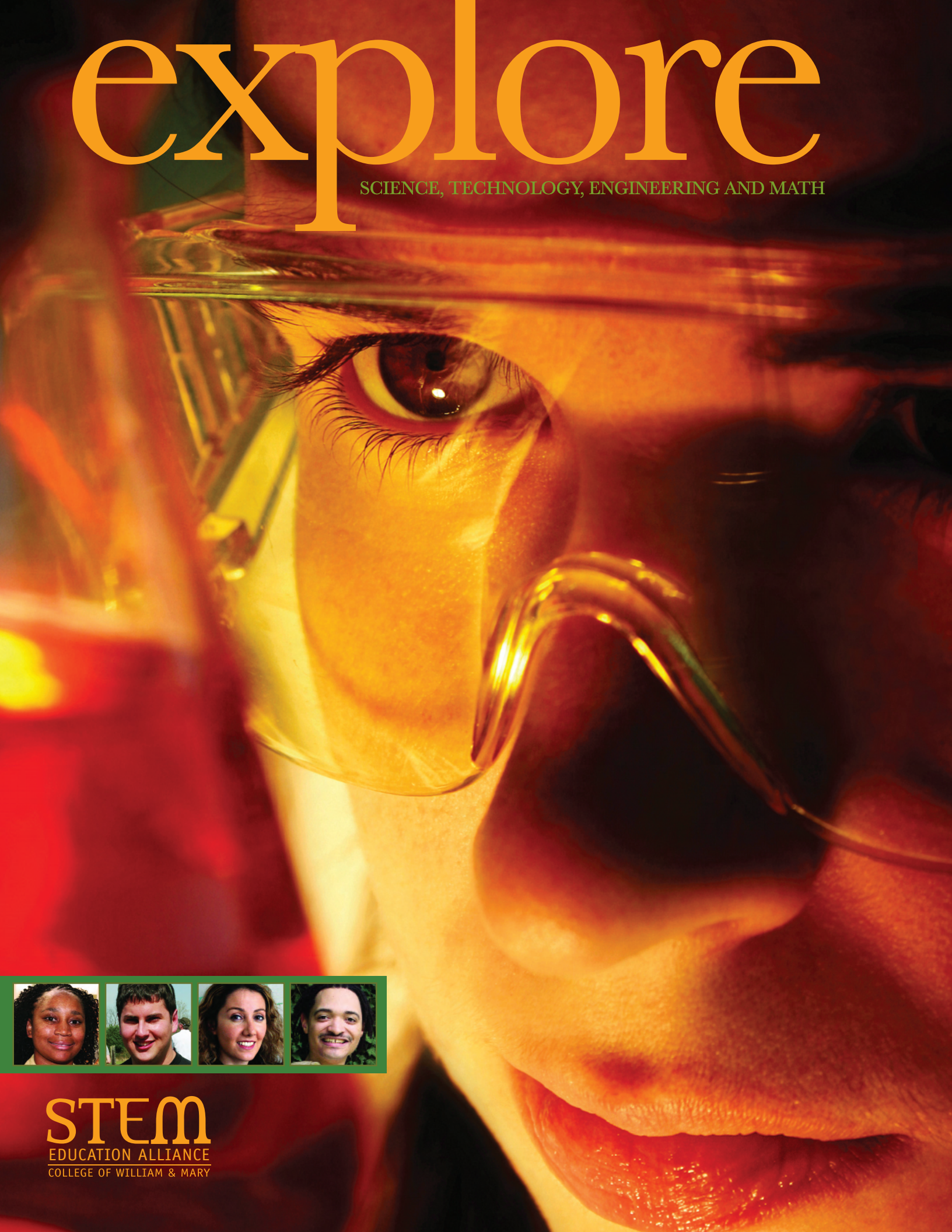
explore

SCIENCE, TECHNOLOGY, ENGINEERING AND MATH



STEM
EDUCATION ALLIANCE
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SCIENCE, TECHNOLOGY, ENGINEERING AND MATH

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Students go beneath the surface in Sea Perch, p. 22



Visit the *Explore* Website

www.stemeducation.org

Visit the NDEP Website

www.NDEP.us

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TOP 8 REASONS

To Become a Scientist, Technologist, Engineer or Mathematician

You've heard all the geek and nerd jokes. Right?

Scientists are locked away in labs. They're boring and don't have any fun. Engineers can only speak in numbers. And mathematicians … they're really in the fast lane to dullsville.

Forget all that! Scientists, technologists, engineers and mathematicians are cool. Yes, really!

How would you like to hang from a helicopter 50 feet above a glacier? Explore the surface of Mars? Cure a deadly illness in Africa? Use instruments that make Darth Vader's light saber look like an antique? These are just a few of the opportunities offered by these careers and featured in this magazine. But before you begin to explore…

[Consider the TOP EIGHT REASONS to tackle a career in science, technology, engineering or math.]



8. These careers are fun.

Imagine yourself playing the "greatest video game in the world." That's what modern scientists do, according to Pardis Sabeti (page 6). Like all good games, science, math and engineering are challenging and entertaining. Once you know the rules, you can explore new forms of energy, space travel or your brain.



7. You'll explore cool places.

Take a look at Ian Howat (page 10), a geologist who's a 21st century "Indiana Jones." He's climbed Himalayan Mountains, explored ice caves in Antarctica and scampered into the cones of extinct volcanoes. Where could your imagination take you?



6. You'll get to play with awesome toys.

Scientists and engineers often think of their instruments as toys, because they are so much fun to play with. Look at Terita Norton (page 8), who helps build communication systems for top-secret military satellites. Or David Petkofsky (page 4), who helps Navy jets fly faster.



5. Anybody can play.

Girls can join the excitement, as well as people from all races, nations and ethnic origins. Even disabilities can't defeat you. And if you become good at what you do, the sky's the limit, as astrophysicist Mary Urquhart (page 18) has demonstrated.



4. You don't have to be a genius to be a great scientist.

Hard work – rather than innate brilliance – is the key to achievement in any field. Even though John Rinn (page 20) had only a 1.9-grade-point average when he graduated from high school, he learned that constant effort and persistence can lead to a great science career.



3. Jobs are plentiful and pay is exceptional.

Employers are lining up to hire Ryan Harrison (page 14), who is about to complete his undergraduate degree in biomedical engineering. Corporations, agencies and universities are offering high salaries to women and men who know science, math and engineering.



2. You'll have a life outside the lab.

Look at Shelie Miller (page 16), who has time for mountain climbing in North Carolina. Or Pardis Sabeti (page 6), who rocks out in a band. Mary Urquhart (page 18) is raising a great daughter. Andrea Armani (page 12) plays in a demanding soccer league.



1. You'll strengthen our nation and improve the world.

This is the real payoff. Can you imagine how awesome you'd feel if you helped a child regrow a lost limb? If you developed a tool so that the Navy could detect germ warfare attacks? If you found new resources on Mars? Or if you discovered a new fuel to sustain the economy while reducing global warming? One of these opportunitites is waiting for you.

Now, take a look at the people on the next few pages and come on in! Explore the future.

HELPING THE U.S. NAVY PROTECT OUR NATION

David Petkofsky

Aerospace Engineer





FUNFACTS

EDUCATION:
B. S. in aerospace engineering,
University of Virginia

URL:
www.stemeducation.org/
www.navair.navy.mil/

CHILDHOOD HOME: Williamsburg, Virginia

FAVORITE HIGH SCHOOL SUBJECT: U. S. history

CAREER IDEA IN 9TH GRADE: Aerospace engineer

FAVORITE BOOK IN YOUTH: *Rainbow 6* by Tom Clancy

FAVORITE HIGH SCHOOL SPORT: Baseball

CAR: Honda Civic Hybrid

CD IN CAR: Kings of Leon

HEROES: Werner von Braun; Chuck Yeager; Cal Ripken Jr.

ADVICE TO FUTURE SCIENTISTS: "Read about new developments and think about how they were engineered."

AMBITION: To be a part of the manned spaceflight program














As long as David Petkofsky can remember, he has loved airplanes. Now, the 22-year-old is helping build them for the U. S. Navy. A recent graduate of the University of Virginia, the aerospace engineer develops new systems for advanced jet fighters at the Naval Air Warfare Center at Patuxent River, Maryland. The details of David's work are secret, but the aircraft include the Joint Strike Fighter and the Super Hornet – cutting-edge planes that help preserve peace worldwide.

"I hope that, in a small way, my work will make the Navy safer and more effective," says David. "My college roommate is training to be a Navy pilot, and I like to think that what I am doing will eventually help the aircraft he flies perform better."

It seems that the young engineer has been preparing for this job for his entire lifetime. His father recalls that even as a toddler, David wanted to play with model airplanes rather than toy cars. As soon as he knew how to operate a computer, he bought a flight video game. The game eventually led to an interest in computer programming, when David and a group of friends began to program new features for use in games.

"Doing extensive modifications on a game can be quite complex. You need experts in coding, digital art and other specialties," the Navy engineer explained. "I took on a leadership role, recruited the technical people and coordinated their activities to develop enhanced games."

To learn more about aviation, David joined the Civil Air Patrol when he entered high school. Open to both girls and boys, the organization educates the public about flying, introduces young people to aviation and searches for missing aircraft. As the result of a lot of hard work, David won the Mitchell Award — a CAP award equal to the Eagle Scout rank — when he was 17. In the same year, he learned how to pilot a plane, and flew solo.

The leadership skills he mastered in the CAP helped the young engineer a great deal in college, where in his senior year he led a team that designed an aircraft for international competition.

"Our airplane was sturdy, but it proved not to be able to carry as much weight as one from Brazil," said David. "We worked two semesters on the project, one designing it and the other building it. The main thing is that we learned so much, while we were having fun and working together."

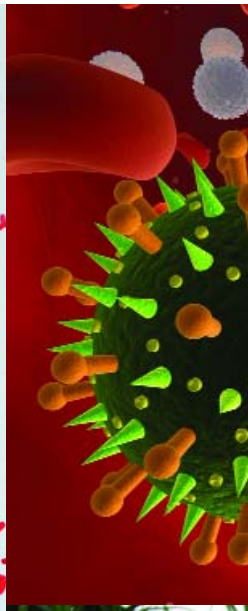
David advises those who would like to follow him "to read magazines like *Popular Science* to see the latest developments in the field, take as many math and science courses as you can and get involved with organizations and activities that can give you practical experience in the thing that you are passionate about. With that inspiration, you'll go a long way."

ROCKING THE WORLD WITH CURES FOR DEADLY DISEASES

Pardis Sabeti

Research Biologist







WATCH MORE ONLINE! Check out the interview at www.stemeducation.org/explore/video

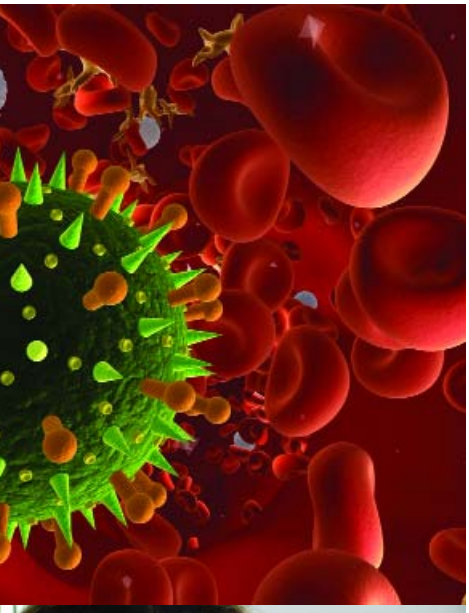
FUNFACTS

EDUCATION:
B. S. in biology, Massachusetts Institute of Technology
M. Sc. in human biology, Oxford University
Ph. D. in biological anthropology, Oxford University
M. D., Harvard Medical School

URL:
www.stemeducation.org/explore/video
www.sabetilab.org/about.php

FAVORITE HIGH-SCHOOL SUBJECT: Math
CAREER IDEA IN 9TH GRADE: "I had no idea."
COLLEGE SPORT: Tennis
CURRENT SPORT: Volleyball. "I've organized my lab into a team."
FAVORITE YOUTH BOOK: *Lord of the Rings*
FAVORITE FOOD: Home-cooked Persian food
FAVORITE MUSIC: Indie-alternative rock (Block Party; Frightened Rabbit)
CD IN CAR: "My band's own songs that I'm working on."
HERO: Eric Lander, head of the human genome project at MIT
PROUDEST PROFESSIONAL ACHIEVEMENT: Saving lives in Nigeria
PROUDEST PERSONAL ACHIEVEMENT: Creating a campus program to promote racial harmony and good citizenship at MIT









Just when you were convinced that "scientists are nerds," along comes someone like Pardis Sabeti. The lead singer in the band "Thousand Days," Pardis is a genuine rock star with three CDs to her credit and concerts in Boston, New York and up and down the East Coast.

