SCIENCE // TECHNOLOGY // ENGINEERING // MATHEMATICS // EDUCATION

CarnegieScience

FALL 2015

STEM EDUCATION

★ ★ ★

SPECIAL EDITION

Image courtesy Blonde Photography

ON THE INSIDE: ***Why Get Involved, Tips from STEM Experts, The Power of Role Models, and more***

CARNEGIE SCIENCE

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Bridging the Gap Between Wonder and Ignorance

"We have the freedom needed to limit and direct technology, to devise intelligent ways . . . of developing and limiting our power; and to put technology at the service of another type of progress; one which is healthier, more human, more social, more integral. In this regard, I am confident that America's outstanding academic and research institutions can make a vital contribution in the years ahead."

—**Pope Francis' speech to Congress,** *September 24, 2015*

Scientific discoveries continue to dazzle: *NASA's New Horizons Probe Glimpses Pluto's Icy Heart;*[1] *Homo Naledi, New Species in Human Lineage, is Found in South African Cave.*[2] Big breakthroughs first appear in science journals and then travel through major news organizations and social media outlets. Many of our country's strengths, personal freedom, wealth, health, longevity, military, vibrant art have been firmly based on science and technology, sometimes summarized as STEM (Science, Technology, Engineering, and Math). Do you have access to a free press? How? Do you hear opinions and events from around the world? How? Where did you hear the latest music you love? How did you hear it? Inventions and discoveries in mathematics, chemistry, physics, biology, and engineering produced manned flight, modern agriculture, cell phones, the internet. Similarly, science and technology allow us to detect and correct problems: epidemics, invasions by people or foreign species, pollution, food contamination, environmental destruction.

Technology also brings concern, dismay, and fear—the frightening power of weapons, invasion of privacy, online theft. To take advantage of the good, and to strengthen it, and to respond to the bad, it is crucial for everyone to have some understanding of scientific processes of observation, deduction, testing, and inference, and about how technological design and production builds upon the science. A starting point for improving the world is fact-based assessment of the present and possible futures. A modest level of familiarity with STEM equips people with an understanding of possible benefits and possible dangers of technology and stimulates ideas about how to maximize the former and control the latter.

Deeper in the news pages lie troubling statistics about our nation's scientific literacy. A recent Gallup poll[3] reveals that two out of five Americans believe that the Earth has existed for less than 10,000 years (a blink of an eye compared to the 4.5 billion years deduced from radioactive decay age dating, and in contradiction to essentially all that is known from astronomy and physics). In 2014 and 2015, record numbers of measles outbreaks were spread

by people who had not received the safe vaccine.[4] **Ignoring facts can be destructive or fatal.**

We react to numbers like these first aghast and then with disbelief. As science-inclined types, we read such reports and then nervously reassure ourselves that the poll bears a fatal flaw—a poorly phrased question, perhaps—or that the outbreaks only represented outliers, and that surely STEM education can't have failed so badly. **We shake our heads, sit back, and too often take no action.**

But we cannot ignore the mounting evidence that scientific literacy is in trouble. As STEM professionals, educators, and citizen scientists, we have great opportunities to get directly involved in addressing this problem. ("Why Get Involved," p. 5). But we need to do it right. There are many ways to do it wrong; they've all been extensively tested! **How can we teach STEM in a way that brings engagement and fun and joy and insight?**

Voices of Experience

Carnegie Science has a long history of efforts to advance STEM literacy, through First Light, a Saturday science school for children, which grew in 1994 into the Carnegie Academy for Science Education that now also offers hands-on, inquiry-based training for Washington, D.C., teachers of STEM topics. In this special issue, *Carnegie Science* shares a wealth of expertise learned from subjecting the process of STEM education itself to the scientific method—what works and what doesn't?

Here in this issue, top educators and STEM professionals share their perspectives on common pitfalls and time-tested paths to success ("STEM Tips," pp. 10-13). Unanimously, they agree that student curiosity is the most powerful catalyst to learning. We're encouraged to find out what young people are interested in and to run with that topic—whether that's germs, fireworks, spaceships, or baseball. Leave behind the classroom lecture format, these experts say, to invigorate the learning process: Get students into active inquiry learning, where activities prompt them to ask their own questions. Actual science is all about looking at amazing things and testing ideas about them, not memorizing dogma.

Why I Became a Scientist

Veteran teachers remind us that watching a real scientist in action can spark a lifetime of STEM engagement for students (pp. 14-17). Astronomers at Carnegie's Observatories in Pasadena have been making this happen for high school students from local public schools by bringing them directly into the department. There, they experience a day in the life of a scientist, learn what STEM careers really look like, and can discover what paths are open to them and what coursework may be involved.

Finding these role models and mentors embedded in STEM fields becomes even more important among underrepresented minority communities (pp. 7-9). Karl Reid, Executive Director of the National Society of Black Engineers, advocates a message that's echoed in many of the "Why I Became a Scientist" stories throughout this issue: **Without encouragement and exposure to STEM professionals, students neither know what they can achieve nor have the confidence to succeed.**

The DC STEM Network

Now, all of these recommendations can be put to use through one efficient channel. Carnegie Science is proud to announce the recent launch of the DC STEM Network, where teachers, STEM professionals, and students can all get involved. For this project, the Carnegie Academy for Science Education joined forces with the Washington, D.C., Office of the State Superintendent of Education to connect local partners in creating and advocating STEM learning opportunities for local D.C. students. The Battelle Memorial Network leads a nationwide network of 24 of these state initiatives, which are now joined by the DC STEM Network. Ideas and plans developed by the DC STEM Network will, we believe, be useful and relevant in many other places in the U.S. and elsewhere.

A launch event in April brought together educators, industry partners, and community leaders in student-led experiments and interactive workshops. The DC STEM Network also trained its first round of educators as STEM ambassadors this summer, to drive up community engagement. Beyond enabling improved classroom experiences that emphasize critical thinking and communication skills, the network provides greater exposure for students to the daily life of STEM professionals.

The information in this special issue provides paths for everyone—students, families, STEM professionals, educators, and organizations—to take action with the DC STEM Network website, so please join us there: www.dcstemnetwork.org. We look forward to your help in advancing science literacy. **Remember: STEM Needs You!**

Margaret Moerchen, *Science Deputy*

Matthew Scott, *President*

[1] *The New York Times*, 18 Sept. 2015
[2] *The New York Times*, 10 Sept. 2015
[3] Gallup Values and Beliefs survey, May 2014
[4] http://www.cdc.gov/measles/cases-outbreaks.html

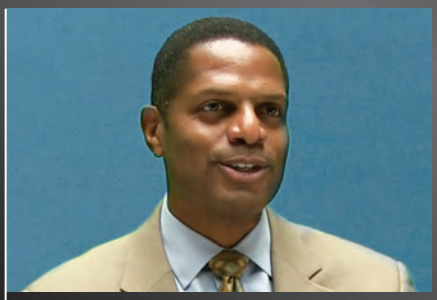
Meet the Experts

"We can't have a democracy without the spirit of science."

— Bruce Alberts

Bruce Alberts

Was the president of the National Academy of Sciences, 1993 to 2005; former Editor-In-Chief of *Science*, 2009-2013; National Medal of Science Award winner, 2014; and the current Chancellor's Leadership Chair in Biochemistry and Biophysics for Science and Education at the University of California, San Francisco.



Karl Reid

Executive Director for the National Society of Black Engineers (NSBE)

David Evans

Executive Director of the National Science Teachers Association (NSTA)

Courtney Robinson

Microbial Ecologist at Howard University

Aimee Kennedy

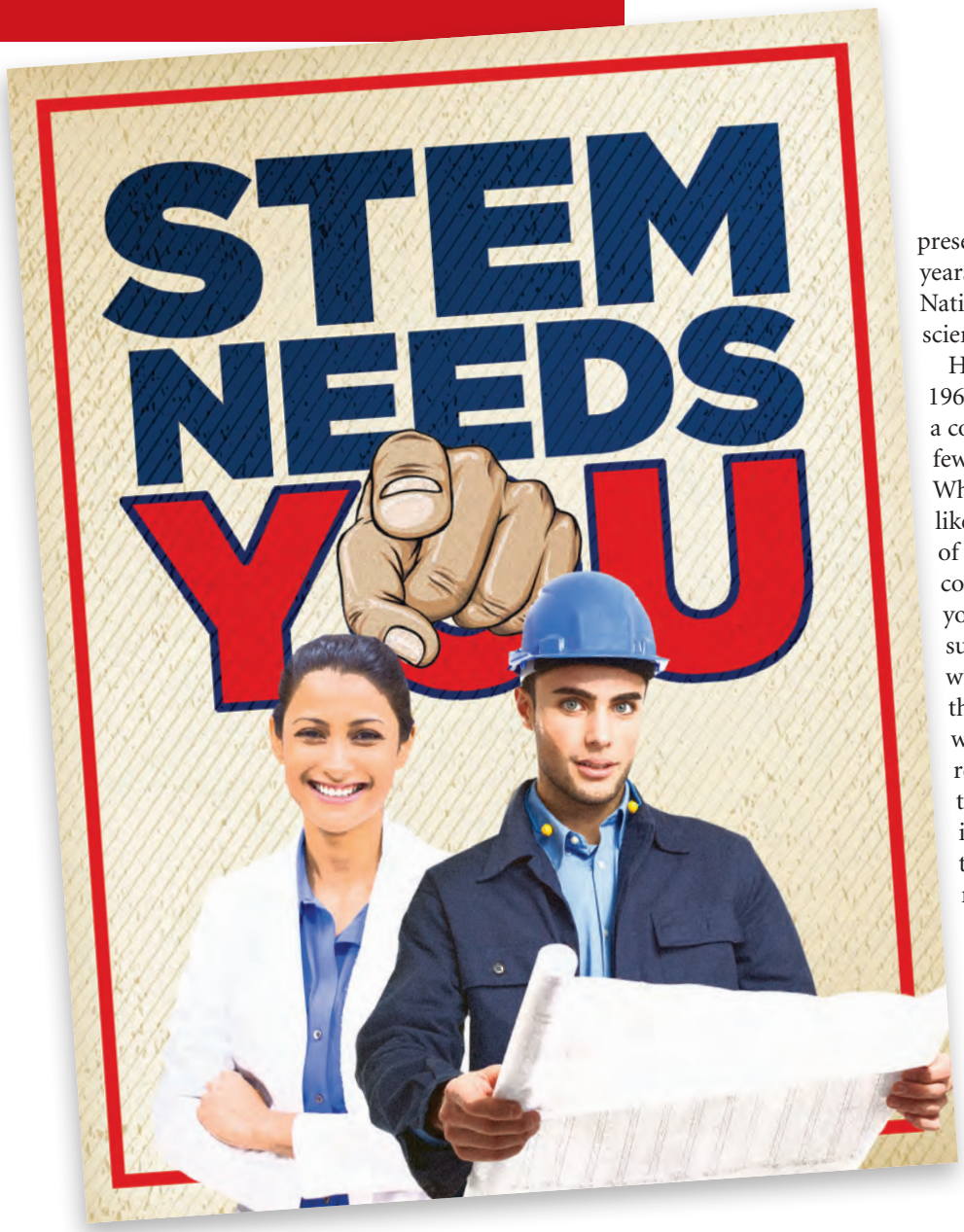
Vice President of Education, STEM Learning, and Philanthropy at Battelle

