student Assessment), 55, 206, 246
PLTW (Project Lead the Way) curriculum model, 71
Policy issues, 19, 26, 28, 32, 35, 36, 41, 45, 55, 56, 59, 60, 105, 135, 161, 206, 216, 219, 230, 236, 248
Postdoctoral opportunities, 2, 20, 25, 33, 34, 41, 102, 148, 156. *See also* Fellowships
Power Walkthrough model, 132
Preservice teachers, 82–83, 84, 85, 91, 115, 120, 125, 137, 138, 202, 206, 234, 268
President's Scientific Research Board, 242
Problem-based learning (PBL)
  effect on at-risk female middle school students, 266–267
  in Illinois Mathematics and Science Academy, 129, 130, 137, 139–140
  in STEM Academy, 70, 71, 72
Problem-solving skills/training, ix, 4, 65, 71–72, 79, 83, 96, 102, 205, 215, 269
  in Academy for Future Teachers Program, 115–117, 119, 123
  active learning strategies for, 265–266, 267
  in Camp Invention, 8–10, 11, 13, 14, 15, 17
  in Iowa Mathematics and Science Education Partnership Real World Externship program, 184, 193, 195, 196
  in Science Olympiad, 238, 239, 243–244, 245, 247, 253
  in Steppingstone Magnetic Resonance Training Center, 147, 150
Professional development
  in Camp Invention program, 14–16, 17
  in Illinois Mathematics and Science Academy, 136–137
  Iowa Academy of Science opportunities for, 230–234
  NSTA Learning Center for, 99
  real world externships for, 183–203
  Science Olympiad and, 240–241
  to support inquiry-based science education, 206
  to work toward Kids Inquiry Conference, 87–88
Professional Development Institutes (NSTA), 99
Programme for International Student Assessment (PISA), 55, 206, 246
Project Lead the Way (PLTW) curriculum model, 71
Project Wet, 232, 234
Putz, Gerard J., 238

Q

Quinn, Helen, 131

R

Radio science programs, 23–24, 30
Reading skills, 3, 4, 83–84
Real world externships, 183–203. *See also* Iowa Mathematics and Science Education Partnership Real World Externship program
  advantages of, 185, 186
  challenges of, 201–202
  examples of, 185
  future of, 202
  history of, 185–186
  mechanics of, 186–187
Reddinger, K., 164
Religion combined with science, 37–38
Research advisors, 2
Research design, 3
Research Experiences for Teachers (RET), 185
Research laboratory, 2
RET (Research Experiences for Teachers), 185
Rising Above the Gathering Storm, 63–64, 242
RMC Research, 167
Ross, Eleanor, 103
Rueda, E., 164
R_xeSEARCH: An Educational Journey, 214–215, 219–220

S

Sagan, Carl, 97
Saho, Tracy, 257, 259, 265–268
SAM (Science and Mathematics Attitude) Survey, 119–120, 121–122
Sanford, Kirsten "Kiki," 23–24
Sarwate, Anand, 101–102
SAT test, 138, 242
Saul, W., 87
Scarborough, J. L., 245
Scarisbrick-Hauser, AnneMarie, 16
Schiller-Holland, Alicia, 229

Scholastic Bowl, 139
School Administrators of Iowa, 202
School-to-Work Initiative, 185
Schroth, S. T., 245
Science, 19
Alberts's editorials in, viii, 1–6
career paths of employees at AAAS and, 19–49
Prize for Online Research in Education, 26
Science and Children, 98
Science and Engineering Festivals, 103–104
Science and Engineering Indicators, 65
Science and Mathematics Attitude (SAM) Survey, 119–120, 121–122
Science education, viii–ix
for acquisition of cultural capital, 52–56, 59
applied science classroom track, 215–217
big ideas in, 14, 55, 60, 131
connecting literacy lessons with, 3
core concepts for, 4, 131
learning progressions for, 5
to develop scientific habits of mind, 55–56, 116, 130, 131, 132, 142, 207
in elementary schools, 81–93
goals of, 55, 56, 59, 81
history of, 242–243
inquiry-based (*See* Inquiry-based science education)
to prepare students for employment, 205–220 (*See also* Talent marketplace)
prioritizing of, 3–4
reform of, 206
reframing standards for, 4–5
role in producing next generation of scientists, 56, 57
standards for, vii, viii, xiii, 1, 4, 206 (*See also* National Science Education Standards)
status in 21st century, 206–207
students' conceptions about, 56–57
Science Education for Middle Level Students, 8
Science fairs, 23, 47, 82, 87, 90, 91, 104, 155, 225–226, 227, 228, 240
Science Matters program, 105–106
Science Olympiad, 237–249
alignment with National Science Education Standards, 239, 251–254
competition structure of, 239–240
early research used as backbone of, 241–242
extracurricular activities, student motivation and, 244–245
future of, 248–249
impact on career choice, 237–238, 240–241, 244, 245–247
inquiry components of, 243
mission and goals of, 238–239
professional development and event design for, 240–241
research on impact of, 243–244
scientific literacy and, 243
STEM workforce pipeline and, 247–248
team organization for, 243
Science policy, 19, 26, 28, 32, 35, 36, 41, 45, 55, 56, 59, 60, 105, 135, 161, 206, 216, 219, 230, 236, 248
Science Rocks community event, 106
Science Scope, 98
Science standards, 269–271. *See also* National Science Education Standards
as guide for elementary science instruction, 86
reframing of, 4–5
Science, technology, engineering, and mathematics (STEM), 63–79
barriers to interest in, 161
building a knowledge base around, 66–67
in Camp Invention program, 9
current workforce in, 65
definition of, 207
education in U.S., 65–66
importance of educating students about careers in, 51–60, 66
in India and Asian countries, 63–64
interest vs. pursuing career in, 66
jobs in, 65
NRC study of successful education in, 67–69
criteria for, 68
goals for, 67–68
NSTA's efforts related to, 95–109
preparation for college courses in
college student survey of, 66–67
vs. preparation for STEM careers, 68, 70
proposed challenge awards in, 5–6