And that's just her night job.

During the day, Pardis can be found in her lab at Harvard University conducting research into two of the deadliest diseases in Africa: malaria and Lassa fever. By using techniques developed in her study of genetics, Pardis has discovered secrets of the diseases that kill two million people a year, and she now works with doctors in Africa to help develop treatment.

"Every summer I go to Nigeria to visit clinics, and it is so gratifying to see that the techniques we've developed are already having an impact," said Sabeti.

The daughter of an Iranian immigrant, Pardis grew up in Florida, where she became fascinated with solving math puzzles. This pastime helped her recognize mathematical patterns, a skill she put to good use in studying biology at the Massachusetts Institute of Technology.

"Think of the DNA of diseases as big piles of data, which you can analyze," said the researcher. "I developed mathematical tools to identify and analyze the changes that allow these infectious diseases to survive and continue to infect humans. I use this information in hopes of finding ways to stop them."

Pardis compares science to a video game: "If a game is too simple, you can master it quickly, but then it begins to bore you. Science is like playing the best video game in the world. Of course, you must spend time learning how it works, but then you get to play with the coolest toolsets forever."

When she finished college, Pardis was determined to become a medical doctor, but she won a Rhodes Scholarship to study at England's Oxford University, where she continued her research and earned a doctorate in biology. When she learned what she could accomplish in the laboratory to cure diseases, her future was set. She returned to the U. S., enrolled in medical school and graduated with high honors – only the third woman to do so in the history of Harvard University.

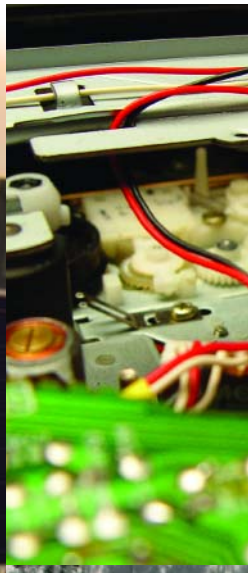
"In medicine, we are now reaping the benefits of the research of the last half century. The advances in cell biology, genetics and other fields are all there. Now we are putting it together to make big differences in people's lives," said Pardis.

She believes that the opportunities open to future scientists are "too many to name. They are just skyrocketing. All you need is creativity and imagination. I don't believe that every kid should go into biology, but all students should at least have the opportunity to experience it to see if they like it. That's why I go to Boston's schools to demonstrate to students how fascinating science is."

Terita Norton

Electrical Engineer







FUNFACTS

EDUCATION:
B. S. in electrical engineering,
Florida State University
M. S. in electrical engineering,
Florida State University

URL:
www.stemeducation.org/explore/video
www.aero.org/education/students.html

CHILDHOOD HOME: Tampa, Florida

FAVORITE HIGH-SCHOOL SUBJECT: Math

CAREER IDEA IN 9TH GRADE: Engineer

CURRENT ACTIVITIES: Attending sporting events and plays

FAVORITE YOUTH BOOK: *The Berenstain Bears* by Stan and Jan Berenstain

FAVORITE FOOD: Anything Italian

PLACE TO GO: Australia

MOST IMPORTANT ADVICE RECEIVED: "Always remember to help others."

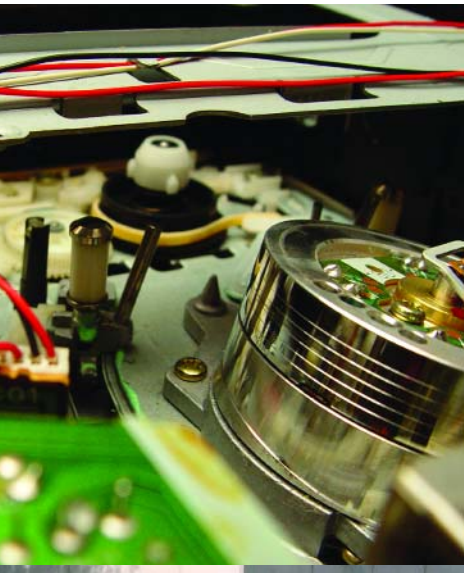
HEROINES: Twin sister Terri, who is an assistant professor of engineering, and sister Pam, who is able to juggle the ownership of a group home for individuals with special needs and the duties of wife and mother to her husband and three children.

AMBITION: To own my own company and use it to inspire others

WATCH MORE ONLINE! Check out the interview at www.stemeducation.org/explore/video









Do you enjoy taking things apart to see what makes them tick? So did Terita Norton, and look where it has gotten her. She's now a project engineer at the Aerospace Corporation, developing top-secret communication systems for America's military and civilian satellites.

Tinkering is a time-honored scientific method, and Terita learned very quickly how to put it to good use. As a child in Florida, she began by taking the covers off televisions and remote controls to figure out how they worked.

"I quickly became the VCR and cable repair person in my family," she recalled. Terita credits strong support from her parents and opportunities provided by two federal programs with helping her take the next steps toward her career. She participated in Upward Bound at the University of South Florida, and attended Trio programs at the University of Tennessee, where she worked in labs and mastered the scientific method.

"These programs and my school work gave me the skills I needed to succeed at Florida State University," said Terita. She earned a bachelor's and master's degree in electrical engineering. In addition to studying for long hours, she found the time to participate on the varsity track team.

"I am vertically challenged," Terita joked. "At a little over five feet tall, I was always one of the smallest women in the triple jump and long jump competitions. But I always did my best." She also credits athletics with teaching her valuable time management skills, which are especially important in the fast-paced life she's now leading in Los Angeles.

"I was the project leader for the development of a laser communication system for satellites that support the National Reconnaissance Office, the eyes and ears of our intelligence community," Terita explained. "I work on systems that expand the satellites' capabilities and extend their useful lives in space."

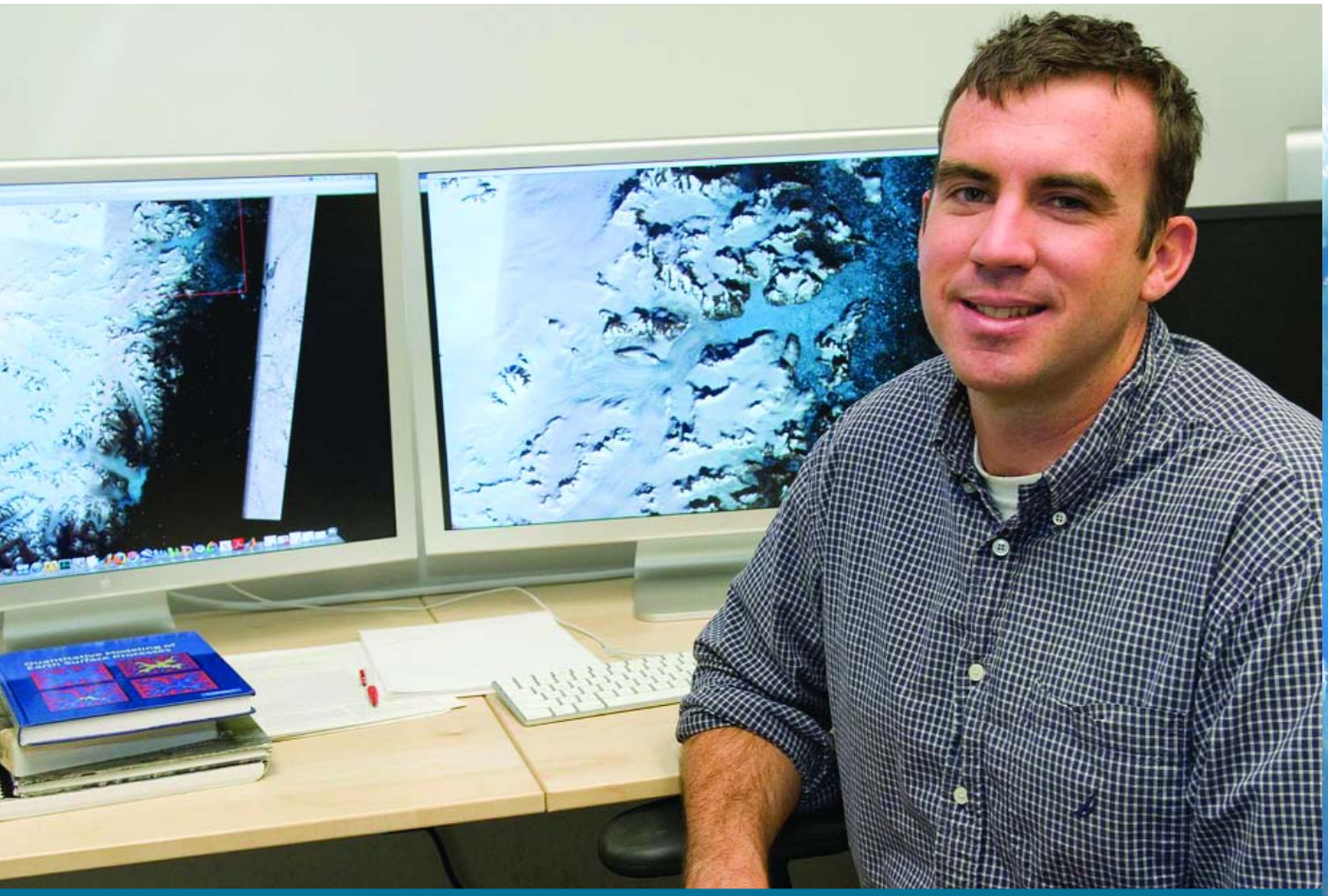
Speaking of energy, Terita has enough left after fulfilling her management responsibilities to direct two programs to encourage young people to explore science careers. One is the Robert H. Herndon Science Competition, sponsored by the Aerospace Corporation for the past 32 years.

"I also lead a Saturday Science Academy to stimulate interest in science, technology, engineering and math and to encourage school students who have been traditionally underrepresented in these areas," explained Terita. "These sessions combine instruction in math with hands-on engineering projects and exercises designed to enable the kids to present themselves well."

Overall, Terita leads a demanding life, but one filled with meaning: "I was taught that 'to whom much is given, much is required.' This was instilled in me as a child, and I am determined to keep my part of this bargain."

Ian Howat

Geologist and Glaciologist





FUNFACTS

EDUCATION:
B. A. in geology, Hamilton College
Ph. D. in earth sciences, University of California, Santa Cruz

URL:
http://bprc.osu.edu/~ihowat/

CHILDHOOD HOME: Connecticut

FAVORITE HIGH-SCHOOL SUBJECT: Economics

CAREER IDEA IN 9TH GRADE: Investment banker; "Like Michael J. Fox in *Family Ties*, I wanted to be a really rich person."

COLLEGE ACTIVITIES: Rock climbing; skiing

FAVORITE FOOD: "I will eat absolutely anything."

PET: A Labrador puppy named Buckley

CAR: A Subaru Outback, of course

PLACE TO GO: The Mediterranean coast of Spain or France, where it is warm

MOST IMPORTANT ADVICE RECEIVED: "In life, choose the path that leads to the most opportunities."

ADVICE TO FUTURE SCIENTISTS: "Ask a lot of questions."





Ian Howat is a real-life Indiana Jones. He may not carry a whip or leather pack, but he does get to hang from helicopters, climb volcanoes and trek up glaciers. Wherever he is, you can bet your bottom dollar that he's having fun.

"I decided to study glaciers when I learned that the subject offered so many opportunities for adventure," confessed Howat. "A few years after college, I was mountain climbing in Tibet when I met some scientists who were studying glaciers in the Himalayas. What they were doing and where they were doing it were so cool that I decided that type of life was for me."



Having already earned a bachelor's degree in geology, Ian enrolled in a graduate program focused on glaciers. The program took him to some of the coldest places on earth, including Antarctica, Alaska and Greenland. There, he studied the factors that cause glaciers to flow more swiftly into the sea, where they melt and raise sea level around the world. Many experts believe that global warming has accelerated the process.

"Other scientists and I are trying to develop a model that will predict how quickly this process will advance. This task is difficult because there are so many variables involved, including air temperature, snowfall, saltiness of the sea, density of the ice, even the type of rock on which the glacier or ice cap rests," the Ohio State University geologist explained.

Although Ian spends a good bit of time at his computer developing a mathematical model of the process, he also gets to travel to glaciers around the world where he descends into ice caves and climbs up frozen rivers of ice.

"Some glaciers barely move, while others can speed along at the rate of a football field a day," said Howat. "We measure the speed by using helicopters to plant Global Positioning System (GPS) instruments on the surface of the glacier. By tracking the day-to-day movements, we can precisely determine whether the glacier is moving a millimeter or a hundred yards a day."

The stakes are very high. As sea level continues to climb, more and more land is threatened. Some scientists envision New York City, Miami or Los Angeles covered by water unless we take preventive action.