Sue White

Mathematics teacher, administrator, and consultant from the Washington, D.C., area and on the national stage since the 1980s

FOR VIDEO GO TO CARNEGIESCIENCE.EDU

WHY GET INVOLVED



FOR VIDEO GO TO CARNEGIESCIENCE.EDU

Several national leaders in STEM outreach voiced their opinions about the most compelling reasons that they believe that STEM professionals—those in the sciences, technology, engineering, and mathematics disciplines—should lend their expertise to the teaching community to ensure a better future.

David Evans, Executive Director of the National Science Teachers Association (NSTA), gave some context to the issue. "STEM is not a large part of the population," he said. "But STEM is a large driver of the economy. A recent Gallup poll showed that, currently, 42% of the U. S. population are Young Earth Creationists—people who believe that the Earth and humans in their present forms were created no earlier than 10,000 years ago. That information is consistent with National Science Foundation surveys; the state of science literacy is very low," he remarked.

He went on: "I heard a talk recently that in the 1960s only about 10% of the U.S. population had a college degree. Now only about 30% do. Very few scientists would agree with that number. When I pose the question to them I get numbers like 70% or 80%. A surprisingly small number of adults have college degrees. When you consider how few of those are in a STEM field you realize it's a pretty small group. We tend to suffer from selection bias. We tend to hang out with people like us, and we tend to forget that that is not a very good sample of what the whole population is like . . . Scientists should realize the sampling problems and understand that that they have a vested interest in getting it right. That would go a long way, recognizing the nature of the problem and that there are no short-term solutions."

Evans also said that most science teachers do not have a personal experience with people in the STEM professions and that most students do not know what those professions are. "We need to build a system to better connect STEM professionals and teachers. It is the personal experience we need to communicate to students."

Evans' goal, as the leader of NSTA, is that the whole population should be literate in the STEM fields. "It is more important to raise the level of science literacy for everybody than improve the next generation of AP tests and get the next Nobel Laureate. Our future really depends on it," he said. When people ask him how long it will be until we see an impact, he says a generation—at least a decade—before the new standards will have a measurable impact. "The problem is serious and it's really important. Scientists really need to play a role and an active role in their communities. They need to think of it as a community problem, not as a science problem."

42% of U.S. adults agree God created humans in present form within the last 10,000 years.

69% ATTEND CHURCH WEEKLY

47% ATTEND CHURCH NEARLY WEEKLY OR MONTHLY

23% SELDOM/ NEVER ATTEND CHURCH

Gallup Values and Beliefs Survey, 2014

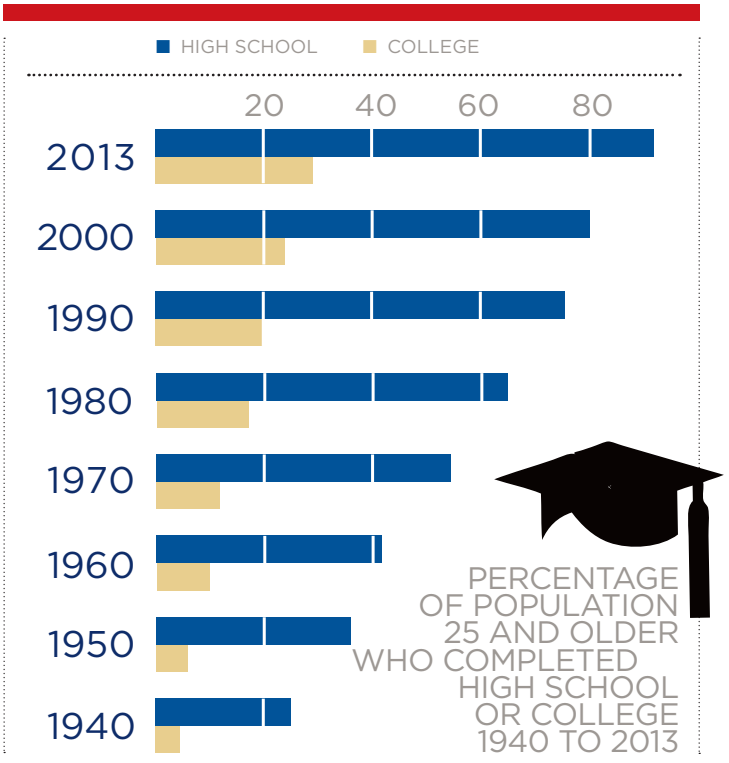
Karl Reid, Executive Director for the National Society of Black Engineers (NSBE), has been involved in STEM outreach since his freshman year at MIT. So he, and NSBE, also takes the long and practical view. In 2008, Bureau of Labor statistics projected that there would be a 17% increase in STEM jobs by 2018. "So the demand is there," he said. "The market needs this technical workforce in terms of economic security and national security. But more so, engineering creates and produces solutions that serve the common good. Think about the quality of life that we have today. It's because the greatest engineering achievements of the 20th century have been operationalized. The National Academies produced this list of the 20 top engineering achievements of the 20th century: air conditioning, the superhighway system, airplanes, aerospace, and computers. The things . . . that boost the quality of life. Think about what the 21st century will look like. We need engineers. Beyond that we need engineers in our communities to solve problems. So we are trying to increase the representation of young people from 4% to 12%." NSBE has set a vision to exceed parity in terms of the black population to produce more solutions and solve problems that are not just in the country and community but also across the world.

Bruce Alberts is an icon in STEM outreach for his decades of work. He was the president of the National Academy of Sciences, 1993 to 2005; former Editor-In-Chief of *Science*, 2009-2013; National Medal of Science Award winner, 2014; and the current Chancellor's Leadership Chair in Biochemistry and Biophysics for Science and Education at the University of California, San Francisco. He became aware of the need for revamping science education through his children. "Like everybody," he said, "it starts when you have kids. You see what's happening to them in school. You recognize that what they are doing in school is not teaching science. They teach science words, which fails to reflect the nature of science. The world is interesting, and it's not a place where you memorize all the facts. It is more important to understand the process of discovery."

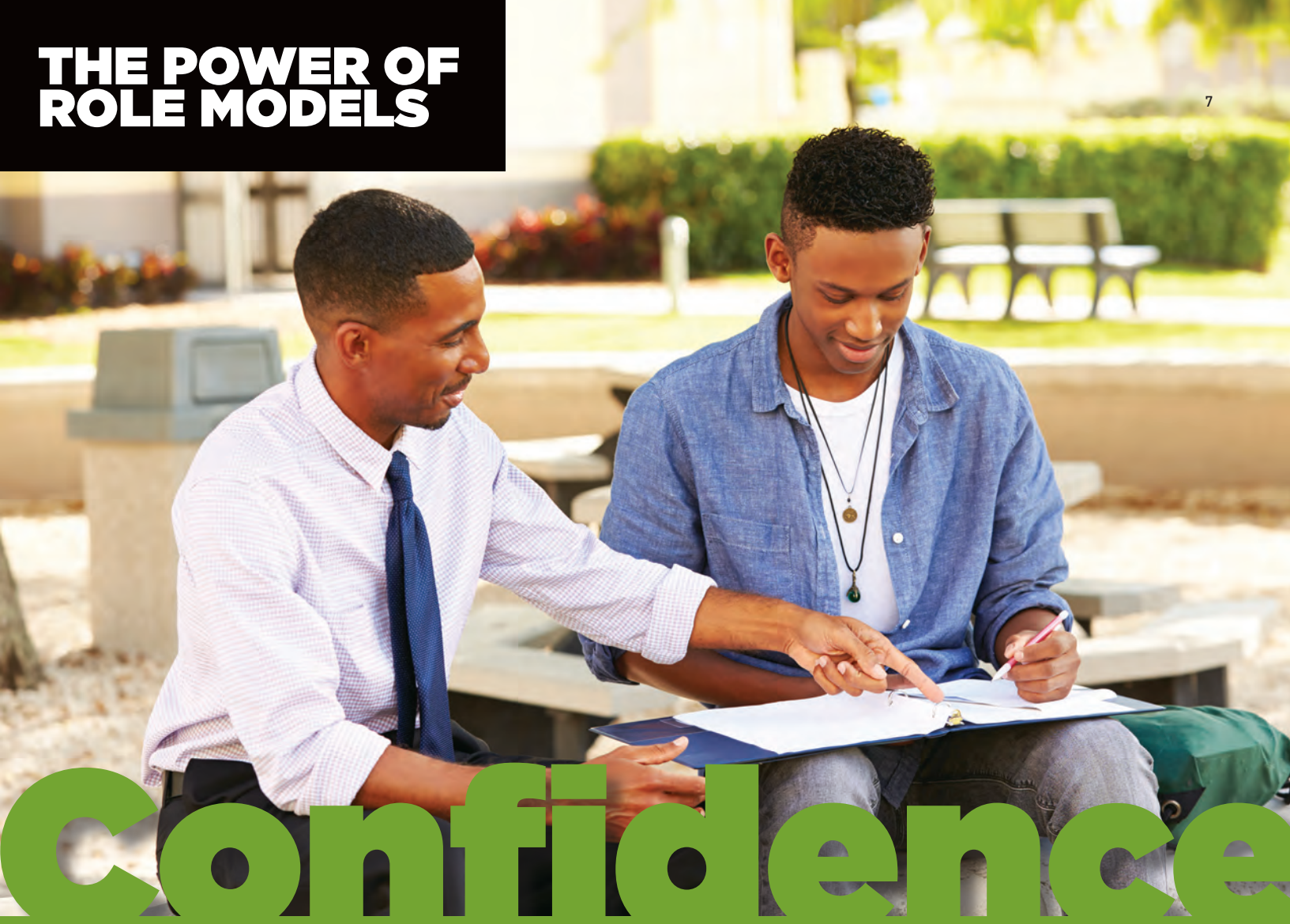
The problem with memorization is twofold according to Alberts. A word does not mean anything without its repeated use in a variety of contexts. And if a child memorizes two to three sentences about something like the endoplasmic reticulum, the sentences don't make any sense to them. It is merely an exercise in word association. "Science is taught this way partly because it is easy for fill-in-the-blank and multiple choice tests." The textbooks, he remarked, give no understandable explanations. Critical concepts like the remarkable fact that a cell can self-replicate is missed in most materials. "In science education it should be that before you are told the answer, you should struggle with the problem. We are doing the complete opposite," he said. And it continues at all levels.