public-private initiatives supporting education in, 212–213
science class enrollment and interest in, vii–viii
U.S. dominance in, 63
Science, technology, engineering, and mathematics (STEM) schools, 68–79
for career and technical education, 69
educational practices in, 69
implications of NRC committee report for, 69–70
models for, 68–69
recommendations for STEM researchers and, 70
within regular high schools, 69
rush to establish, 67
selective vs. inclusive, 69
STEM Academy, 70–79
for students from disadvantaged backgrounds, 70, 71
Science textbooks, vii, viii, 6, 25, 27, 29, 31, 35, 53, 55, 83, 87, 131, 150, 193, 206, 260, 265, 269–270
Science workplace, 207
Scientific habits of mind, 55–56, 116, 130, 131, 132, 142, 207
Scientific literacy, vii, 1, 51, 55, 68, 81, 82, 83, 114, 116, 118, 206, 207, 243, 256
Scientific method, 83, 149
Scientific Software Services, 145, 148
Scientist(s)
Alberts's editorials on becoming, 1–3
characteristics of, 108–109
education of, 20, 64
examples of career paths of, 19–49
exploring nature of science, 107
habits of mind of, 55–56, 116, 130, 131, 132, 142, 207
historical, 108
real work practices of, 82, 87, 149
role of school science in producing next generation of, 56, 57
shortage of, 64, 242
stereotypes of, 19, 52, 95
students as, 147
U.S. employment of, 63
Serlin, R., 164
Service-learning, 161–180
Academy for Future Teachers program, 111–128
components of, 162, 163
definition of, 162
effects of participation in, 162, 179
examples of, 162
formative assessments of, 163
impact on students' interest in mathematics, 162–164, 179
instructional approaches to, 179–180
mentors for, 180
program design for, 162–163
role of narrative in, 163–164
STEMester of Service, 164–179
Siemens Competition, 104
Silverman, Jeffrey, 245
Slavin, R., 163
SMART Center. *See* Steppingstone Magnetic Resonance Training Center
Smithsonian Institution, 206, 214
Social studies combined with science, 83
Society for Science and the Public, 104
Software design and science, 39–40
Sosniak, L. A., 241
South Korea, 64
Sputnik, 64, 237, 242
State Science or Technology Fair of Iowa, 226
Stearns, Toren, 247–248
STEM. *See* Science, technology, engineering, and mathematics
STEM Academy, 70–79
academic achievement of students in, 73, 78
analysis of data from study of, 73
areas for improvement in, 74
description of, 70–72
goals and study questions for study of, 72, 78
interviews and focus groups in study of, 77–78
learning outcomes in, 71
methodology for study of, 72–73
New Tech model for, 71, 76
problem/project–based learning strategy in, 71, 72, 76, 77
Project Lead the Way curriculum model in, 71
school culture of, 73, 74, 77, 78
STEM career focus of, 71, 72, 79
student population of, 70–71, 73
student questionnaire responses about, 74–77