"We need to determine with some degree of certainty how soon these events are likely to happen. Whether they are 200 years in the future, or only 50 years," said Howat. "If we could develop a model to predict that accurately, we could begin to make relatively small annual investments in building floodwalls or dikes, rather than waiting until water is lapping up Wall Street."

ALERTING THE WORLD TO BACTERIA AND VIRUSES

Andrea Armani

Applied Physicist







WATCH MORE ONLINE! Check out the interview at www.stemeducation.org/explore/video

FUNFACTS

EDUCATION:
B. A. in physics, University of Chicago
Ph. D. in applied physics and biology, California Institute of Technology

URL:
www.stemeducation.org/explore/video
chems.usc.edu/armani/

CHILDHOOD HOME: Memphis, Tennessee

FAVORITE HIGH SCHOOL SUBJECT: Band, in which she played the flute

CAREER IDEA IN 9TH GRADE: Astronaut

FAVORITE YOUTH BOOK: *The Big Friendly Giant* by Roald Dahl

CURRENT ACTIVITIES: Soccer and hiking

FAVORITE FOOD: Lamb

PETS: Cat named Jersey; dog named Corky

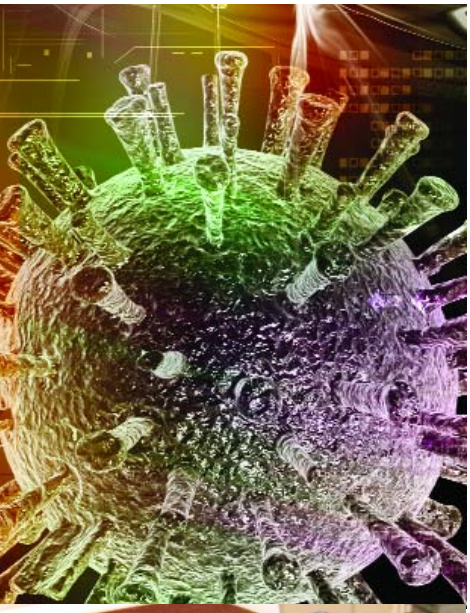
MUSIC IN IPOD: Beyonce

PLACE TO GO: Bali

HERO: Scott Fraser, a biology professor at Cal Tech who studies developmental biology

PROUDEST PROFESSIONAL ACHIEVEMENT: Having a paper published in *Science*







Germs can't hide from Andrea Armani. She is well on her way to inventing a device to detect even the smallest molecule of a bacterium or virus. About the size of a single human hair, the laser-powered sensor will be linked to a buzzer that will alert those in danger.

Think of what this will mean. In schools, detectors could signal administrators about the presence of swine flu bacteria so that they could wipe surfaces down with disinfectants. In hospitals, doctors would be warned of deadly infections, well before the virus could attack patients. On battlefields or warships, detectors could alert soldiers and sailors of germ warfare agents so that they could avoid or eliminate the threat. The U. S. Office of Naval Research is so impressed with Armani's work that it presented her a Young Investigator Award to fund development of the device.

Now an assistant professor at the University of Southern California, Armani first became entranced by science when she was in the 7th grade. She was convinced that she wanted to be an astronaut, so much so that her parents agreed to send her to a Space Camp in Huntsville, Alabama. The centerpiece of the experience was a simulated trip in the Space Shuttle, and Andrea played the role of mission scientist.

"One of the experiments on the flight involved mixing chemicals to cause a foam reaction," she recalled. "The foam literally boiled over. It covered everything, and I was fascinated. When I returned home to Memphis, I found a chemical engineer who explained the dynamics of the experiment to me. I was hooked."

Armani took all the standard science courses in high school, and majored in solid-state physics and optics at the University of Chicago. After graduation, she moved on to Cal Tech where she received her doctorate in applied physics, and took numerous biology courses.

"I am an applied physicist. That's a scientist who focuses on inventing high-tech gizmos to accomplish specific tasks, like detecting bacteria and viruses. To be effective, I have to be able to use skills from several subjects, biology and math as well as physics," Andrea explained. "Today, most scientists need interdisciplinary skills, and students who are preparing for a future in this field should take courses from a wide array of areas. Very soon, all science will be interdisciplinary."

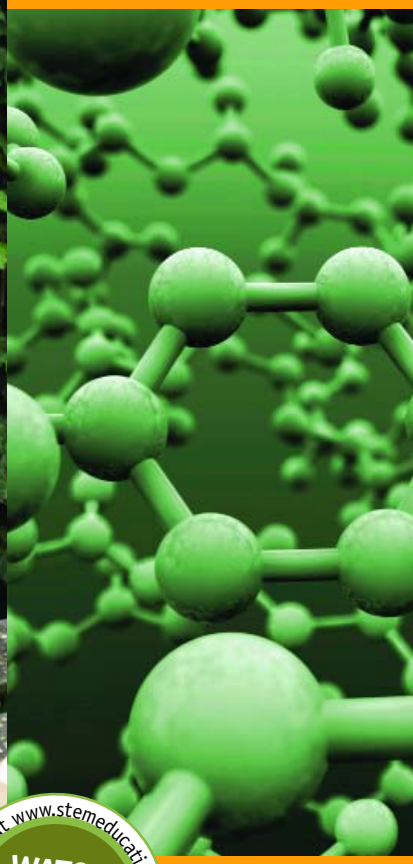
Armani stressed that students should not get discouraged as they take various subjects: "People learn at different rates. They should keep this in mind, and be confident that they will master the necessary skills if they give them enough time. Don't listen to people who tell you that you can't accomplish something. It's your life, not theirs. Your actions determine your fate, not theirs. You are the only one who knows your true abilities."

[EXPLORING BOTH ENDS OF THE BIOLOGICAL SCALE]

Ryan Harrison

Biomedical Engineer





WATCH MORE ONLINE! Check out the interview at www.stemeducation.org/explore/video

FUNFACTS

EDUCATION:
B. S. in biomedical engineering (2009), Johns Hopkins University

URL:
www.stemeducation.org/explore/video
www.jhu.edu/~jhumag/0605web/scholar.html

CHILDHOOD HOME: Baltimore, Maryland

FAVORITE HIGH SCHOOL COURSE: Contemporary American issues

CAREER IDEA IN 9TH GRADE: Something technical

HIGH SCHOOL ACTIVITY: The worst trumpet player in the band

COLLEGE ACTIVITY: Engineers without Borders

FAVORITE YOUTH BOOK: *Tunnel through Time* by Lester Del Ray

FAVORITE FOOD: Pecan pie

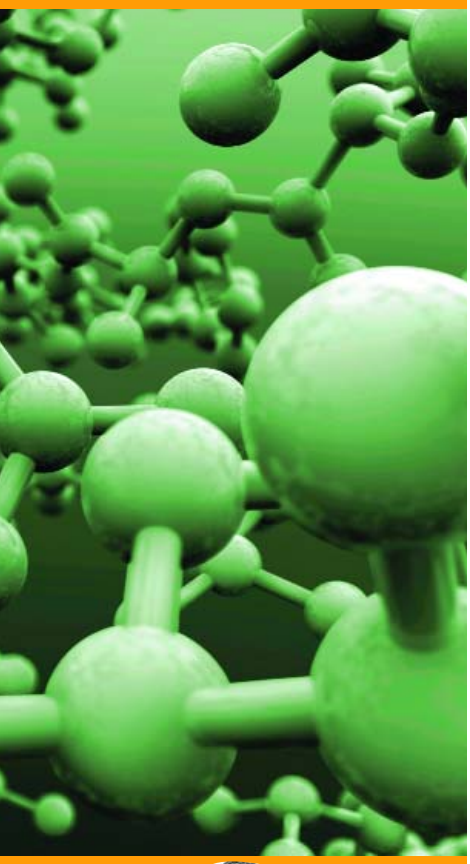
HEROES: Parents

PETS: Goldfish

ADVICE FOR STUDENTS: "Do what you like, and find teachers who will support you."







When Ryan Harrison was in elementary school, he daydreamed about sauropods, 100-ton dinosaurs that dominated the Jurassic Period. He would spend hours drawing the long neck and powerful legs of the largest known organism of the Prehistoric Era. Now, Ryan focuses on the other end of the biological scale. He's studying human molecules and the proteins of which they are made.

"All living things are made of proteins," explained Ryan. "If we better understood their behavior, we could fight cancer and other diseases more effectively."

Ryan has been fascinated with molecular biology since he was in the 9th grade at Baltimore Polytechnic Institute. One of his teachers encouraged him to examine the subject, and he shortly began working in a biomolecular engineering lab at Johns Hopkins University. The work paid off in a big way for Harrison, when he finished fifth in the 2005 Intel Science Talent Search. Known as the Junior Nobel Prize, the competition annually attracts 1,600 high school students from around the nation.

"My project was to make improvements to Rosetta, a computer program that predicts protein structure and interactions," said Ryan. "With Rosetta, doctors may be able to take samples of cancer cells from a patient, analyze them and design an antibody specifically designed to fight that cell."

Ryan is quick to share credit for his success with his high school research coordinator, Charlotte Saylor, and Jeff Gray, his lab director at Johns Hopkins University. "To be effective in science, you have to learn to be part of a team. You learn to depend on your instructors and fellow students. You discuss your results, swap ideas and learn from others," Ryan said.

Teamwork is an increasingly important part of Ryan's experience. He worked with a group of other students on an Engineers-without-Borders project to design a system to bring drinking water to a hilltop village in Guatemala. The team demonstrated that there was enough water flow in a nearby stream to enable the design to work. The study helped win a $10,000 grant to build the system.

"Sure, all of this requires a lot of work. I've spent 50 to 60 hours a week in the lab sometimes. But it makes you feel great when you discover something new and exciting," said Ryan. "If you have a passion for something, you don't mind spending the hours. That's what I would advise students. Find your passion, and you'll do well."

When he's not in the lab, Ryan is passionate about many other things. He enjoys running the lighting systems for student drama productions, and he chills by developing winning strategies for board games like Risk and Monopoly.

"When you're playing Monopoly," he confided, "buy the orange-colored properties first."



Shelie Miller

Environmental Engineer







WATCH MORE ONLINE! Check out the interview at www.stemeducation.org/explore/video

FUNFACTS

EDUCATION:
B. S. in chemistry, Denison University
M. E. in civil and environmental engineering, Clarkson University
Ph. D. in civil and materials engineering, University of Illinois at Chicago

URL:
www.stemeducation.org/explore/video
www.clemson.edu/ces/departments/eees/people/facultydirectory/miller.html

CHILDHOOD HOME: Garfield Heights, Ohio

FAVORITE HIGH-SCHOOL SUBJECT: Drama; Shelie's favorite production was "Fiddler on the Roof"

CAREER IDEA IN 9TH GRADE: Nature guide for Outward Bound

HIGH SCHOOL SPORTS: Volleyball and basketball

CURRENT SPORTS: Running half-marathons and rock-climbing

FAVORITE YOUTH BOOK: *The Outsiders* by S. E. Hinton

FAVORITE FOOD: Cheese fries

FAVORITE SINGER: David Bowie

PET: Rufus, a mutt dog

CD IN CAR: Detroit Cobras

PLACE YOU WOULD LIKE TO GO: India

MOST IMPORTANT ADVICE RECEIVED: "Not to take yourself so seriously"















When Shelie Miller was growing up in a Cleveland suburb, she enjoyed wading in neighborhood creeks, turning over rocks and observing the creatures that emerged. Over time, she was disturbed by a decline in the number of species that appeared. That was the birth of Shelie's strong interest in the environment.

"In high school, my chemistry teacher taught me that pollutants draining into the creek endangered aquatic life. She also gave me a way to analyze the situation," recalled Shelie. "In college I majored in chemistry, and began to explore ways I could have the biggest impact on improving our natural world. For me, that was to become an environmental engineer."

Now at Clemson University, Shelie is helping develop methods to convert plant material — called biomass — into fuels. The most promising is switchgrass. The fast-growing prairie plant is environmentally friendly and has the potential of producing 25 times the amount of energy that gasoline does. However, finding an alternative to petroleum products is just half the battle.

"Think of it this way: All products have a birth, childhood, adulthood and death, just like a human being does," Miller explained. "In each phase, the product affects our surroundings. We want to make sure that it is as environmentally friendly as possible. For instance, what is the impact on the land of growing switchgrass? Are toxic chemicals used in the process? Are there dangerous by-products that could worsen global warming?"

This technique is called "life-cycle analysis," and Shelie is analyzing how growing the tall grass will affect the environment.

"It looks very positive. Unlike food crops, switchgrass sprouts again each spring. Thus, it requires less cultivation that causes erosion. It can grow to six or eight feet on poor ground and requires little fertilizer, which can pollute streams. Best of all, switchgrass takes carbon dioxide out of the air and puts it into the soil, where it can't contribute to global warming," the engineer explained.