Alberts believes that the Next Generation Science Standards provide a great opportunity. The National Academy of Sciences produced the framework for those standards. "It talks about emphasizing the practice of science. This will only happen if scientists help. It will not happen otherwise because most teachers have only experienced big lecture classes, no active inquiry learning in science. They are not familiar with the kind of teaching that we want them to do. What is really needed is a partnership between scientists and teachers."

He also discussed why a STEM education has much broader implications. All people need to think more scientifically, he said. There is so much irrationality around the world. He talked about democracy in India, an incredibly diverse nation, religiously and linguistically. "We can't have a democracy without the spirit of science," he remarked. He talked about what he calls a scientific temper—people who are tolerant of others, who look at issues rationally and at the evidence at stake, and who are not fooled by slogans. "This is critical for every nation. It is reason for scientists all around the world to get organized and work together," he said. ■



U.S. Census Bureau



Confidence

What Works for The Underrepresented

An interview with DR. KARL REID, *Executive Director of the National Society of Black Engineers*

The National Society of Black Engineers (NSBE) has over 31,000 members.

Its mission is "to increase the number of culturally responsible black engineers who excel academically, succeed professionally, and positively impact the community." The organization is committed to expanding the pool of engineering talent from communities of color from around the world through innovative programs targeted at K-12 grades, college students, and professionals.

Karl Reid has been a leading advocate for low-income and minority youth to increase their access to college for over 15 years. Prior to NSBE, Reid was senior vice president of research, innovation, and member college engagement at the United Negro College Fund. Before that he was associate dean of undergraduate education and director of the Office of Minority Education at the Massachusetts Institute of Technology (MIT) where he also earned his Bachelor's and Master's of Science degrees in Materials Science and Engineering. Reid went on to receive a Doctorate of Education from the Harvard Graduate School of Education. In addition to his work in education and nonprofits, he also worked for IBM.

THE POWER OF ROLE MODELS

For his Harvard dissertation, Karl Reid chose to explore the factors that contribute to how certain students are successful in college, particularly African American males. One powerful factor is a high level of so-called self-efficacy. That is, the confidence one has to be successful at a task or, more broadly, in a domain like academia. It turns out that one of the components of self-efficacy is something called the vicarious experience—the power of role models. When a person sees someone to whom they can relate having success, it gives that person the confidence to succeed. Researcher Albert Bandura discovered this factor in the 1970s and 1980s. He made the argument that students with a high degree of self-efficacy are much more persistent and more resilient, they put in more effort, and they are much more successful in numerous areas including academics. Reid emphasizes that the role of mentors, advisors, and others of influence is key to building up that sense of confidence.

Another component of self-efficacy is subjective judgements. Reid calls it the Home Depot approach: "You can do it, we can help." When a person hears someone they value tell him or her that he or she can be successful in a particular task, it builds confidence. He gave an example from his own life. When he was a freshman at MIT he took multivariable calculus. The professor pulled him aside and asked him if he would consider majoring in mathematics because he was having success in that class. "I do not think that I touched the ground for another week after hearing from this notable lecturer about my possibilities," Reid remarked. Ultimately, Reid did not choose math, but hearing that he had possibilities from that teacher built his confidence. "And I got an A in that course," he said with a laugh.

Reid believes that role modeling and mentoring is the role that STEM professionals should play. He urges them to speak to young people and encourage them. NTSB has self-efficacy built throughout its entire network. NTSB's summer engineering experiences for kids from third to fifth grade are taught by college students, many of whom are majoring in engineering. These young people look up to the collegiates and think, "This is what I will look like in 10 or 15 years." The society's professionals serve as advisors and mentors to the precollegiates, collegiates, and even young professionals. "I think we need to do this at a much larger scale across the country and institutionalize this process," he concluded. ■

Mentor

Sue White

My role model was...
My 8th Grade Teacher

"I have always been interested in and had a talent for mathematics. I also recall that I had such great and memorable mathematics teachers from junior high through high school . . . Teachers who made mathematics interesting and relevant . . . who seemed to love mathematics and infected me with their enthusiasm.

"The single event, however, that gave me the confidence that I could pursue mathematics as a possible career occurred in junior high school. My eighth grade mathematics teacher took me to a mathematics/science contest at a nearby college, Virginia State College. I competed and won first place in the eighth-grade competition, which was truly an amazing experience for me. It helped build my confidence and ultimately set me on the course for selecting mathematics as a major in college, which ultimately led to a career in mathematics education.

"Additionally, in my family, I was always engaged using puzzles and games that stimulated my ability to problem solve."

WHY I BECAME A SCIENTIST

STEVE SHIREY *Carnegie Geochemist*

"I was always a very curious person, and I loved the natural world. One of my dad's friends gave me a hand lens when I was around 10 or so. I knew by the time I was in high school that I was headed for a career in science."

Courtney Robinson

My role model was...
Diane B. Jones

"I typically think about Mrs. Jones, Diana B. Jones, at Oxon Hill High School who was my microbiology teacher. And there were many others. They were always so encouraging and whenever you wanted to do a special project, somebody was there to say, 'Well these are the things you are going to need. And sure, I will stay after work to help you.' I think that those are probably just really good teachers, who turned out also to be mentors. You can be a teacher without being a mentor.

"Other opportunities came later in graduate school; my Ph.D. adviser was really involved in science education, Jo Handlesman. I joke with her now that I was paying so much attention to the research that I probably was not paying as much attention as I should have been to the science education. But I picked up enough that it really sparked an interest."

Image courtesy Blonde Photography

David Evans

My role model was...
Mrs. Kennedy

"There were several influential people. I was in the sixth grade in 1957 when Sputnik went up. My teacher Mrs. Kennedy sat me down and told me what I was going to do. There was no one in our family, in my parents' generation, who went to college. She told me that I was going to go to college, that I was going to study science, and that I would get a Ph.D. and become a professor and have my own students and do research. I did not know what a Ph.D. was. That was not a language in my household. She wasn't specific, but it never occurred to me to just not do that because, after all, if Mrs. Kennedy said you were going to do it you just did. That was a really important marker. And it stayed with me for a very long time after.

"I was also very fortunate in my early teens. There was a chemical engineer, an outside neighborhood friend with my parents. He was actually very helpful. He would share journals and talk about things. I think he worked for a paper company. So I got tours and saw the kinds of things and got sort of a feel of what science was like, other than what you read in books.

"They had an impact on me at a really critical time. That late elementary, middle school, early high school time is a time that we know is very, very important. We lose a lot of kids to science and STEM fields in middle school. That's when kids decide that science is too hard, it's kind of boring, and—unfortunately if you are a girl—it's really not cool. It's really important to get people involved at that point and provide inspiration and continuity for kids."

FOR VIDEO GO TO CARNEGIESCIENCE.EDU

STEM TIPS from STEM Professionals, Outreach Leaders, and Teachers

STEM professionals, leaders in STEM outreach, and teachers in the trenches suggest some rules of the road of what works and what does not when STEM volunteers try to engage students.

**The excerpts from interviews have been edited for clarity*

The Take Away

Many teachers do not know STEM professionals and many students do not know what jobs there are in STEM, except possibly working in a lab.

Talk about the possibilities and the adventures you have had, especially if you travel or do fieldwork for your profession.

Talk about the science and math of everyday things and activities.

Don't lecture; have hands-on activities.

EMPHASIZE

Emphasize the practical application of a STEM education.

Prepare and consult with teachers before going into a classroom, camp, or other forum.

Get students interested early in the K12 EXPERIENCE

Talk about your adventures in the field.

Image courtesy Lara Wagner

TIPS from STEM Professionals and Outreach Leaders

WHAT NOT TO DO

"To try to teach them chemistry or biology is a big mistake. It is not for scientists to go into the classroom and start lecturing. That is the worst thing they can do. We want active learning. We don't want them to lecture the way they do in college. When you do that you overwhelm the teacher in the class with all these complicated things that neither the teacher nor students understand. You will leave the teacher with all the questions that the kids will ask, and she or he cannot answer."