closed items, 75–76
open-ended items, 76–77
teacher responses to questionnaires about, 74
areas for improvement, 74
positive aspects, 74
vision of, 71
walk-throughs of, 73
STEM: Good Jobs Now and for the Future, 96
STEMester of Service, 164–179
duration and intensity of, 172, 179
findings of study of, 171–172
focus areas of, 171
grants awarded for, 164–165
limitations of study of, 170
locations of schools participating in, 165
program design for, 164–170
data analysis procedures, 170
research design and sample, 165–167
research questions, 165
student survey respondents, 166–167
survey measures, 167–169
student outcomes of, 173
factors influencing, 173–179
student perceptions of service-learning quality of, 172, 174
teacher perceptions of service-learning quality of, 171, 175–178
Steppingstone Magnetic Resonance Training (SMART) Center, 145–159
course materials for, 149, 151–154
description of, 148
equipment for, 148, 149
evidence of success of, 152, 155–157
funding for, 158
implementation of, 149–150
laboratory rules for, 149–150
lessons learned from, 157–159
mission statement of, 148
motto of, 146
pilot training sessions for, 152–154
purpose of, 149
student applications to, 152
student fees for, 154–155
student participation in, 145, 146
Steppingstone School for Gifted Education, 145, 148
Stokking, K. M., 57
Stombler, M., 243
Stone, David, 102
Students
conceptions about school science, 56–57
cultural literacy of, 54–55
curiosity of, 14, 24, 27, 66, 69, 79, 83, 85, 93, 96, 108, 115, 164, 260
developing scientific habits of mind in, 55–56, 116, 130, 131, 132, 142, 207
with disabilities, 39, 48, 161, 266, 267
motivation of (*See* Motivating students)
preparation for careers that do not yet exist, 129–142
Summerlin, Brent, 249
Swardt, E., 266
Swift, T., 267

T

Taiwan, 64
Talent Development vs. Schooling, 241
Talent marketplace, 205–220
addressing problems with, 212–214
establishing dialog between education and workplace sectors, 212–213
establishing "win-win" adaptable centerpiece program, 214
staying connected to sustain efforts, 213–214
curriculum-based programs for talent development, 214–219
applied science classroom track, 215–217
R_xeSEARCH: An Educational Journey, 214–215, 219–220
workplace track, 217–219
developers of talent, 208
dynamics of, 211
implications of changing science workplace for, 211–212
interactions between developers and users of talent, 209
as seller's vs. buyer's market, 209–210
shortage of talent, 209
talent economy, 210
users of talent, 208–209
Taylor, Calvin W., 241
Teacher Candidate Institutes (TCIs), at Illinois Mathematics and Science Academy, 129, 137, 138, 142
Teachers
Academy for Future Teachers (AFT) program, 111–128

content knowledge of, 84–85
of elementary school science, 84–85
preservice, 82–83, 84, 85, 91, 115, 120, 125, 137, 138, 202, 206, 234, 268
professional learning in Camp Invention program, 14–16, 17
real world externships for, 183–203
as source of career information, 52, 57–58, 66
underrepresentation of racial/ethnic minorities among, 111
Teachers Working in Science and Technology (TWIST), 185
Technology Association of Iowa, 202
Test question evaluation combined with science, 41–42
The Astrophysical Journal Letters, 139
The Journal of Physical Chemistry, 139
The Man Made World, 270–271
The Race to the Top, 56
The Science Teacher, 98, 139
The World Is Flat, 64
"Thinking starters," 85–86
This Week in Science, 23, 24
3M Corporation, 185
Tibben, DeAnna, 227–228
TIMSS, 120, 207
Todd, Mike, 201
Torrance, E. Paul, 16
Toshiba/NSTA ExploraVision competition, 100–103
Tourre, Mark, 248
Toyota TAPESTRY Awards, 100
Toyota TAPESTRY Foundation, 148, 154
Toyota TAPESTRY Grants for Science Teachers, 100
Travel combined with science, 27–28
Tufte, R., 266
Turnbull, W., 268
21st-Century Life and Career Skills (New Jersey), 217–218
21st-century skills/learning, 217–218
active learning strategies for, 256
in Camp Invention program, 7–11, 14–17
in Illinois Mathematics and Science Academy, 130, 132, 134, 137, 140
in Iowa Mathematics and Science Education Partnership Real World Externship program, 183, 187, 188, 191, 192, 193, 194, 196
in Science Olympiad, 237, 242, 243, 244, 247
in STEM Academy, 65, 72, 74, 77, 79
TWIST (Teachers Working in Science and Technology), 185

U

U.S. Department of Commerce, 65, 96
USA Science and Engineering Festival, 103–104

V

Vagelos, P. Roy, 4
Van Niekerk, E., 266
Vermeer Corporation, 185
Video games combined with science, 39–40
Vignoles A., 59
Virtual-learning activities, in Camp Invention, 11–12

W

Wallas and Kogan Creativity Verbal Ideation test, 16
Walton, Peggy M., 65
Wang, Tom, 31–32, 48
Watkins, S., 267
Weirather, Nadine, 228–229
West, Peyton, 37–38, 48
Wheeler, Gerry, 99
Wigginton, Nick, 33–34
Wirt, Jennifer, 244, 246, 247
Wong, Harry, 241
Workforce
shortage of skilled employees in, 64–65, 242
STEM workforce pipeline and Science Olympiad, 247–248
talent marketplace, 207–220
Workplace Learning Connection (Iowa), 185
Writing skills, 3, 264

Y

Yager, Robert E., xiii, 1, 265
Yajima, Rieko, 27–28
Yarema, Sandra, 241
Youth Service America (YSA), 164–165. *See also* STEMester of Service
Youth Service Institute, 164

Z

Zhao, J., 267
Zhe, J., 267