These and other considerations make up the life-cycle analysis that is central to Shelie's work. She is also teaching the technique to her students who will leave Clemson with a much better sense of how to develop solutions to real-life problems that are both sustainable and environmentally friendly.

"This is fun, as much of my job is. There's a notion that scientists and engineers are boring, and that is simply not the truth," said Shelie. "To give you an example, many of my students are involved in Engineers without Borders, an organization that sends kids around the world to help people. The students help develop water-purification plants for poor communities, deal with severe erosion that reduces the sustainability of farming and tackle problems that directly affect people's lives.

"And when you can have a direct impact on the lives of people, that's what I call fun," declared Shelie.

Mary Urquhart

Astrophysicist and Science Educator



FUNFACTS

EDUCATION:
B. S. in both astrophysics and geophysics, New Mexico Tech
Ph. D. in Astrophysical and Planetary Sciences, University of Colorado at Boulder

URL:
www.stemeducation.org/explore/video
http://cindispace.utdallas.edu/education/cindi_comic.html

CHILDHOOD HOME: Richardson, Texas

CAREER IDEA IN 9TH GRADE: Planetary scientist

FAVORITE YOUTH BOOK: *A Wrinkle in Time* by Madeleine L'Engle

FAVORITE FOOD: Mac & cheese

PET: A Lhasa-poo named Mädchen (German for little girl)

CAR: A Saturn, of course!

PLACE TO GO: "Mars. I realize that this is unrealistic for me, but maybe my daughter will make it."

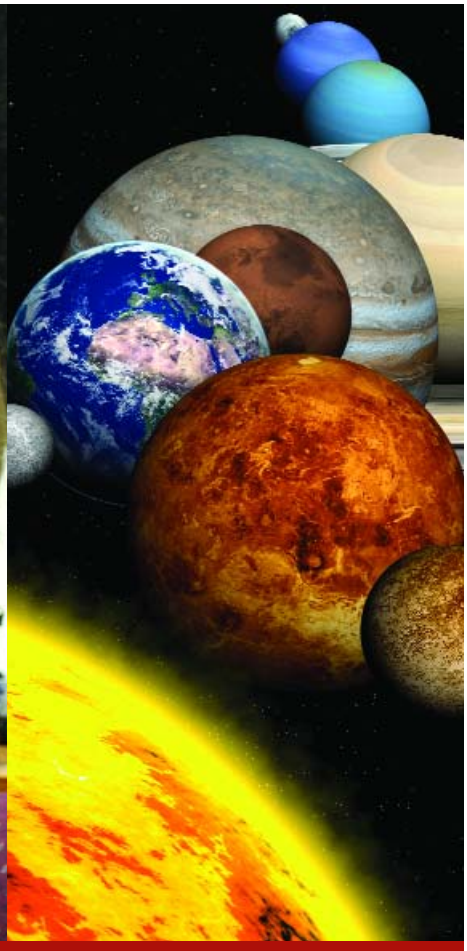
PROUDEST PROFESSIONAL ACHIEVEMENT: Working on NASA's Mars micro-probe mission at the Jet Propulsion Laboratory

PROUDEST PERSONAL ACHIEVEMENT: Having a wonderful daughter

ADVICE FOR SCIENCE STUDENTS: "Keep your eyes and mind open to the world around you."









To this day, Mary Urquhart remembers the experience that changed her life. She was in the fourth grade when she entered a small auditorium and took her seat. She still recalls its cool darkness and the quiet that hushed her classmates. It was a little like naptime.

But when the tiny lights on the curved ceiling began to glow, so did Mary's imagination. The stars and constellations were the brightest, but the planets truly captured her attention: Saturn, Venus, Mars and the Earth. The thrill of visiting the planetarium in her hometown of Richardson, Texas, was so powerful that Mary spent every Wednesday afternoon in the facility. She soon set her sights on becoming a planetary scientist.

"The path wasn't easy," Mary recalled. "I have a learning disability that slowed the development of my reading and math skills. My brain reversed letters and numbers that I saw on the page. But my teachers and family were supportive and helped me follow my passion."

Mary read *National Geographic* articles about space, and her grandfather bought her a telescope. She even saved babysitting money to buy a college textbook on planetary geology. Mary couldn't quite believe that she could actually achieve her goal, but after college and graduate school, she landed a dream job – studying the geology of planets for the National Aeronautics and Space Administration (NASA).

"During my NASA career, I used computer modeling and my hard-won math skills to investigate planetary processes and conditions. I have researched how heat from the sun and deep inside Mars affects the possibility of accessible water. Other topics included remote ways to find buried rocks on the Moon that could be a danger to future spacecraft, and the possibility of a greenhouse effect on the icy moons of Jupiter," Mary said.

Because she was so excited about her work, NASA sent Mary to talk to students about the latest advances. She enjoyed sharing her discoveries, and the experience opened an exciting new doorway for her.

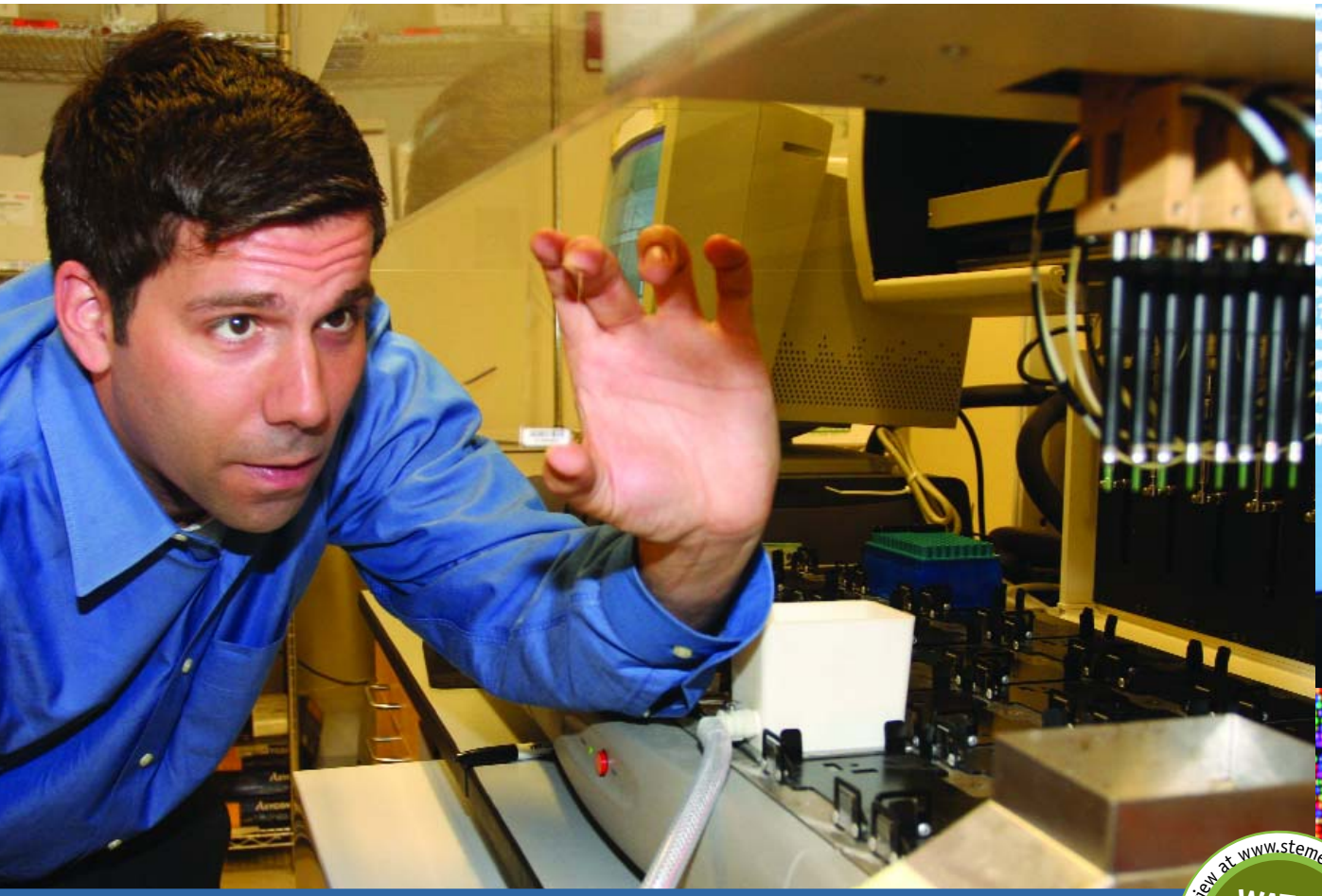
"I became a professor of science education and physics at the University of Texas at Dallas, where I work directly with students ranging from pre-kindergarten to graduate school," she explained. "I have developed a 'Stars and Planets' teaching segment that helps kids understand their place in space, and I continue to work with NASA."

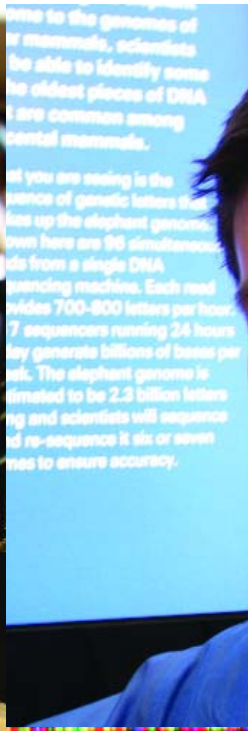


Currently, Mary is helping share a space experiment – called CINDI – that is orbiting the Earth. Kids are able to follow CINDI's exploration in their classrooms with teachers whom Mary has trained. The experiment is also the topic of a comic book located at *http://cindispace.utdallas.edu/education/cindi_comic.html*

John Rinn

Research Biophysicist









WATCH MORE ONLINE! Check out the interview at www.stemeducation.org/explore/video

FUNFACTS

EDUCATION:

B. S. in biochemistry, University of Minnesota Duluth
Ph. D. in molecular biophysics, Yale University

URL:

www.stemeducation.org/explore/video
www.rinnlab.com/

CHILDHOOD HOME: Eden Prairie, Minnesota

FAVORITE HIGH SCHOOL SUBJECT: Math

CAREER IDEA IN 9TH GRADE: Professional skateboarder

CURRENT ACTIVITIES: Snowboarding and skateboarding

FAVORITE YOUTH BOOK: *The Odyssey* by Homer

CD IN CAR: TI

PET: A white rat named Charlie. "Rats are so intuitive. They are like dogs and want to play with you and to snuggle with you."

HERO: The distance runner, Steve Prefontaine, who said, "To give anything less than your best is to sacrifice the gift."

PROUDEST PERSONAL ACHIEVEMENT: Running the national 20-kilometer championship in 68 minutes

ADVICE (FOR TEACHERS): "The kids who are the biggest pains often contain the greatest surprises."





To be honest, John Rinn was not a great high school student. Because he was more interested in mastering the latest skateboard stunts than in hitting the books, he graduated with a 1.9 grade-point average. A bit of a rebel, John wanted to become a professional skateboarder. He might have made it, had he not suffered a serious knee injury.

"I was lying in bed recuperating, and I happened to read *The Fountainhead* by Ayn Rand. The novel is the story of Howard Roark, who sticks to his principles and becomes a great architect. The book inspired me to give education one more try, and to take my best shot at it," Rinn recalled.

Although he had never done well in science, John enrolled in a junior college and registered for all the hard courses – chemistry, physics and biology. He made a "D" on his first chemistry test, but the idea that chemical compounds could be diagrammed fascinated him. It was his first glimpse into the logical structure of matter, and it led him to earn a doctorate at Yale University.

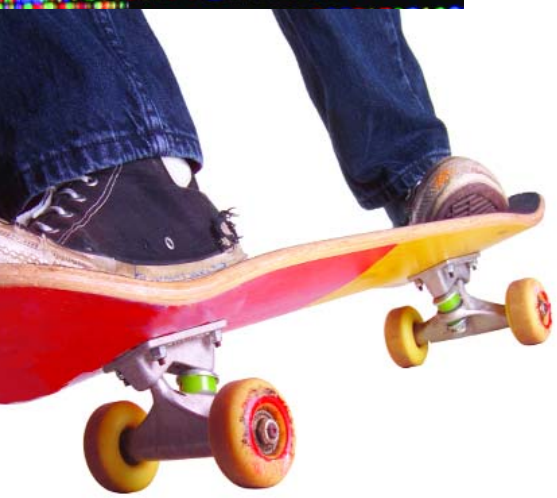
Now John peers into an electron microscope in his own lab at Harvard University, and through it, he envisions marvelous developments in cell chemistry. Like many other scientists, he focuses on the human genome – the genetic material in every cell that governs growth and development. In keeping with his rebellious streak, John decided not to study the genome's DNA, which draws the most attention because it contains the genetic code. Instead, he's examining RNA, a substance that most scientists have ignored.