FOR VIDEO GO TO CARNEGIESCIENCE.EDU

Bruce Alberts
Get 'em Talking

WHAT TO DO

"The Next Generation Science Standards provide a great opportunity. They talk about emphasizing the practice of science, enabling kids to actively learn science and become logical thinkers, logical problem solvers, people who understand scientific judgments and how science works through the K-12 experience. This will only happen if scientists help. It will not happen otherwise because most teachers have only experienced big lecture classes, no active inquiry learning in science. They are not familiar with that kind of teaching. What is really needed is a partnership between scientists and teachers.

"Scientists have to be aware that teachers have this image of scientists being very smart and arrogant. We have to come in and interact with teachers in a true partnership and listen to them. If you listen to our good teachers, you'll be very impressed with what they do every day. I could never do it: Teach five classrooms with 40 kids each on several different subjects? I mean it's a killer. Teachers I know who are just wonderful are incredibly admirable people. Scientists learn a lot from teachers by listening to what they say about pedagogy. Because most of us do not know anything about how students learn.

"A very important preparation for going into the classroom is to read what experts say about how to do it. UC-San Francisco has had a science education partnership for 30 years. Go to their Web site and get information on active learning. Read about what works before going into a classroom. I think it's great for scientists to talk about what they do in their life, how they became a scientist. Don't just talk at kids, but have them ask questions.

"Make sure that the kids talk. The teachers will help you with this. One of the real clever things I realized is the difference between a good classroom and a classroom that is all teacher directed. Observe a class and count how many times a student in the class says a second sentence. Saying one word or one sentence does not mean that there is active learning. Where students are thinking, students will not just say a word or sentence but two sentences or sentences that apply to what other students have said. We need to make a science out of science education."

NEXT GENERATION SCIENCE STANDARDS For States, By States

WHAT TO DO AND *NOT* TO DO

Image courtesy Blonde Photography

David Evans
Excitement is Contagious

WHAT TO DO

"Many kids don't know what the opportunities are. They don't know what the career paths are. They don't know that studying science does not mean that you are going to wear a white lab jacket and spend your time in a laboratory. Having personal stories makes it exciting. The Next Generation Science Standards prompt kids to ask their own questions. Realize that the process of science is the process of asking questions. The first seven questions you ask, you won't get an answer. You will find out that they are not even the right questions to ask. That is a lot like exploring a game space when you realize that the path you took and are convinced will be the one to take you there, in fact, has you being consumed by a fire-breathing dragon.

"Be exciting; conveying excitement is really important. Once and done is not sufficient. The real need is science education programs with continuity, like libraries, maker spaces, and mentoring relationships with teachers. The main idea is programs with continuity and time rather than one cool lecture.

"I think the out-of-school programs are really the place to work. There are lots of these that focus on STEM activities. There are informal programs in museums, zoos, science centers, and homework study programs. Right now there is a lot of emphasis on STEM programs. Many of the programs have foundation funding or corporate funding to support them so there is kind of a framework in a lot of communities, especially in economically disadvantaged communities. The President is behind this in his agenda: STEM education and careers are a way of lifting prospects for disadvantaged groups."

FOR VIDEO GO TO CARNEGIESCIENCE.EDU

WHAT NOT TO DO

"Unfortunately we have fewer happy experiences when scientists and engineers feel that the best they can do is visit a classroom. Most of us are not all that skilled at conveying our science to people who are not in the 'club,' especially to children: Often these are bad experiences. We are poorly trained in how to communicate. Working with other community organizations, cafes, and connecting in informal settings is probably a better way to go."

Matchmaking

"One of the problems we have in engineering is that we tend not to be the most outgoing, the most gregarious personalities. As a result, we fail to speak to the joy of engineering, and we need to do more to speak with enthusiasm about engineering. So go into local communities and after-school programs, boys and girls clubs, the YMCA, and local elementary and high schools and ask for an opportunity to speak.

"I was invited to participate in the Youth Baseball Academy that the Washington Nationals host. They have an after-school program and a career day. The academy invited about 30 professionals to the event. We spoke to about 100 students, and I ran into two third graders who said that they wanted to be engineers. I gave one of them my card and asked him to have his parents contact me. The next day I got a call from his dad asking about resources and programs for his young son who wants to be an engineer."

– Karl Reid

Courtney Robinson
Curiosity's Cool

WHAT TO DO

"What you learn about kids is that they are curious. Any time I meet a kid who is curious at all about what I do, I tell them about the science that I do, that I get to work with bugs, and 'have you heard of germs?' Well there are real names for germs. They are bacteria and viruses, and I study these things, and that is super cool. Something else I focus on is letting people know that you do not have to be some sort of super genius to be a scientist. You just need to be curious.

"Make science accessible . . . I study microbial communities that are host associated, and I am interested in host microbe interactions that lead to changes in the immune system. That is not something I am going to say to everybody. It goes back to the idea that there are these things that you know of as germs. Here is how they interact with your body. Everybody has a body. Everybody has a microbiota.

"I coordinate a course that is funded by the Howard Hughes Medical Institute, and we start students in genuine research as freshman. It's hugely important for STEM educators that if you have high school students going into college make sure they ask about research opportunities. If you have a curious high school or middle school student get them involved in research. Get them involved with that university professor down the block, because we love talking about our research; we love having students come into our laboratories for what we think is the coolest thing ever. Don't be afraid of scientists. We really do want to help and love to have people take part in our research."

Image courtesy Blonde Photography

Karl Reid
Fireworks and Baseball

WHAT TO DO

"We need to keep young people not only competent in mathematics in third, fourth, and fifth grade but also confident in math so they can enjoy it. No one can do that better than those who practice it because they can bring relevance. The first thing we have to do is find out what the students are interested in and we could build a whole curriculum around that. If you are interested in fireworks, there's a lot of science in fireworks. If you are interested in baseball, we could do that as well. Seasoned engineers and scientists can bring relevance to that young person. But the first step is finding out what they are interested in.

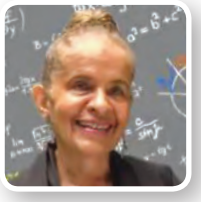
"When I was at IBM years ago, the company had a partnership with Junior Achievement. I spent a semester teaching economics to a seventh-grade math class, which gave them an opportunity to understand why they were learning the math and how it could be applied. There are other opportunities for a school to welcome a professional, to give a demonstration, and to make it exciting. That's the advantage of having seasoned engineers or scientists bringing their experience into the classroom. They can make it exciting by linking the course work to something the professionals have mastered."

FOR VIDEO GO TO CARNEGIESCIENCE.EDU

WHAT TO DO AND *NOT* TO DO

Image courtesy Sean Solomon

TIPS *from* Excellent Teachers



Sue White Game Up!

WHAT TO DO

"It is imperative that we get into the schools, become friends with the schools, and involve the parents, and we have got to do it at the grassroots level. We have got to get into the space where kids live and study and play. We've got to teach these kids that these video games and puzzles really are mathematical and science based. I am a living example of that.

"Students need access to professionals to really understand what the field involves. Often our teachers don't even know what these STEM careers look like. So it is imperative that our STEM professionals get involved with schools. STEM professionals tell me that they do not know how to permeate the school environment. So you have to teach them how to get into a school. My suggestion would be to get in touch with a principal and get them to understand that the knowledge of STEM in any area really impacts and changes students' lives. We need to insist that science be taught early, at the pre-K level and on. I have not yet met a STEM professional who came out of a school who was not excited when they left. It only takes one encounter with a STEM professional for a student to decide his or her life's course. In Neil de Grasse Tyson's speeches, he often recounts his story about his first visit to a planetarium during which he determined this would be his career.

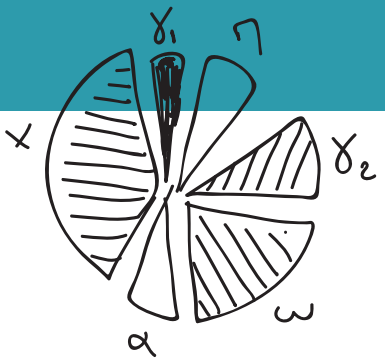
"I insist that when someone comes to the school that they let me see what they want to do and we rearrange it so that it is interesting. We forget that kids like to move around, and there are so many ways to engage kids in an active way. Bring me something that's interesting, and show kids how it is related to the mathematics and the science they are learning. I am thinking of a guy who does MatheMagic. He did it at my school with 300 kids. The kids got so excited.

"Volunteer, but not for the moment, rather for the long haul. I had a volunteer with MATHCOUNTS who was a retired statistician from the Labor Department. He stayed with me as long as I was there. The greatest thing in the world is to be able to influence someone else's life with what you do."

FOR VIDEO GO TO CARNEGIESCIENCE.EDU

Sue White ON MATHCOUNTS

"As a mathematics educator, I took an active role in engaging students in STEM activities. One such example was forming a MATHCOUNTS team each year in the junior high where I taught. Each year I served as coach, the teams managed to reach the citywide competition, and some teams went on to compete at the national competition. I encouraged the principal to have school-wide MATHCOUNTS pep rallies prior to the team's competition, which made the team members proud to be mathletes and not embarrassed to be 'nerds.' I sought to motivate as many students as possible at the onset of the year by inviting all students interested in mathematics to participate in the MATHCOUNTS test for team selection. Each year, at least 100 students would participate. I also engaged STEM professionals in the community to be mentors to the team, which gave the students access to STEM practitioners. The huge known outcomes from this effort (as I am still in touch with most of them) was that all of my former MATHCOUNTS students have entered STEM careers, and many of them have received their doctorates or the equivalent in mathematics, science, and medicine. Some became accountants, and some are entrepreneurs in the varying fields of technology."



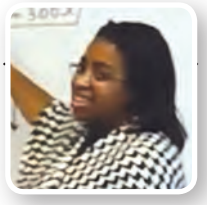
WHAT NOT TO DO

"One of the things we have got to remember: Don't come in with a lecture, but come in with good hands-on ideas that stimulate. The students are fascinated when you take a game and show them the mathematics in it."

Several master teachers in the Math for America Master Teacher Program housed at Carnegie headquarters give some tips. To qualify for the Master Teacher Program, candidates must have taught math for at least four years, have demonstrated leadership, and have developed unique tools and activities. The program's goal is to establish a community of leaders in mathematics in the larger community who teach mathematics in an engaging way. These master teachers, who receive stipends, commit to teaching five years in the Washington, D.C., school system.

Theresa Simmons

An Explosion of Examples



WHAT TO DO

Offer examples of how you use math and science skills in your job. "Math teachers don't live under a rock. We understand that most people don't use the equation for a circle in their professional lives. I think kids think teachers are trying to convince them of something that isn't really true when we tell them that they'll use this stuff." Simmons uses monuments on the Washington Mall and the Metro system to study geometry. Other everyday examples to use include electrical and mechanical devices and chemistry explosions.

WHAT NOT TO DO

Don't talk over the kids' heads. When STEM professionals come in "they sometimes forget who their audience is and they don't necessarily keep in mind their grade level."

Image courtesy Blonde Photography

Matchmaking

"Reach out to the school. Meet with the school's principal and offer to volunteer in the classroom or volunteer to be a judge at the Science Fair, sponsor a STEM club, sponsor field trips to area STEM institutions, or serve as a mentor for students who have demonstrated interest in STEM. But find someone who really knows the school to best access the school rather than going in blindly. Find someone who knows how to permeate the school. It is not hard."

– Sue White

"I think that there are different opportunities depending on where you are in your career; I would even take it down to high school. If you are in AP Biology, then go to the elementary or middle school. Get them excited about it. If you are in college or are a graduate student, this is a great opportunity to consider STEM education as a career path. There are plenty of scholarship and fellowship opportunities that are available specifically for STEM education, even postdocs. There is the scholarship of teaching and learning area that has blossomed over the last decade or so—huge opportunities to really make a difference."

– Courtney Robinson

WHAT TO DO AND *NOT* TO DO

Bill Day
Expect Hurdles

WHAT TO DO

Talk to the teacher in advance about what to expect in terms of the kids' knowledge level. Be mindful that literacy can be a hurdle to the kids understanding the program you have planned, even before you get to the math or science part. "Talk to the teacher about how to convey the background knowledge necessary to engage with the task you have planned. Work with the teacher to cocreate a lesson plan based on knowing the students and the school environment."

Expose kids to scientific career paths. "One issue that we come up against is that doing math and science in school is very different from doing math and science in the workplace. A big way that STEM professionals can affect students is by giving students exposure to those career paths and demystify those positions."

WHAT NOT TO DO

Do not criticize the kids' existing level of knowledge if it is not up to your expectations. "Don't slam their educations. We need to meet kids where they are. It's not productive to say, 'kids today. . . '"

Karl Reid

My role model was...
My Dad

"I was fortunate that my personal connection was to my dad. My dad never graduated from college. He went to Hampton Institute, now University, for two years and dropped out and joined the Navy. But he had an engineering mind. When I was three years old he had me repeat 'Massachusetts Institute of Technology.' When I was five years old he saw my interest in trains. He said, 'Karl, engineers drive trains.' I said that's what I want to be, an engineer. And as I got older, he expanded the definition: 'Well they actually design and build trains too.' I was seven years old and trying to decide whether I was going to drive a train, design a train, or build a train. And as I got older he expanded the definition more to include airplanes.

"He was a police officer, at one point, and he used to take me to Kennedy Airport and tour the hangers. And I just loved that. A lot of what I do is, in a way, a tribute to him: creating access and opportunity for young people. So, here's to you dad."

FOR VIDEO GO TO CARNEGIESCIENCE.EDU

Will Stafford
Build 'em Up!

WHAT TO DO

Acknowledge the work kids are doing; be respectful of it. Know what to expect the students will know. "When you're in a classroom, acknowledge the work students are doing and then build up from there." Bring supplies you can leave behind for future projects. Stafford did a city-planning project in geometry class. An architect came in at the beginning and then again at the end to serve as an audience for the kids' final projects. The top students selected by the architect got to go to the firm's office and give a presentation there. He also had representatives from the National Security Agency visit his class with a cipher code that they taught the students how to break. Then they gave the kids another one to work out on their own.

WHAT NOT TO DO

Don't lecture. "The biggest pitfall I've seen is when professionals come in and try to give a presentation on what it is that they do for more than five minutes. The best advice is talk for five minutes, include some kind of video or hook, and then get the kids doing something."

Image courtesy Robin Kempster

David Tansey

Share Your Joy

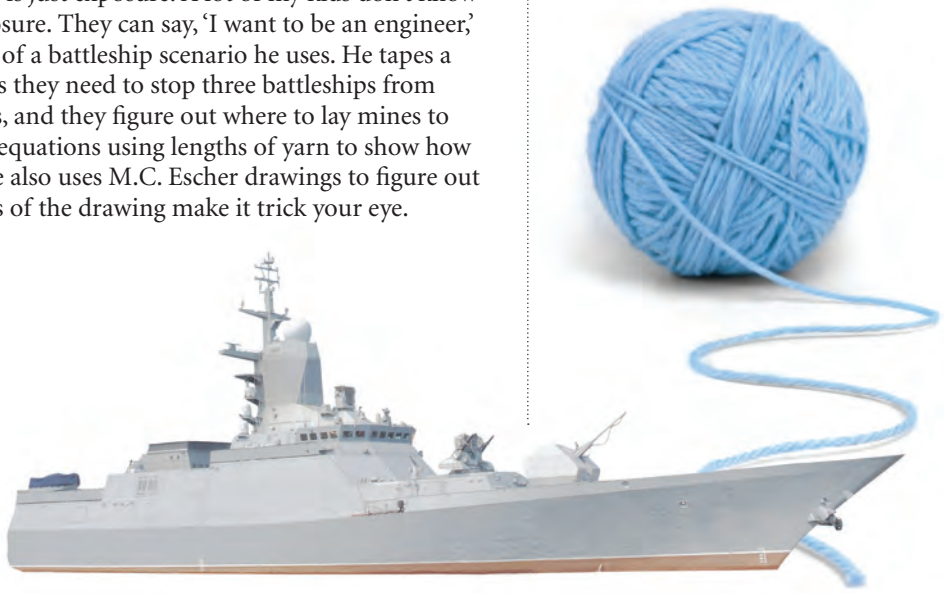
WHAT TO DO

Tell kids how you became a scientist; show by your example that they could, too. "If you're trying to help out at your neighborhood school, a lot of it is just exposure. A lot of my kids don't know what scientists do. A lot of my kids don't have exposure. They can say, 'I want to be an engineer,' but they've never met one." Tansey has an example of a battleship scenario he uses. He tapes a grid on the floor of the classroom, and tells the kids they need to stop three battleships from coming to D.C. They see the trajectory on the grids, and they figure out where to lay mines to stop the ships. Then they turned those results into equations using lengths of yarn to show how far different engines could travel in ten seconds. He also uses M.C. Escher drawings to figure out how to isolate variables and figure out what aspects of the drawing make it trick your eye.

WHAT NOT TO DO

Don't lecture. "That's never exciting. Sometimes you have to, but let that be the teacher's problem. Don't be adding to the boring parts of class; add to the active parts. Don't make them think scientists just sit around all day listening to lectures."

Don't come in unprepared. "You're not adding to their world by just showing up. If you're going to do it, do it right."



What Works in

The Private Sector/ STEM Partnerships

Image courtesy Battelle

Battelle is the world's largest, independent, nonprofit research and development organization. It produces products and services for government, consumer, industrial, energy, environmental, health, pharmaceutical, and national security uses. Its mission also includes a strong commitment to community development and education, particularly science, technology, engineering, and mathematics (STEM) programs. Aimee Kennedy, the vice president of Education, STEM Learning, and Philanthropy at Battelle in Columbus, Ohio, has a background in STEM education. She and Battelle want to demystify what STEM professionals do and pull back the curtain to see how STEM education works and why it is essential to our future. She spoke at the launch of the DC STEM Network hosted by the Carnegie Academy for Science Education. It is part of similar programs in other states led by Battelle.

Kennedy emphasizes that STEM educators need to encourage students to dream beyond what is currently possible, like Battelle's innovators. One essential ingredient is to create classrooms where mistakes are a welcome and necessary learning tool. Putting kids in front of a computer does not make a school a STEM school, she emphasizes; technology in and of itself is not enough.

Battelle
The Business of Innovation

Battelle, in collaboration with surgeons and others, conducted a decade-long project to assist the paralyzed. It serves as a model for STEM educators and students for what can be accomplished with this education. In the Battelle system, a chip monitors the brain activity, relays it to a computer with software, which translates that activity to a language that muscles can understand to open and close the hand. The first test of the system was for a 19-year-old who was paralyzed from an accident.

The Real World

Battelle Education has operated in more than 35 schools since 2006 to engage students in transdisciplinary, problem-based learning by addressing real-world issues. The teachers serve as facilitators to help teams solve problems rather than presenting solutions in a lecture. Some projects mimic the real world of Battelle and other research organizations.

One extraordinary Battelle project serves as a vivid example. This project, which took more than 10 years to complete and involved 39 Battelle staff in partnership with surgeons and others, developed a revolutionary system known as neural bridging. This system bypasses the spinal cord to help quadriplegics regain some movement in their hands and arms.

The project's compelling story features an athletic 19-year-old who had a diving accident, leaving his limbs useless. In an unprecedented medical trial, he had brain surgery to implant a chip in his brain. This chip monitors the brain activity that directs the hand to move, relays it to a computer with Battelle software, which translates that activity to a language that muscles can understand to open and close the hand. The signals go to a forearm cuff also invented at Battelle, which makes the hand move in the way the brain was thinking. The successful trial required that the doctors and engineers had the vision, drive, confidence, and teamwork to create this life-changing product. It is those qualities that underlie a STEM education.

"STEM educators need to encourage students to dream beyond what is currently possible, like Battelle's innovators."