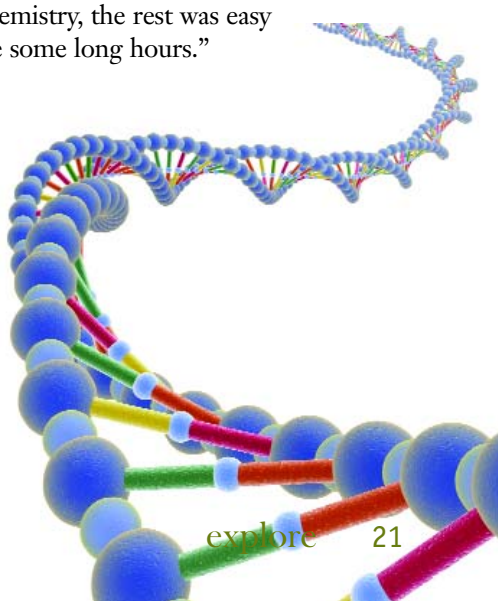
"It's a little bit like finding some overlooked treasures in a big flea market. We've determined that RNA sends messages that tell individual cells when and how to grow. It tells an eye cell how to be an eye, or an arm cell how to become an arm," John explained.

"Think of the human body as a complex piece of Japanese origami – an object made of folded paper. If one of the parts of the origami is destroyed, we might be able to use what we've learned about RNA to send a message to the body to repair the damaged part," explained Rinn. "If we could actually do that, the sky is the limit."

Like any scientist, John is cautious about describing the future too precisely, but the mind jumps to the possibility of sending genetic messages to regrow amputated limbs or to stop the spread of cancerous tumors. It's difficult to grasp the fact that a rebellious high school student who refused to accept standard answers may convert these and other possibilities to realities.

"Take a fresh look at everything. That's what I would tell kids thinking about science or any other career. It was my rebellious nature that led me to question the prevailing wisdom that studying DNA could be more valuable than examining RNA," said Rinn. "I would also tell them to find their passion, and pursue it. It is really all about passion. Once I found that my passion was chemistry, the rest was easy despite some long hours."



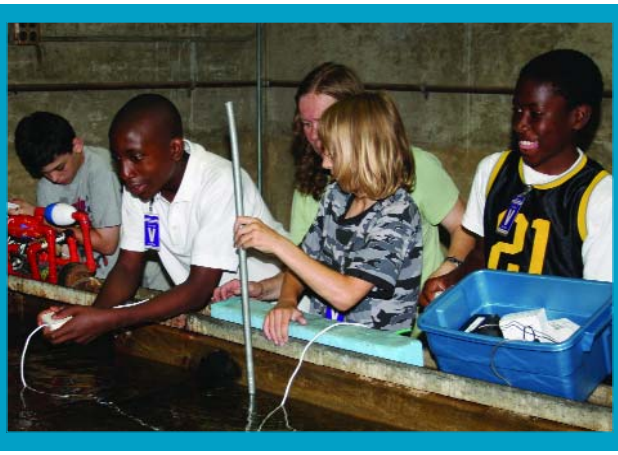




Diving BENEATH THE Surface

With the
U. S. S. Sea Perch







On one of the summer's hottest days, a big yellow school bus pulled up at the gate of a secure U. S. Navy facility near Washington, D. C. Seated inside the sweltering vehicle were 20 excited middle-school students clutching strange objects.

Constructed of plastic pipe, the two-by-two-foot contraptions bristled with large fishing floats, tiny electric motors coupled to propellers and a net serving as a storage compartment. Each of the devices trailed a long electrical cable leading to a small, white switch box.

The Navy guard smiled as he glanced at the contraptions and realized why the group of sixth, seventh and eighth graders had arrived. The kids had come to test their underwater crafts at the site where the Navy develops designs for the world's most advanced ships and submersibles. Called Remotely Operated Vehicles (ROVs), the students' miniature devices are part robot, part submarine and all fun. Building them provides great opportunities for learning, and testing them at the Navy facility is icing on the cake.

The Carderock Division of the Naval Surface Warfare Center is located on a beautiful bend of the Potomac River a few miles northwest of the nation's capital. At the site, the Navy has constructed buildings containing long, narrow pools – one of them as long as 10 football fields. They are used to test scale-model hulls that are the exact shape of ships and submarines that later will be built of steel to protect the United States. By towing the models through the long tank, Navy engineers can determine how swiftly and quietly the hulls will be able to slide through the world's oceans. More importantly, the Navy collects test data that will be used to reshape the hulls so they perform better.

"I can't believe we got in here," said one excited seventh grader. "This place is top secret."

The kids "got in" thanks to a Navy engineer, Mrs.Toby Ratcliffe, who enjoys explaining what she does to the future scientists and engineers. Toby made sure that the students not only toured the base, but they also were able to test their own underwater robots in pools normally reserved for Navy ship models.

"I've been bringing middle school students to Carderock for about three years now," said Toby. "I wanted to demonstrate to kids how much fun engineering can be. I hope that some of them will follow after me doing research for the Navy."

Building an Underwater Robot

Toby has been going out to schools to teach science and engineering for more than a decade. A few years ago, she learned that the Massachusetts Institute of Technology had developed a low-cost kit for a small underwater robot named *Sea Perch*.

"I immediately thought about using it with my kids. The kits are furnished by the Office of Naval Research through its National Naval Responsibility for Naval Engineering program to expose students to careers in



ocean and marine engineering and naval architecture," explained the 30-year Navy employee. The kits cost approximately $100 each.

Toby established the first summer *Sea Perch* camp in Montgomery County, Maryland, schools with the help of her educational partner Harriet Hamlin, a Takoma Park Middle School teacher with many years of science education experience. Ratcliffe and Hamlin now teach two one-week camps each summer, and they radiate pride in the achievements of their students. The kids spend four days building the crafts and the fifth day at Carderock testing their underwater robots.

"In addition to demonstrating that engineering can be fun, we want to do two things. The first is teaching the kids new skills, including reading plans, cutting PVC pipes and soldering wires to electronic circuit boards," explained Toby. "The kids really get into soldering. They would solder all day long."

One of the students, Yvonne from Takoma Park, said constructing her *Sea Perch* was the most enjoyable part of the week. While the work was difficult, she said seeing it all come together was rewarding.

"In addition to teaching construction skills," said Toby, "we also help the kids learn to troubleshoot their projects. You know, things don't always work correctly, and we have to develop the persistence and know-how to examine and test certain aspects to find and correct problems. I use that skill every day, and it's useful in school and in any job the students may encounter later."

The final-day trip to Carderock was the ultimate test of the kids' construction ability. In a cavernous building that holds two gigantic pools and a number of smaller test tanks, the kids started by checking out the various parts of their ROVs and carrying them on to a steel deck. Gingerly, they lowered the crafts into the blue water, as they held their breath to see if the subs would float just beneath the surface. Only one sank, but it was soon reclaimed from the bottom and quickly balanced by removing a few steel washers from its storage compartment.

After all of the crafts were ship-shape, a Navy engineer gave a countdown, the kids flipped the switches and the underwater robots churned through the water from one side of the pool to the other. Then came the order to "dive," and the kids sent their subs into the deep. Screams and cheers went up as the students watched their submersibles zoom to the bottom, and just as magically rise to the surface on command from the control boxes.

"This is way cool," said one boy. "I never dreamed I could construct a real sub, and that it could dive and surface like this."

Enthusiasm like this is infectious. As a result, *Sea Perch* programs are popping up all around the country. In Hawaii, students at several high schools have built and are operating the ROVs, as are kids in many schools in Massachusetts, Rhode Island and Florida. *Sea Perch* has even gone international, as the government of the Mediterranean island of Cyprus has purchased several kits for its schools.

Sea Perch is a wonderful instructional toy. For kids raised on rubber duckies and wind-up submarines, the experience of building and operating the remotely controlled craft is a revelation of what a little education and applied elbow grease can

accomplish. In addressing the challenges and the inevitable problems, students learn that engineering can be fun.

A Platform for Scientific Research

Once a *Sea Perch* is assembled, it offers even more potential for learning by conducting real, live science experiments. That's what Nancy West, a science education consultant with the College of William and Mary, has been exploring.

"This submarine is a super platform for conducting a wide variety of science experiments," Nancy explained. "You can attach a thermometer to take readings at various levels of a pond or lake. And if you're particularly clever, you could design a sampler that could take water from various locations and levels."

West has even attached an underwater video camera to her ROV and used it to explore the bottom of Virginia's Lake Matoaka and ponds in the Rocky Mountains. She is helping schools develop programs to use *Sea Perch* to study problems in nearby coasts. Around the Chesapeake Bay, for instance, kids will investigate the ways that poor water quality is contributing to the decline of oysters and blue crabs. Florida students might study pollution in the Gulf of Mexico and the way that aquatic plants can help filter sediment out of the water.

"This is a great way to investigate things like water quality. Once kids recover samples, they can analyze them for things like dissolved oxygen, pH and salinity, and they can put drops of water under the microscope to see what's living there," said Nancy. "That helps them develop an understanding of the environment. Kids can get really excited about that."

The creator of *Sea Perch* – the Massachusetts Institute of Technology – is collecting environmental information from participating schools and developing a nationwide database. The university maintains a web site featuring the data at *http://seaperch.mit.edu*, and a complementary website, *www.seaperch.org*, provides tutorials on building the robots and on various activities. Both sites have information on purchasing kits. The MIT program is supported by the Sea Grant Program of the National Oceanic and Atmospheric Administration and by the U. S. Navy Office of Naval Research.

To see videos of the ROVs in action, go to the following URL: *www.stemeducation.org/explore/submarine*



Fetch:

The Grown-up Brother of *Sea Perch*

The ROV *Sea Perch* has a grown-up brother, the AUV *Fetch*. Just as ROV stands for Remotely Operated Vehicle, AUV stands for Autonomous Underwater Vehicle – or as it is better known, *Fetch*. Unlike *Sea Perch*, *Fetch* can be programmed to operate on its own to conduct a wide variety of scientific research and national security tasks.

Fetch is literally the brainchild of Mark Patterson, a professor of marine biology at the College of William and Mary's Virginia Institute of Marine Science (VIMS) in Gloucester, VA. Patterson dreamed up the idea while he was lying in the bunk of a research vessel in 1991.

The concept was simple. Combine a computer with scientific instruments and communication devices and build a submersible container around it. Patterson contacted Jim Sias to construct the waterproof skin, and the project was up and running — or more precisely, down and diving — by 1995. Six feet in length, the craft can dive 1,000 feet below the surface and stay submerged for as long as four hours.

Scientists have used *Fetch* to measure water quality (such as salinity, pH, temperature and oxygen content), study coral reefs, map the murky floors of oceans and bays and determine the populations of various species of fish. Surveying marine populations is particularly important these days as over-harvesting and worsening environmental conditions are reducing the numbers of high-protein fish to feed the world's growing populations.

The robot has conducted some impressive missions in its short life, including trips to the North Atlantic Ocean, Pacific Ocean, the Caribbean Sea and the Antarctic. In Iceland, it helped investigate vents in the ocean floor from which fresh, heated water was emerging. Warmed by the volcanic activity in the area, the vents spawned an unusual variety of sea life. Off the coast of California, *Fetch* helped map beds of marine plants called kelp. Like switchgrass and corn, fast-growing kelp can produce energy, if it can be harvested economically. While mapping the kelp beds, the underwater robot was attacked by an angry sea lion defending his territory. But *Fetch* proved tougher than the sea lion, and emerged safely to dive another day.

The U. S. Navy is excited about *Fetch*'s capabilities to thwart those who might attack our nation from the sea. Although the exact uses that the Navy has in mind are classified, *Fetch* could serve as an underwater sentry to guard ships and bases, a scout for explosive mines or an unmanned probe to determine the strength of enemy bases or ships.

Patterson and his associates have been granted a U. S. patent for the AUV, and a wide variety of the vessels is marketed by Sias Patterson Incorporated of Yorktown, Virginia.



I&D

[Inventions & Discoveries]

If you can think of it, odds are that some scientist, mathematician or engineer is at work trying to invent it or to discover it. From personal submarines to army bots, from the farthest star in the universe to wire so fine that it makes you invisible, women and men around the globe are working to expand our horizons and improve our lives.





1 Empowering the Tides

Movements of the sun and the moon propel the immense power of ocean tides, but little has been done to harness that energy to satisfy our needs. Around the globe, scientists and engineers are exploring ways to accomplish this task, and one of the most promising is being developed off the shore of Perth, Australia. The device called CETO – named for the Greek goddess of the sea – is anchored to the ocean floor where the gentle motion of the swells operates a piston pumping sea water to shore, where it powers an electrical generator. The energy generated by CETO is free, infinitely renewable and, best of all, environmentally clean. Oh, and one more thing: The device also produces fresh water to meet the needs of those living on the shore.