A STEM Model

The schools where Battelle is involved teach their students to work in the same way. One school uses a design cycle framework for a given problem. It begins with teams of students who brainstorm about how to solve an assigned problem, design a solution, build it, evaluate and test their models, modify what does not work, and share their results with others to reinforce what they learned. As one student said, it is all hands-on and fun to get things to work. The fact that solutions do not always work is where the learning begins.

The Finished Person

Kennedy talked about how many in the STEM community make the "workforce argument" to advocate for a STEM education, noting that it prepares kids for work in the real world. It certainly does. But a student named Jack, who graduated from the Metro Early College High School where Kennedy taught, summed up a better reason why STEM is so important. After high school, he graduated from Ohio State University with a degree in business, and he is now a local entrepreneur/film maker. "I don't remember very much curriculum and I don't think that's an uncommon thing," Jack said. "But I do remember the excitement that I learned to have when it came to solving a problem . . . I do not forget my education . . . every single day, when I am working in the field, I use the 'Metro habits' we call them: critical thinker, inquiring learner, collaborator, active and responsible decision maker, and engaged learner. Those are constantly just burned into the way that I approach things." ■

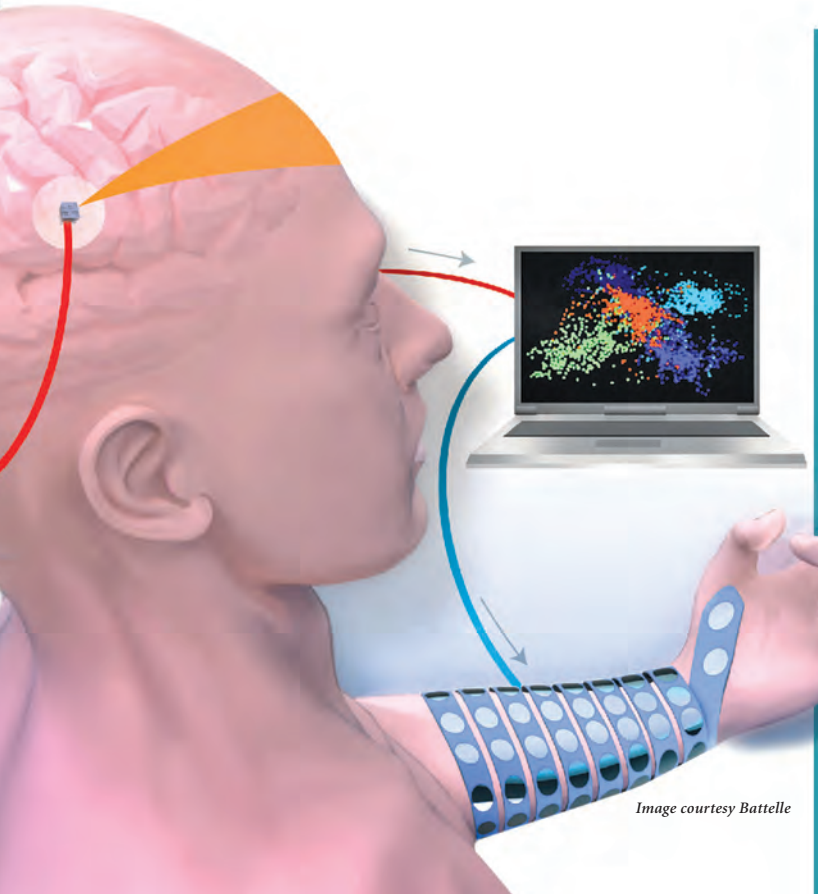


Image courtesy Battelle

Karl Reid

ON ENGINEERING CAMPS

"The National Society of Black Engineers manages a summer engineering program, in 17 camps in different cities. About 4,800 third through fifth graders get high-quality STEM experiences. These young people get so excited. They are actually building toys. They are building rocket-propelled vehicles, fuel-cell cars, solar cars. They learn how to translate potential energy into kinetic energy with the vehicles that they build. So during the course of the week, they are building and learning key science concepts—Newton's three laws. They are learning about velocity and acceleration, and other physics terms. Every Friday is 'Competition Friday.' Teams of young people compete with one another with their vehicles, not just how fast but also how accurate, and then they also give oral presentations about what they have learned. So the learning is reinforced. I was in New Orleans visiting my first camp, and the fifth grade team chose to use a talk show format to demonstrate their knowledge. The host asked 'the guests' to tell him 'about velocity' or 'can you talk a little about acceleration?' So they are reinforcing their learning, and they are excited about it. We invite professionals from the communities to judge the competition as volunteers. We train them to evaluate the students' performance. There is a remarkable interest in learning. When you see 300 young people reciting Newton's three laws it's wonderful."

WHAT WORKS

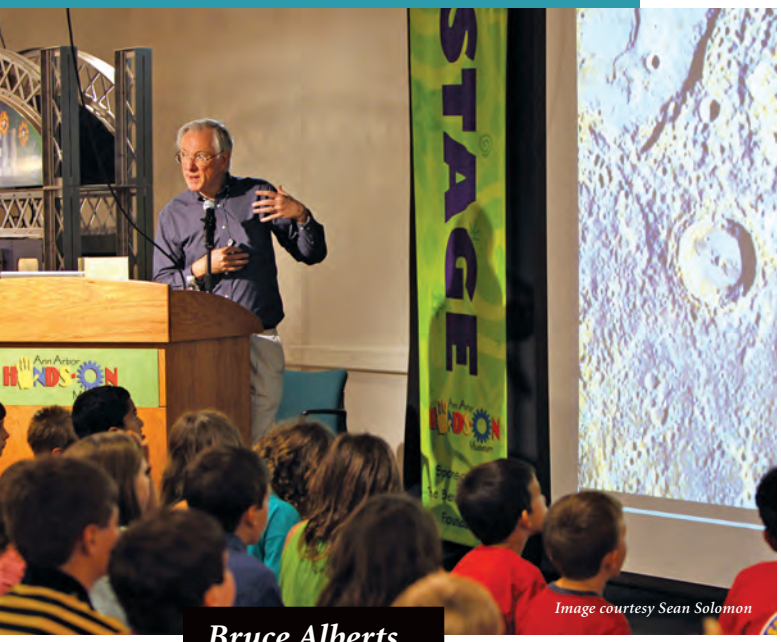


Image courtesy Sean Solomon

Bruce Alberts

ON THE UCSF SEP HIGH SCHOOL INTERN PROGRAM

"UC-San Francisco has a program that won an Obama mentoring award. It's about 30 years old. They ask the teachers of the San Francisco school system to nominate kids whose parents have not gone to college, who are excited about science—whether they are doing well in science or not. Every year something like 150 kids are nominated and about 20 are selected. Each of the 20 works in a lab with a postdoc or graduate student, and they meet a couple of times every week to talk about their future—especially about college: how do you get into college and get help, and writing applications to college. It has been an incredibly successful program. About 95% of them have gone on to college, and most of them have majored in some kind of scientific field. This program could be replicated at every research institution."

Battelle's Aimee Kennedy (top) spoke at the DC STEM Network launch event hosted at Carnegie headquarters. The network is co-led by Julie Edmonds of the Carnegie Academy for Science Education (bottom).

Sue White

ON OTHER WAYS TO ENGAGE

"Experiences should be hands-on, show application to the real world, and be interactive. Career days, for example, should move from the lecture format to the hands-on format where students can see and explore interesting 'big ideas' in STEM. Hosting 'Math and Science' evenings with parents and students provides a wonderful opportunity to show how interesting STEM can be. Parent involvement is essential, where possible. I have observed schools where STEM guests do incredible demonstrations in large and small school environments. The results are amazing in stimulating interest in STEM, however it must be continued and not a 'one-shot' visit. Other ways of engagement include mentoring students, helping to raise funds to equip a lab, sponsoring the science fair, or serving as a judge at the science fair."


Image courtesy Battelle

Getting Started:
Select STEM Resources

T Teachers
P STEM Professionals
S Students

LINKING EDUCATORS WITH STEM PROFESSIONALS

National Academy of Sciences strategic education research partnership
http://serpinstitute.org/

—

STEMLink is an online matchmaking service at the University of Colorado
http://www.xsci.org/stemlink/

STEM GRANTS

Guides to STEM Funding Opportunities
http://stemgrants.com/

—

http://www.stemfinity.com/STEM-Education-Grants

—

http://www.stemfinity.com/index.php?route=information/information&information_id=7

—

National Science Foundation
Robert Noyce Teacher Scholarship Program seeks to encourage talented science, technology, engineering, and mathematics majors and professionals to become K-12 STEM teachers
https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5733

—

Search this NSF page
http://www.nsf.gov/funding/

—

The Howard Hughes Medical Institute (HHMI)
Selected 37 research universities to receive $60 million in grants to improve how science is taught
https://www.hhmi.org/news/hhmi-announces-60-million-initiative-improve-science-education-undergraduates

CLUBS/PROJECTS/ FUN WAYS TO LEARN

MATHCOUNTS
http://www.mathcounts.org/

—

MatheMagic!
http://www.mathemagic.com/site/

—

STEM Finity
http://www.stemfinity.com/?utm_source=adroll&utm_medium=display&utm_campaign=retargeting

—

Makerspaces
These are spaces where people can gather to create, invent, and learn in many libraries and elsewhere
http://oedb.org/ilibrarian/a-librarians-guide-to-makerspaces/

—

http://makerspaces.meetup.com/

—

National Education Association STEM Resources
http://www.nea.org/tools/lessons/stem-resources.html

—

National Science Teachers Association Resources
https://www.nsta.org/publications/

—

National Society for Black Engineers, Camps, Competitions, and More
http://www.nsbe.org/Programs/NSBE-Programs.aspx#.VcTCXEYWMXg

—

MIT Office of Engineering Outreach Programs
http://oeop.mit.edu/programs/stem

—

UC San Francisco Science and Health Education Partnership
http://biochemistry2.ucsf.edu/programs/sep/

—

Active Learning On Line Lesson Plans Database
http://www.seplessons.org/search/node/

—

UCSF SEP High School Intern Program
https://diversity.ucsf.edu/program/ucsf-sep-high-school-intern-program

—

PBS STEM Resources
http://www.pbs.org/teachers/stem/

SELECT STEM ASSOCIATIONS/SOCIETIES

Career Cornerstone Center for Science, Technology Engineering, Mathematics, Computing, Healthcare/Aggregates STEM associations
http://www.careercornerstone.org/assoc.htm

—

National Academy of Sciences
2101 Constitution Avenue, NW
Washington, D.C. 20418
202-334-2000
http://www.nasonline.org/

National Academy of Engineering
500 Fifth Street, NW
Washington, DC 20001
202-334-3200
https://www.nae.edu/

—

American Association for the Advancement of Science
1200 New York Ave NW,
Washington, DC 20005
202-326-6400
http://www.aaas.org/

—

National Education Association
1201 16th St NW
Washington, D.C. 20036
http://www.nea.org

—

National Science Teachers Association
1840 Wilson Boulevard
Arlington VA 22201
703-243-7100
www.nsta.org

—

National Society of Professional Engineers
1420 King Street,
Alexandria, VA 22314
703-684-2800
www.nspe.org

—

National Society of Black Engineers
205 Daingerfield Road
Alexandria, Virginia 22314
703-549-2207
www.nsbe.org/home.asp

—

American Society for Engineering Education
1818 N St. NW, Suite 600
Washington, DC 20036
202-331-3500
www.asee.org

—

Junior Engineering Technical Society
1420 King St., Suite 405
Alexandria, VA 22314
703-548-5387
www.jets.org

—

American Mathematical Society
201 Charles St.
Providence, RI 02904
800-321-4267
www.ams.org

—

Mathematical Association of America
1529 18th St. NW.
Washington, DC 20036
800-741-9415
www.maa.org

Society for Industrial and Applied Mathematics
3600 University City Science Center
Philadelphia, PA 19104
215-382-9800
www.siam.org

—

American Indian Science and Engineering Society
2305 Renard SE, Suite 200
Albuquerque, NM 87106
505-765-1052
http://www.aises.org

—

Some World Science Academies
http://www.interacademycouncil.net/25185/27752/25196.aspx

—

http://www.unesco.org/new/en/natural-sciences/science-technology/sti-policy/global-focus/young-scientists/world-association-of-young-scientists-ways/

STEM JOB PROJECTIONS

U.S. Department of Education Resources
http://www.ed.gov/stem

—

U.S. Government Labor Statistics
Overviews of STEM employment
http://www.bls.gov/opub/btn/volume-3/an-overview-of-employment.htm

—

http://www.esa.doc.gov/sites/default/files/stemfinalyjuly14_1.pdf

—

http://2010-2014.commerce.gov/blog/2012/02/06/state-our-union%E2%80%99s-21st-century-workforce

—

http://www.stemedcoalition.org/wp-content/uploads/2010/05/BLS-STEM-Jobs-report-spring-2014.pdf

—

Outlook for Specific Fields
http://www.bls.gov/careeroutlook/subject/stem.htm

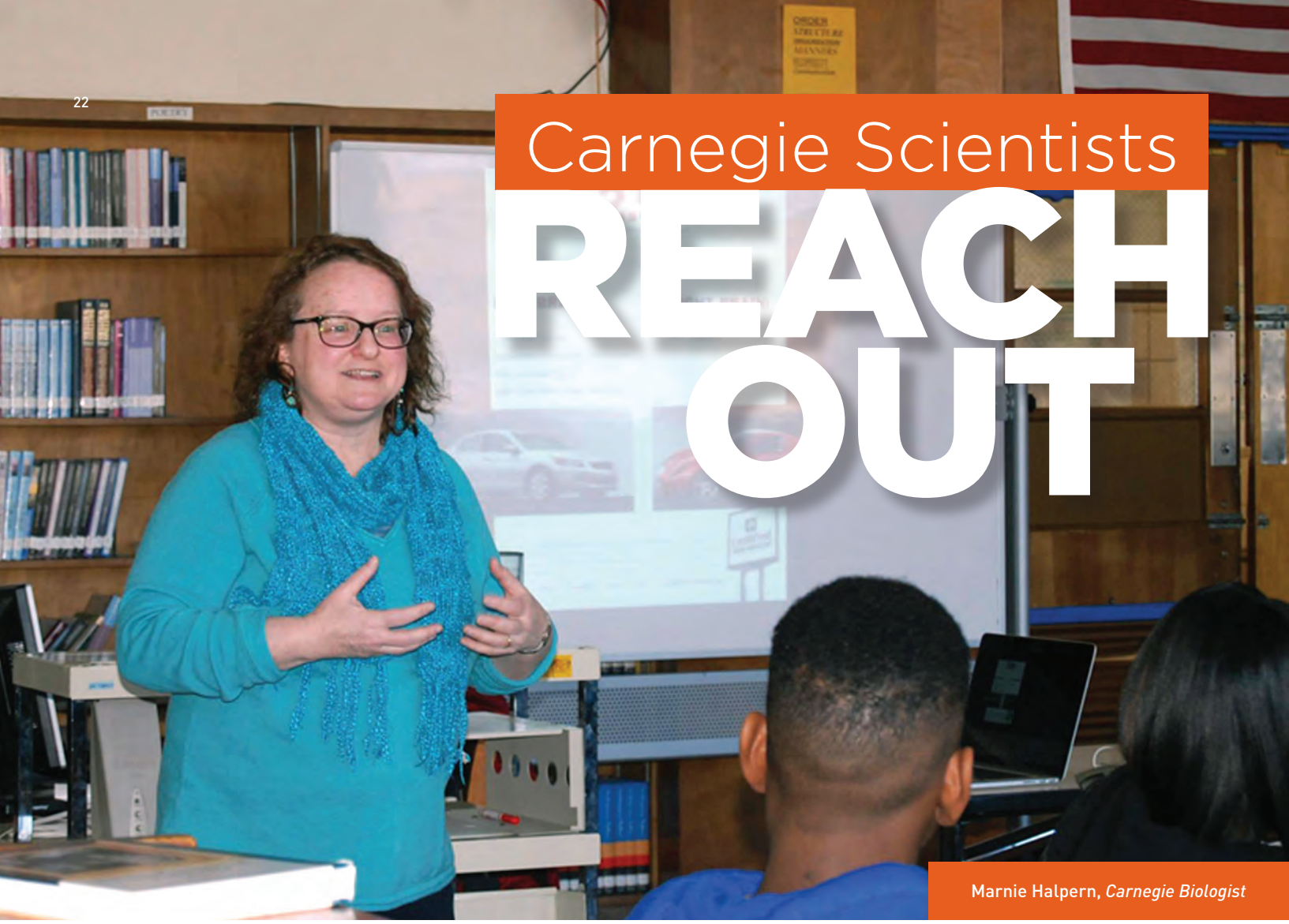
—

Bureau of Labor Statistics STEM search
http://data.bls.gov/search/query/results?cx=013738036195919377644%3A6ih0hfrgl50&q=STEM+jobs

—

The Women in Science, Technology, Engineering, and Mathematics ON THE AIR!
http://www.womeninscience.org/resources.php

Carnegie Scientists REACH OUT



Marnie Halpern, *Carnegie Biologist*

Image courtesy Marnie Halpern

When it comes to educational outreach, many Carnegie staff scientists and postdocs engage. Some start their own programs or regularly work with a particular organization or initiative. Others engage on an ad hoc basis. But all who reach out are dedicated to improving science literacy for the next generation.

John Mulchaey, director of the Carnegie Observatories, says that showing students what it's like to be a scientist was one of his primary goals for the three education programs he's started.

"I totally lacked this when I was coming up through the system as a high school student," Mulchaey said about a new program that offers mentoring days with Carnegie postdocs to high school students, which he designed to show kids what it's actually like to be a scientist. "I've been thinking about this my whole life, and now I'm in a position where I can direct more of it."

"It really opened my eyes to what a modern-day astronomer actually does. I learned a lot of useful information that not only encompasses their position at Carnegie as a scientist but also advice for undergrad and then requirements if I ever wanted to pursue graduate studies," said participant Jasmin Ionescu. "It was also really friendly and inviting, especially for a shy person, like me."

Other Observatories programs include the popular Astronomy Nights, managed by Chris Burns, that has been bringing telescopes to schools for evening events for the past decade and another that helps local schools design a special "science space" that's vibrant and engaging for the students.

The importance of offering educational opportunities to the next generation of potential scientists is also at the forefront of the minds of the Carnegie staffers managing the internship programs at Plant Biology and Global Ecology.

Grayson Badgley, a graduate student in Chris Field's lab, says he works with interns because "somebody did it for me. I definitely wouldn't be in science if it weren't for undergraduate research opportunities."

Sue Rhee, a Plant Biology staff scientist who coordinates the internship program there, said undergraduate research was a big part of her own education, and she loves that the program provides research opportunities to curious students who haven't had the chance to do much of this hands-on work.

"The program is good to foster those sorts of students, but it's also good for the

WHY I BECAME A SCIENTIST

GWEN RUDIE *Carnegie Astronomer*

"I was blessed to have two amazing scientists as parents, so I grew up in a very scientific household. As a result, there is not one moment in which I decided to be a scientist but rather an upbringing that valued questioning why things happened and worked—and I suppose my choice to be a scientist professionally is just an offshoot of that sort of inquisitive approach to life."

Grayson Badgley, *Carnegie Postdoctoral Ecologist*

Image courtesy Robin Kempster

Steve Farber, *Carnegie Biologist*

scientists in our department—to put them in touch with the younger generation," she explained. "I was a lot more interested in just pursuing my own curiosity. They are of course curious, too, but they also have a lot more feelings of social responsibility and wanting to do good things."

Timothy Rodigas, a postdoctoral fellow at Terrestrial Magnetism, noted that it's important to him to reach out not just to the science superstars but also to the kids who are struggling as well.