2 Scoping out the Ground

We all know about those "eye-in-the-sky" drones that can help soldiers spot danger by viewing the earth from the air, but they can't see people or objects that are indoors or camouflaged. That's a job for GroundBot! Called a "spherical sentry," the bot can roll over earth, rocks, sand and even snow, as its two cameras zero in on hidden dangers and transmit the pictures and position back to base. The device can travel up to six miles an hour, and its batteries enable it to operate for 16 hours at a stretch. Originally developed by Swedish scientists to explore other planets, the bot can also help detect dangerous situations in factories, schools or homes.

4 Developing Tsunami Detectors

Remember those giant ocean waves called *tsunamis* that recently destroyed areas of Thailand and Indonesia? Scientists in Southeast Asia are now developing tsunami detector systems that can warn people that waves generated by earthquakes under the sea are coming toward shore. Buoys attached to sensors on the sea floor are now detecting and measuring quakes and transmitting data that can help geologists predict when tsunamis will strike. If the situation is serious, the scientists can alert those who live by the sea to evacuate before a wave can crash ashore.

5 Seeing the Edge of the Universe

What is 13.1 billion light years from Earth and exploded 640 million years after the Big Bang? It's the detonation of a star, and it happens to be the most-distant object ever spotted from our planet. NASA's Swift satellite spied the burst of gamma rays coming from the collapsing star, and the discovery was confirmed by observatories around the globe. Launched in 2004, Swift was designed to detect these events that are the most powerful explosions in the universe.



photo courtesy of NASA

6 Handing off the Wheelchair

Have you ever thought about being paralyzed and depending on others to move your wheelchair around? That situation may be outdated if bioengineers at the University of Essex in Britain have anything to do about it. They're developing a wheelchair that can be navigated by thoughts. To direct the chair, paralyzed people focus on an electronic map positioned on the front of the chair and constantly updated by an infrared camera. A skullcap with 16 electrodes picks up the electrical signals produced by eye movements and directs the wheelchair on its way. Because the electrical signals are unique for everyone, each individual must train to use the chair effectively. But the engineers report that the average training time is only 45 minutes.



7 Cloaking Your Visibility

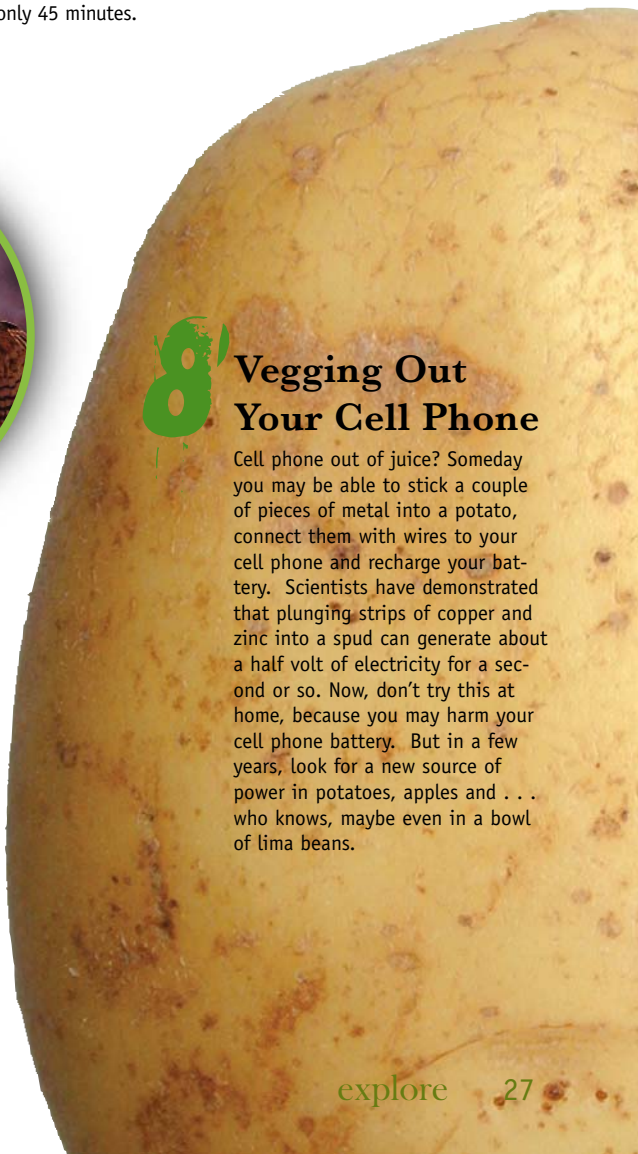
We all thought that Harry Potter's cloak of invisibility was a wonderful fantasy, but never dreamed that it would become a reality. Now scientists at the University of California in Berkeley have developed two synthetic materials that neither absorb nor reflect light. A cloak made of fine silver wires or a metal fishnet could bend the light backward and protect Harry as he pursues his fictional villains. Watch out Lord Voldemort!



EDITOR'S NOTE:
We would show you the actual wires but you can't really see them, so just use your imagination.

3 Turning the Tables on Flesh-eating Infections

Doctors are turning the tables on those flesh-eating infections that don't respond to drugs. Using bacteria-killing substances called bacteriophages, Dr. Randy Wolcott of Texas has applied a few drops of the substances to chronic wounds that are resistant to antibiotics. In some cases, Wolcott's patients have been healed by the treatment within three weeks. Found in dirt, plants and ponds, phages have been used in Eastern Europe for many years, and the U. S. Food and Drug Administration is now investigating the experimental treatment for possible use throughout the nation.



8 Vegging Out Your Cell Phone

Cell phone out of juice? Someday you may be able to stick a couple of pieces of metal into a potato, connect them with wires to your cell phone and recharge your battery. Scientists have demonstrated that plunging strips of copper and zinc into a spud can generate about a half volt of electricity for a second or so. Now, don't try this at home, because you may harm your cell phone battery. But in a few years, look for a new source of power in potatoes, apples and . . . who knows, maybe even in a bowl of lima beans.

[Inventions & Discoveries 2]

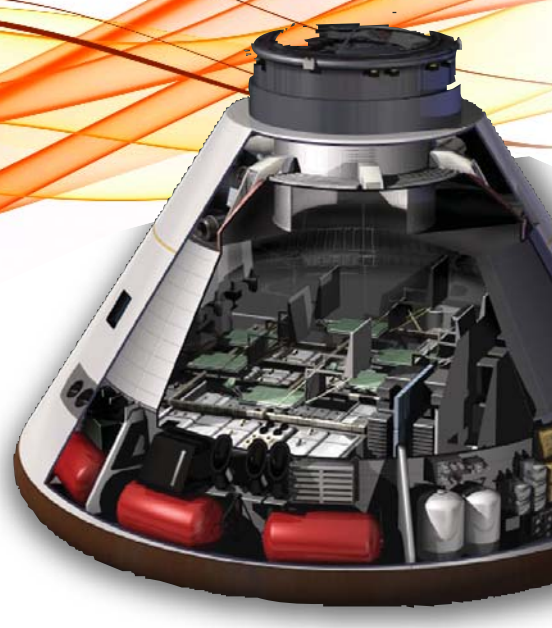


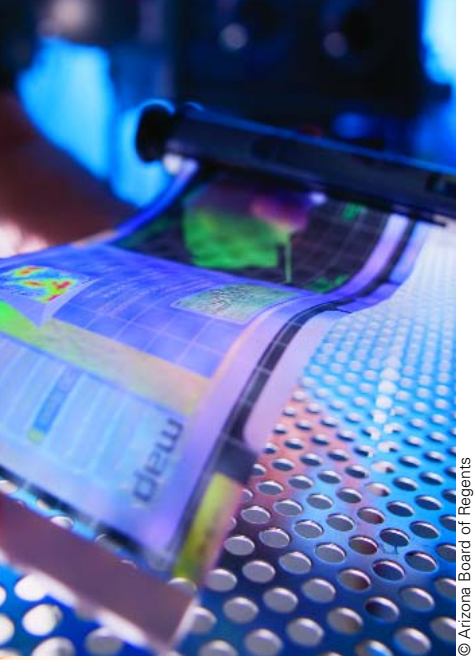


photo courtesy of NASA

9

Blowing its top

Ever wonder what an eruption of a volcano looks like from above? Now you have the opportunity to get a good view of the phenomenon thanks to the National Aeronautics and Space Administration. As the International Space Station recently twirled 220 miles above a remote Russian island in the Pacific Ocean, an astronaut noticed that an eruption was in process. He grabbed his camera and produced some amazing photographs of a rising column of steam, smoke and ash above the Sarychev Volcano. As the column of hot gases rose, it blasted a hole in the cloud cover, revealing this remarkable view. As the column cooled, it created the mushroom-like cap – called a pileus cloud — which is most striking. Pyroclastic clouds of heated gas, ash and lava can be seen racing down the sides of the volcano far below.



© Arizona Board of Regents

10 Keeping an Eye on the Enemy

Visual intelligence like that gathered by the GroundBot on page 26 is useless unless it can be transmitted quickly to those who can put it to use. The U. S. Army, Arizona State University and several corporations are well on their way to making sure that soldiers in the field will have near-instantaneous access to images and data collected by bots, satellites and other surveillance devices. The partners are developing a flexible video monitor to be worn on soldiers' forearms. Providing a complete range of motion to the arm, the device will display maps, photos and video of what lies ahead, so that the soldiers can be aware of obstacles, view enemy soldiers and plan safe ways to achieve their objectives. The information will also be simultaneously available to their commanders. After development is complete, the technology could be adapted to provide information to deep-sea divers, astronauts, scientists and explorers.



11 Pooping Power

It may sound gross, but poop will soon be powering buses in Oslo, Norway. That's right. Scientists have developed a process that transforms a year of your bowel production into 2.1 gallons of fuel. Now just use your great math skills, and you'll determine that the annual excrement of 250,000 people in Oslo can fuel 80 buses for 62,000 miles each. The process ferments the populace's poop into biomethane gas that will be collected in tanks to fuel public transportation. From an ecological perspective, the process will make a huge difference. It is carbon neutral and produces 98 percent fewer particles and 78 percent less nitrous oxide than burning regular fuel. Moreover, the city's engineers say that there is absolutely no bad smell associated with the new fuel.



12 Taking the Next Step in Space

As the National Aeronautical and Space Administration plans to retire the aging space shuttles that have carried us into outer space, the agency is well along in planning the next generation of vehicles designed to take astronauts to the moon, Mars and beyond. Named after the famous constellation, the spacecraft Orion will lift four to six crewmembers into space, with the goal of returning astronauts to the moon by 2020. The new vehicle will be launched from Kennedy Space Center, and it incorporates many advances over the current space shuttle. Orion provides an escape mechanism designed to lift the module safely off the launch rocket, should problems develop. Like the current shuttle, it can dock with the International Space Station and deliver mission specialists, equipment and materials to the facility now orbiting Earth. Orion can return to earth using a system of parachutes and airbags, an arrangement that will enable it to be retrieved on land, as well as in bodies of water. Constructed of aluminum lithium, the spacecraft is durable enough for up to ten launches.

13 Tracking Bald Eagles

The Center for Conservation Biology at the College of William and Mary in Williamsburg, Virginia, has just created a web site that enables viewers to track bald eagles around the Chesapeake Bay. And thanks to the center's efforts, there are many more of our national birds to track. In the 1970s, there were only 30 nesting pairs of eagles in Virginia, but as people have learned to protect bird habitat, the numbers have dramatically increased. Now there are more than 610 pairs in the state. In the past two years, the center has attached Global Positioning System transmitters to 67 eagles. By tuning into the web site, you can watch as your favorite eagle soars up the James River, over the Chesapeake Bay and toward the large metropolitan areas of Washington, D. C., and Richmond, Virginia. To track your very own eagle, click on the following web site: *http://www.ccb-wm.org/virginiaeagles/index.htm*



Tools for exploring STEM

You may not be ready for a job *yet*, but you can still explore careers in science, technology, engineering and math (STEM) by taking advantage of opportunities right in your school, home or city. Some of these activities are collecting data for scientists; exploring interesting web sites; participating in clubs at school; and scanning books and magazines about new developments in the world of science and engineering. The key point is that *you don't have to wait*. Here are some things you can do *immediately*.

1. Help Scientists Solve Problems

Ready to do some science? You can begin today by helping scientists with their research no matter where you live. Take a look at these options that will enable you to help...

Find a cure for cancer or HIV/AIDS – Electronic gamers can use their knack for seeing patterns to fold cell proteins into energy efficient shapes that are better targets for medicine. It turns out that humans can spot these patterns better than computers. To take advantage of your skills, the University of Washington has created a game called FoldIt located at *http://fold.it/portal/*. You could teach the computer a thing or two and help solve some stubborn medical problems.