"When I was a kid I loved astronomy, but I was bad at math and science. Part of me, when I talk to these kids, is trying to reach out to others like me and tell them that all hope is not lost if you're not the brainiac super-smart math kid," he said of recent guest presentations he's given about astronomy at the school he attended growing up.

And even students who don't go into scientific professions can benefit from educational outreach activities led by STEM professionals. Improving science literacy is imperative for our country, noted Steve Shirey, staff scientist at Terrestrial Magnetism who has worked with students and teachers for the Carnegie Academy for Science Education.

"I think we have to start speaking up for science," he said. "Too often we assume the public will appreciate what we do and without a good foundation in science education that won't happen," he added.

"I am a strong believer that the ability to communicate to the public what you do should be a part of our job description," said Jackie Faherty, a postdoctoral fellow at Terrestrial Magnetism who is involved in a wide array of educational outreach efforts in Washington, D.C., and in New York. She previously coordinated a global effort involving school children from six continents and 10 countries to observe the transit of Venus. "We've got the keys to the best car, and I want to give everybody a ride in it."

Another concern that gets Carnegie scientists involved in educational efforts is the desire to increase diversity in their fields.

"Staying on the cutting edge means having a wider range of perspectives is crucial," said Johanna Teske, a postdoctoral fellow at Terrestrial Magnetism.

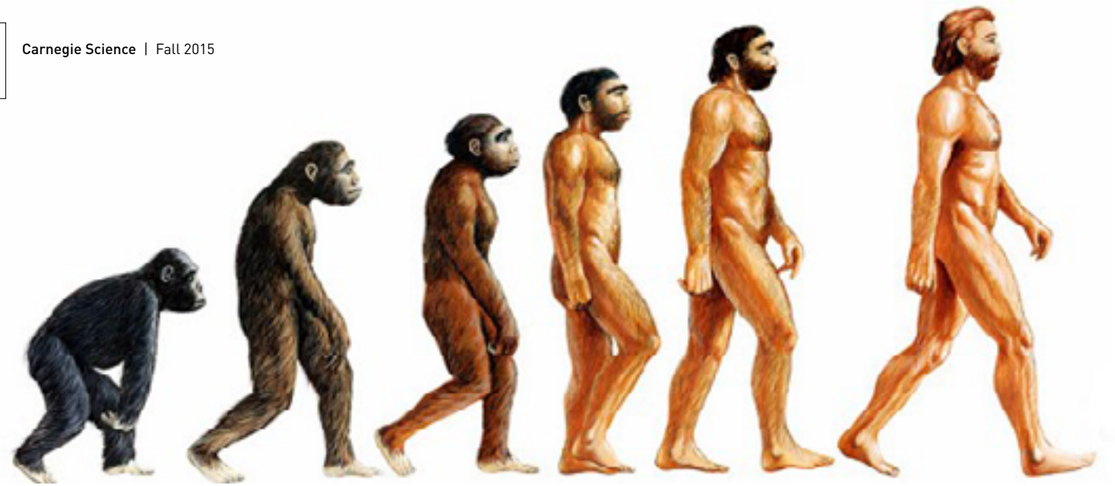
Image courtesy Johanna Teske

Johanna Teske, *Carnegie Postdoctoral Astronomer*

Marnie Halpern, a staff scientist at Embryology, addressed this concern by starting the Women Serious About Science program 15 years ago. The program brings scientists from a variety of disciplines to a Baltimore high school where they talk to girls about their work during lunch periods.

"When I was a grad student, there were so few female faculty members. I was actually pretty discouraged by not having female role models," she said, describing her motivation for developing the program. "Seeing other women who are successful, who have done it, I think I could have really benefitted from that."

Also at Embryology is Carnegie's BioEYES K-12 science educational program. It recently launched a new center sponsored by the University of Utah to introduce students to the scientific method with hands-on learning to watch live, transparent, zebrafish embryos develop. BioEYES is the brainchild of Steve Farber, who partnered with educator Jamie Shuda in 2002 to launch the program. BioEYES provides outdoor and classroom-based learning on environmental and biological concepts. To date, over 86,000 students and 1,450 teachers in the U.S. and Australia have participated. ■



Tackling the Evolution Conundrum

BY CONNIE BERTKA
Cochair of the Smithsonian Institution's Human Origins Program's Broader Social Impacts Committee

"...unfortunately research in science education has revealed that many teachers avoid teaching evolution, and students avoid learning it, if they feel it conflicts with their religious beliefs."

As the formal part of our public event was ending, I rose from my chair and dashed to the back of the room. We had just led a community conversation with forty people about the "meanings" of evolution. Nineteen different public libraries around the country are hosting the Smithsonian Institution's traveling exhibition "Exploring Human Origins: What Does It Mean to Be Human?" As cochair of the Smithsonian's Human Origins Program's Broader Social Impacts Committee, I am part of a team facilitating supporting events. I wanted the family in the back of the room to know we appreciated their participation and the thoughtful way in which they expressed their concerns about the theory of evolution. Given that over a third of the U.S. public share their belief that God created the Earth and humans, in their current form, 10,000 years ago, I suspected many more dashes to the back of the room would be in my future.

A community conversation is one of four events in support of the traveling exhibition; the other events include an evening science presentation, a workshop for educators, and a private tour and discussion with local clergy. Dr. Rick Potts, director of the Smithsonian's Human Origins Program and curator of the traveling exhibition, is participating in all of the events and encourages a unique approach to public engagement with science. The traveling exhibition and science presentation illustrate how science has shed light on our connectedness to the natural world and the origins of sharing, caring, and innovation. The exhibit's title question, "What Does It Mean to Be Human?" and the supporting events, invite individuals and their communities to discuss how scientific discoveries about human origins relate to their personal understanding of the world and their place in it.

The father of the young Earth creationists' family that I spoke with described himself as an engineer and explained that his family loves science, but not the kind that teaches that human beings have evolved. The conversation they wished to have with me was not about age dating, or fossil evidence—questions my Ph.D. in geology ought to help me to answer—but instead they wanted to know, that if humans evolved, about when did we get a soul? I do not share this concern and I am not confident of a unique answer, but I am familiar with the variety of ways theologians might respond.

I have had a long-term scholarly and pragmatic interest in the relationships between science and religion and their influence on the public's understanding of science. This interest eventually led to a degree in theology and several years directing the AAAS Program of Dialogue on Science, Ethics, and Religion. Whereas the first 10-plus years of my career were spent as a research scientist studying Mars at Carnegie's Geophysical Laboratory, I spent the next 15 years tackling a significant challenge to the U.S. public's acceptance and understanding of what science is learning about the origin and evolution of our planet and life—namely the difficulty relating these discoveries to their religious beliefs.

The scientific community may be best prepared to address problems of science literacy by advocating for more and better science instruction, and robust science standards, but unfortunately research in science education has revealed that many teachers avoid teaching evolution, and students avoid learning it, if they feel it conflicts with their religious beliefs. Could acknowledging their cultural concerns make a difference in their willingness to explore the science for themselves? The spectrum of beliefs about nature, "creation," and the degree to which they conflict with science is variable. Avoiding conflict between science and religion by advocating a stance of "non-overlapping magisteria"—that religion and science are simply different areas of inquiry with separate domains of authority—is a common response. This approach helps explain why science, not religion, is taught in a science classroom, but it has proven less successful in encouraging many reluctant students, or their teachers, to embrace the teaching of evolution in their high school biology classes. There is no simple answer to this dilemma, but I think the time has come to try a new approach.

I have come to believe that an important step toward more and better science instruction, and robust science standards, may be to create opportunities for high school students, and future science teachers, to explore the evidence for evolution in an environment that does not ignore cultural concerns about learning evolution but rather acknowledges that these concerns exist. The goal is to help students come to appreciate how the scientific community understands evolution, while respecting that their decision to accept, or not accept, this scientific understanding is their own. Regardless of their personal beliefs, future teachers should recognize this goal. We should not expect scientists or science teachers to become experts in religion or theology, or to resolve students' religious concerns. However, a more informed understanding of the history and variety of relationships between science and religion might help give them the confidence to create a less threatening environment for exploring evolution, both in the classroom and outside of it. Simply acknowledging concerns, but not resolving them or "teaching the controversy," may do more to encourage reluctant individuals to learn about science then the dismissive alternative. Quantitative data to support this idea are limited, but encouraging. I hope future science education research will address this need.

I did not expect my discussion with the family of young Earth creationists to result in their acceptance of evolution. I do hope our discussion encouraged them to continue exploring not only the evidence for human evolution but also the variety of ways people relate scientific discoveries about human origins to their personal understanding of the world. Like scientific exploration and discovery, the latter will be a long and continuing process. ■

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Part of the origin's traveling exhibition included a panel where visitors were encouraged to define what they think it means to be human. Connie Bertka is on the right.

Rick Potts, director of the Smithsonian's Human Origins Program and curator of the traveling exhibition, interacts with some local teachers about human origins.

Reverend Jim Miller (left) and Connie Bertka (right) are leading a community conversation with the traveling exhibition "Exploring Human Origins: What Does It Mean to Be Human?"

Images above, courtesy Jennifer Clark

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WHY I BECAME A SCIENTIST

"Research was actually a pretty big part of my college experience, and I remember how awesome it was to be able to do my own research myself and talk to the professor as colleagues trying to solve a problem together."

—Sue Rhee, Carnegie Plant Scientist

Image courtesy Robin Kempster

"When people ask me when I got interested in astronomy, I ask them when they stopped being interested in astronomy. I don't think I've ever met a kid who wasn't interested in astronomy. The strange thing to me is that people stop."

—Alycia Weinberger, Carnegie Astronomer

Image courtesy Alicia Weinberger

"I definitely had a very big moment in between my freshman and sophomore year when the movie *Contact* came out. I'd never really thought of astronomy. No one told me, 'Find yourself a career with math and science.' I saw Jodie Foster in this role, and then I thought I could do that."

—Jackie Faherty, Carnegie Postdoctoral Astronomer

Image courtesy Jackie Faherty