Explore the types of galaxies in our universe – You don't need a powerful telescope to help astronomers understand galaxies and the details of their formation. At *www.galaxyzoo.org*, there is a collection of clear images that you can examine, as well as a form on which to report your observations. If you see some odd distortion in the images, you may have identified a "gravitational lens." That's when masses of galaxies are so great that they bend light and distort what lies beyond them.

Provide "ground truth" for satellites – Far above the Earth, National Aeronautics and Space Administration satellites photograph clouds, assess solar radiation and collect other weather data. To ensure that the airborne data is correct, NASA is asking earthlings to provide "ground truth" to prove their accuracy. Your job is to examine the clouds, their extent and their height at the time that the satellites are observing them from above. Before you go outside, take a look at *http://asd-www.larc.nasa.gov/SCOOL/Rover/*.

Activities like these are called "citizen science" projects. Check out the latest list of these national programs on *http://www.stemeducation.org/tools*. If you're interested in assisting in a local project, try searching on-line by entering "citizen science" and the name of your state.

2. Investigate STEM on the Web

Across the country, organizations are reaching out to help students learn about science, technology, engineering and mathematics. Many of the STEM web sites are fun as well as educational. We've listed a few of our favorites below, and will maintain a more extensive list at *http://www.stemeducation.org/tools*.

PHYSICAL SCIENCES

See how salt changes the physical properties of water – "Please Pass the Salt," NOAA *http://oceanservice.noaa.gov/education/yos/activities/pleasepassthesalt.pdf*

Generate gas from pencils and a battery — "Got Gas?" TryScience — *http://www.tryscience.org/experiments/experiments_begin.html?electrolysis*

Examine spectra from difference light sources – "Build a Spectroscope," Exploratorium —*http://www.exploratorium.edu/spectroscope/*

Have fun with physics puzzles — *http://fantasticcontraption.com/*




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LIFE SCIENCES

Dissect a cow's eyeball – "Cow's Eye Dissection," Exploratorium — *http://www.exploratorium.edu/learning_studio/cow_eye/*

Measure your lung capacity – "Lung Capacity," TryScience — *http://www.tryscience.org/experiments/experiments_begin.html?lung*

Experiment with yeast reproduction – "Breathing Yeasties," TryScience — *http://www.tryscience.org/experiments/experiments_begin.html?yeasties*

ENGINEERING

Make a U. S. Navy jet nosedive – "Take a Nosedive," TryScience — *http://www.tryscience.org/experiments/experiments_begin.html?nosedive*

Construct and test a bridge of spaghetti – "Spaghetti Bridge," TryScience —*http://www.tryscience.org/experiments/experiments_begin.html?spaghettibridge*

Build a simple submarine – "Build an Underwater Robot," NOAA — *http://oceanservice.noaa.gov/education/yos/activities/buildunderwaterrobot.pdf*

ENVIRONMENTAL AND EARTH SCIENCES

Test for toxic substances in runoff water – "Toxic! Or is it?" NOAA — *http://oceanservice.noaa.gov/education/yos/activities/toxicornot.pdf*

Make a telescope at home – "How do I build a telescope?" How Stuff Works — *http://www.howstuffworks.com/question568.htm*

Look at the night sky – "This Week's Sky at a Glance," Sky and Telescope – *http://www.skyandtelescope.com/observing/ataglance/*

MATHEMATICS

Experiment with algebra – "Pre-algebra," Coolmath *http://www.coolmath.com/prealgebra/*

Give your brain a workout — "Play with Numbers," Mathplayground — *http://www.mathplayground.com/logicgames.html*

Try your hand at math puzzles – "BrainBenders," — *http://www.coolmath.com/0-math-puzzles.html*

3. Enter a Contest

Are you competitive? Do you like working with teams? To sharpen your skills, enter one of the numerous science, engineering and math competitions. Build a better robot, egg protector, rocket or solar-powered machine. The Sloan Career Cornerstone at *www.careercornerstone.org/pcprogproj.htm* maintains a comprehensive list of competitions. Here are a couple of good ones:

Sharpen your math skills – Mathcounts offers excitement, coaching and a competition program for middle school kids — *http://mathcounts.org*

Build a robot and test it against others – For Inspiration and Recognition of Science and Technology (FIRST) – *http://usfirst.org/Default.aspx*

4. Visit a Local Museum or Air Show

Many communities have science and technology museums for kids. The premier example is the Franklin Institute in Philadelphia, PA, but there are many others across the nation. To see a list go to *http://www.childrensmuseums.org/visit/us_members.htm*. Air shows at U. S. Navy and Air Force bases offer a chance for you to see breakthrough technology close up. For a schedule, look at *http://www.festivals-and-shows.com/airshows.html*.

5. Keep Up with Breakthroughs

One of the ways that scientists and engineers learn is by examining the new discoveries and inventions of others. To keep up with the latest wave, go to your school or public library and look at *Popular Science*, *Popular Mechanics*, *Scientific American* and *Science News*. The last two magazines may test your brainpower, but the first two are written so that anyone can understand the technology. There are also several good websites, including

Science News for Kids: *http://www.sciencenewsforkids.org/*
NASA Explorers: *http://education.jsc.nasa.gov/explorers/*
Eurekalert: *http://www.eurekalert.org/kidsnews/*
Engineering Careers: *www.NDEP.us*

6. Ask an Expert

If you have zeroed in on a STEM field that you're especially interested in and want to find out what it would be like to work in the area, ask questions. Talk to your teachers, ask your parents or visit with family friends who work in the field. Some of the questions you might consider are: *How did you get started? What do you do on an average day? What did you study in college? What advice would you give me?*

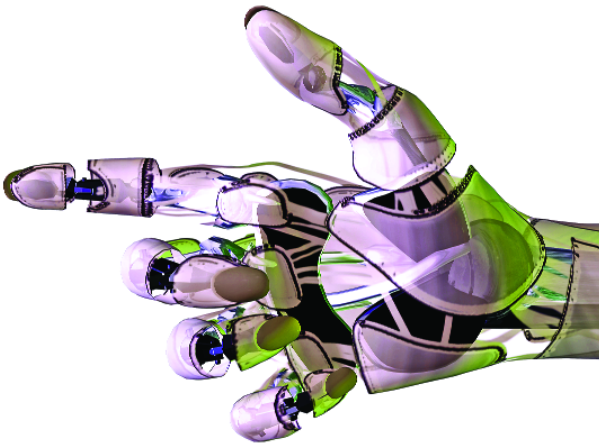
Most career fields also have web sites that explain what is involved in various fields. So just enter "aerospace engineer" or "environmental scientist" in your computer's search engine, and follow the links until you find the information you're looking for. The U. S. Navy has an excellent site that explores engineering careers at *www.NDEP.us*. A list of other good sites is available at *http://www.stemeducation.org/tools*.

7. Go to a Summer Camp

In addition to the summer camps where you swim, row and hike, there are now many camps that help you explore fields in which you may be interested. Many Navy bases around the country offer day camps in the summer to help neighboring kids explore science and engineering. For instance, the camp at the Naval Surface Warfare Center – Dahlgren (VA) Division teaches a snazzy session on robotics (*http://www.nswc.navy.mil/*), and the U. S. Naval Academy offers a STEM summer camp (*http://www.usna.edu/Admission/stem.html*). Across the country at many universities and colleges, there are camps in oceanography, space flight, geology, robotics, bio-organisms and every other topic under the sun. For a list of suggestions, go to *http://www.stemeducation.org/tools*.







advanced placement courses a try also when you get to high school.

When you're taking these courses, keep the following learning strategies in mind:

- Stay curious. Ask questions. Ask more questions until you understand.
- Think creatively about problem solving. Don't settle for a memorized formula. Try to develop a more clever solution.
- Keep your mind open to new possibilities. Find out what is new about a topic, and learn about it.
- Stay organized. Organize your class notes into folders and computer files. Organizing thoughts is a step toward mastering knowledge, and it mimics the processes of math and science.
- Look for patterns. In biology or algebra, try to spot patterns or parallels – in structure, development or purpose.
- Look for connections. Use your math skills to solve science problems. Learn how graphs are built on mathematic equations, how they reflect data and how they express scientific findings.

8. Try an Internship

When you get to high school, you will be able to apply for summer internships in a field in which you are interested. You could even get paid. The U. S. Navy, for instance, opens its research labs to students every year, through the Science & Engineering Apprentice Program (SEAP): *http://seap.asee.org/*. Offering similar opportunities are the National Oceanographic and Atmospheric Administration, National Aeronautics and Space Administration, the National Institutes for Health and other government agencies. Look at *http://www.stemeducation.org/tools* for more opportunities.

9. Learn as Much Math and Science as Possible

Because math is the gateway to STEM opportunities, take as many math courses as possible. Get the basics of algebra down cold, and try calculus or pre-calculus *before* you go to college. Don't just memorize formulas; make sure that you understand math principles before going to the next topic. If you don't understand, ask your teacher for additional assistance.

The big four sciences – biology, chemistry, earth science and physics – will be useful to you in many careers. They're the foundation of today's technological world, and taking each of them will help you sort out what you enjoy the most. Give those

10. Prepare for College

The key task in preparing for college is to find an institution that best matches your interests and aspirations. That might be a two-year college or a four-year university. Ask college counselors, teachers and parents about which college seems to offer the best programs for your interests and learning style. Then, explore the grants, scholarships and financial aid for which you might be eligible. Good web sites to explore these options can be found at:

http://www.collegeboard.com/
http://www.finaid.org/
http://financialaidletter.com/
http://www.navy.com/benefits/education/





ESPECIALLY FOR
teachers

Adding Units of Reality To Abstract Formulas

Let me admit it right up front. I was never good at math, a situation I regretted. You see, my father was a civil engineer, and like many sons, I hoped to follow in his footsteps. But my performance in elementary algebra was so discouraging that I shelved my dreams of building roads, bridges and dams. Thereafter, my mind seemed to freeze when I encountered any formula, even one as simple as $a + b = c$.

What confused me about algebra was the use of letters rather than numbers in algorithms. Beginning in the seventh or eighth grade, my teachers insisted on using *a*, *b* and *c* rather than *1*, *2* and *3* to illustrate every formula they scratched on the blackboard. I can recall suggesting to Mr. Howard, my eighth-grade math instructor, that I might better understand if numbers were substituted for the ever-present letters and the numbers were related to some real-life situation.

Mr. Howard graciously explained that it would be better for me to memorize the formulas using letters, so that I could apply the principle whatever the numerical values and situation happened to be. As a respectful student, I accepted that explanation without question, but at the high cost of remaining deeply in the intellectual dark.

Of course, Mr. Howard was relying on established educational research as he instructed me in abstract mathematical logic. Jean Piaget and his disciples long before had determined that most middle-schoolers have developed the cognitive skills needed to comprehend abstract concepts, like the algorithms Mr. Howard tried to teach me.

Educational psychologists repeatedly caution, however, that *children develop at different rates* and that *they use different modes of learning*. Mr. Howard must have missed that part of the lecture. Although I was an eighth grader, I was clearly stuck in Piaget's earlier stage of intellectual development, in which students depend on the use of concrete examples for learning. I felt like a loner at the time, but I have since learned that there were many other students like me, suffering in the dark.

Fostering Math Understanding

Although the news comes five decades too late for me, help is on the way. Across the nation, mathematicians, professors and math teachers are thinking more creatively about their professions and their responsibilities. The beneficiaries are clearly students like me.

Although many teaching methods and clever techniques have been developed, the touchstone is always the same. The teaching of math must be guided by a determination to foster students' *understanding* of math. No longer will teachers rely on the old saying, "Your's not to reason why, just invert and multiply." Now, reason, not memorization, is the norm. Teachers must ensure that their students understand the mathematical logic behind formulas. That is easy to say, of course, but often hard to do. Thus, the task of teaching math evolves into finding the best methods to enhance understanding.

For many mathematicians, that objective has led to an emphasis on devising useful metaphors to illustrate mathematic principles. The metaphors serve two purposes: They help kids deal with abstractions concretely, and they demonstrate the applicability of mathematical formulas to the real world.

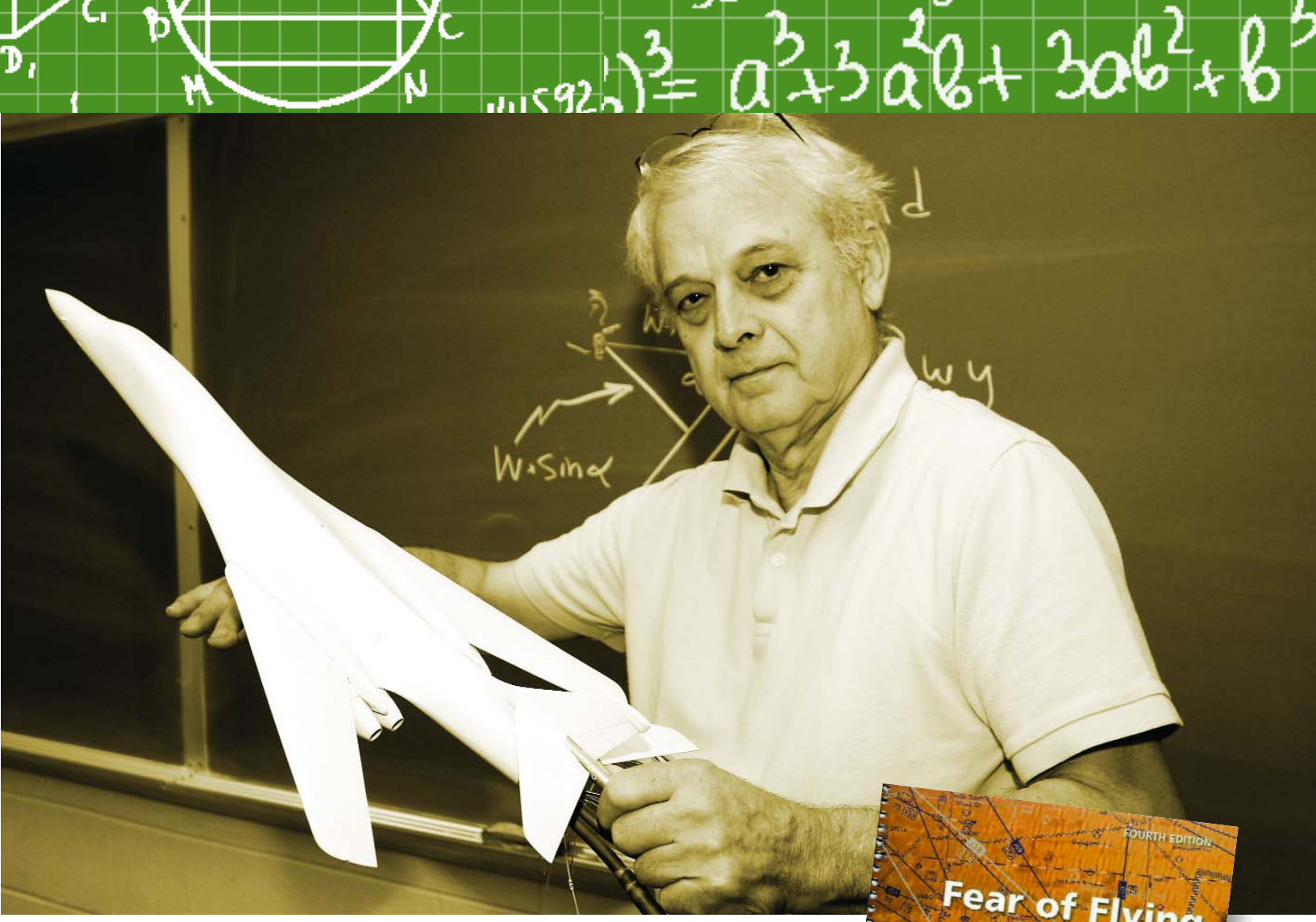
"Adding units of reality to abstract formulas," is what George Rublein calls the enterprise. A veteran mathematics professor at the College of William and Mary in Virginia, George has spent much of the last 20 years devising compelling metaphors to capture students' attention and demonstrate the usefulness of the math they are studying.

"You can show kids some really cool inventions and discoveries, but if you cannot demonstrate the applicability of these things to their lives, the students will immediately go back to their iPODS," said George.

One of Rublein's most successful metaphors is powered flight. Being in an airplane is an exciting event for many of us. We marvel at the invisible power that holds us aloft, and worry about what would happen if that force suddenly were to disappear. We wonder at the skill of pilots' landing in blustery crosswinds, and ponder how airport designers were able to align runways with the prevailing winds so that such landings are few and far between.

To George Rublein, these considerations provide wonderfully concrete opportunities to teach mathematics by solving real-world problems. Because the mathematics of flight are critical to personal safety, they have a natural hold on the imagination. Thus was born Rublein's most successful venture to date, a course for undergraduates called "Fear of Flying."

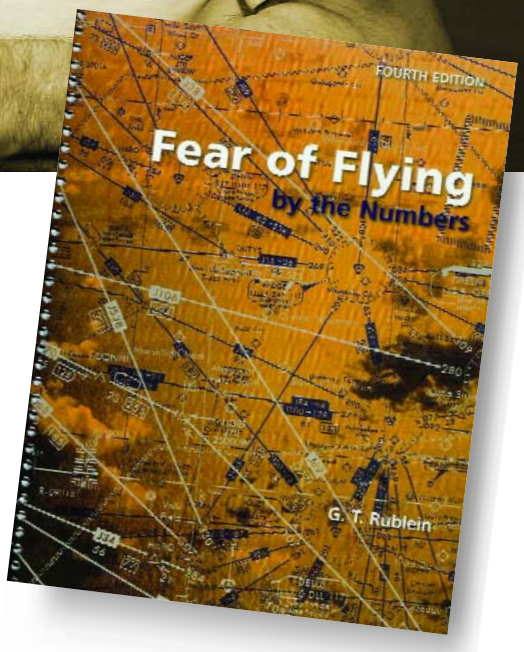
At the beginning of the semester,



George starts class by asking students to use a web site maintained by the Federal Aviation Authority to find a map of an airport near their favorite city. Then, he outlines the way that airport designers use "wind roses" – a flower-shaped representation of a compass that records the history of wind directions and speeds at the site – to determine the best way to align the principal runways. The study of mathematical probability is thus translated into real decisions that can reduce the chances that pilots will have to land in dangerous crosswinds. The students mastered the mathematical principles by designing new airports, a problem-based learning exercise with real-life application.

Rublein developed other mathematical lessons using Microsoft's Flight Simulator — a graphically rich computer program — to add an extra dose of reality to the exercises. By piloting a Cessna C172SP Skyhawk on their computers, students learned about navigation, vectors and wind speed. Each of these required the use of different mathematic applications that became memorable lessons in algebraic reasoning.

Development of the course was funded by a grant from the National Science Foundation. Published by Pearson Custom Publishing, a *Fear of Flying* textbook is now in its fourth edition.



Linking Mathematics and Science

As useful as the flight metaphor was, George Rublein's restless search for new methods to teach math has led him in a new and promising direction, one that ties mathematics to practical applications offered by biology, chemistry, physics and earth science. Using funds from an HHMI Undergraduate Science Education grant to William and Mary, Rublein has begun to develop and teach mathematical exercises that can help advance students' understanding of both math and science at the same time.

"One complaint that kids in high school have is that math doesn't have anything to do with anything. It's not attached to science or anything," said Rublein. "But there are opportunities in the 7th and 8th grade to begin using math to help them understand sciences like chemistry."

The key to seizing this instructional opportunity, says Rublein, is focusing on a real-world problem and demonstrating that math can provide useful

results. One of the most promising exercises is presented by the wealth of information on the web about the International Space Station (ISS). A NASA site presents real-time information about the position of the station as it whirls around the globe. Using other available data and relatively simple mathematics, it is possible to predict when the ISS will pass over any point on Earth.

"Eighth-grade kids can do the math," said Rublein, "and they will have developed a predictive model for the flight path of the ISS. Now this is real-world problem solving that demonstrates that mathematical models can tell us important things about the future. Thus the kids have sneaked into the fascinating world of mathematical modeling."

Rublein is developing another modeling exercise that enables kids to determine what chemotherapy dose to give a patient whose body is about to reject a transplanted kidney. The key is to find the precise strength of the medication needed to suppress the T-cells in the blood that cause organ rejection, without depressing the production of vital red blood cells.

"The answer can be found using a linear equation," explained the math professor. "This is the kind of exercise that reaches out and grabs kids, because we all know someone who has undergone chemotherapy. This is real-world math."

Although Rublein is too modest to say so, his efforts, those of his William and Mary colleagues and of other professionals around the country may lead to a strengthening of the mathematic skills of America's students, as well as to an enhancement of their understanding of science. If that is the case, "adding units of reality to abstract formulas" will indeed prove to be a success and an intellectual boon to students like me who get lost in abstractions.

— Bill Walker
Eighth Grader, 1957

To see some of the exercises that George Rublein and his colleagues are developing, please visit the following URL: *http://stemeducation.org/explore/math.*



STEM Education Alliance

School of Education
College of William and Mary

Dr. Virginia McLaughlin, Dean
Dr. Gail Hardinge, Director
Mr. Jason Kremar, Assistant Director

The STEM Education Alliance at the College of William and Mary is a center dedicated to the development of 21st century science, technology, engineering and mathematics resources and support for the K-12 community. The center provides professional development for teachers and STEM professionals working in the classroom, research-based instructional materials to encourage student career exploration, and consultative services for community and government projects vested in partnering with the educational community.

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21st Century Engagement, Education, and Technology Program

U. S. Navy

National Defense Education Program

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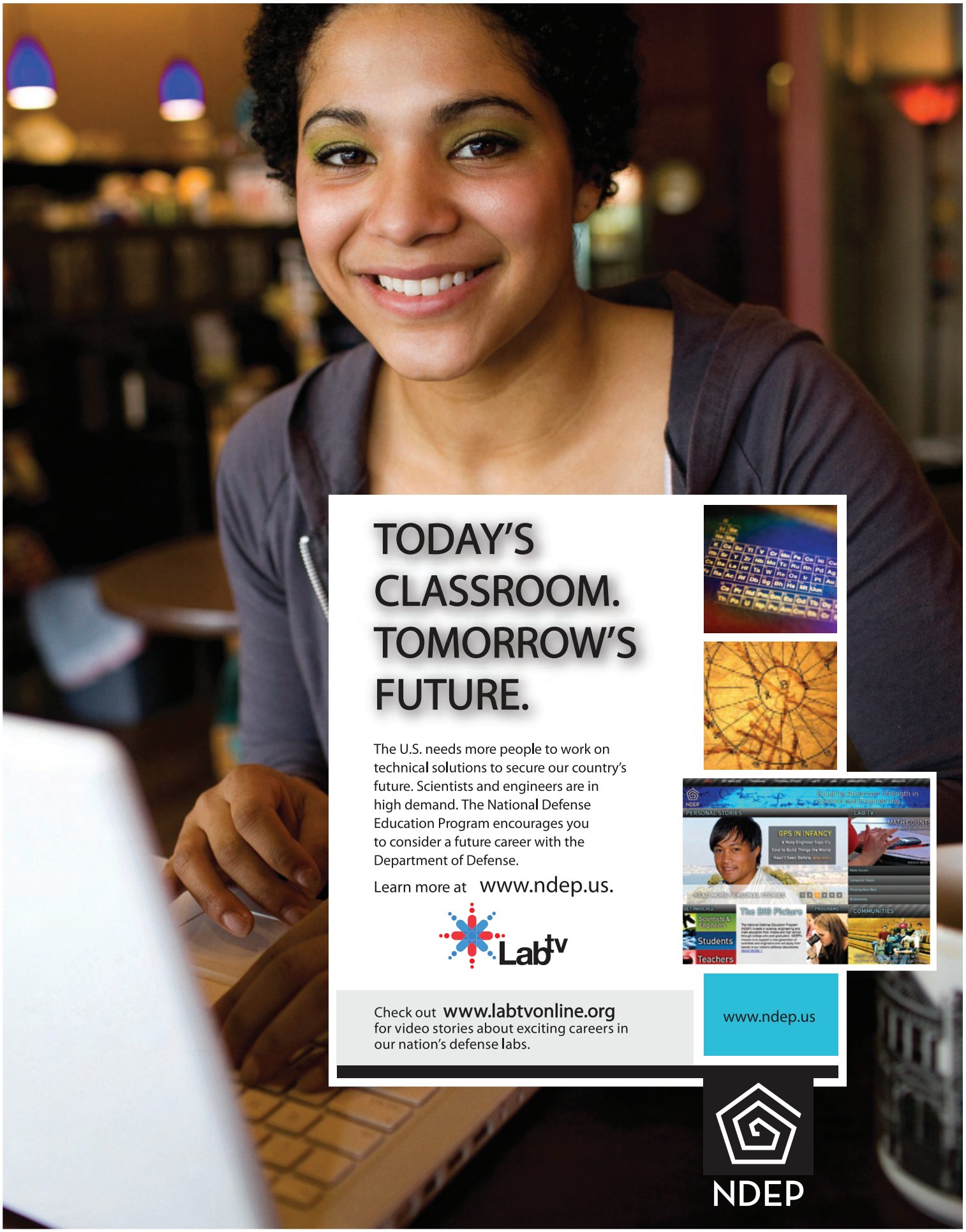
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