Physics in Your Future

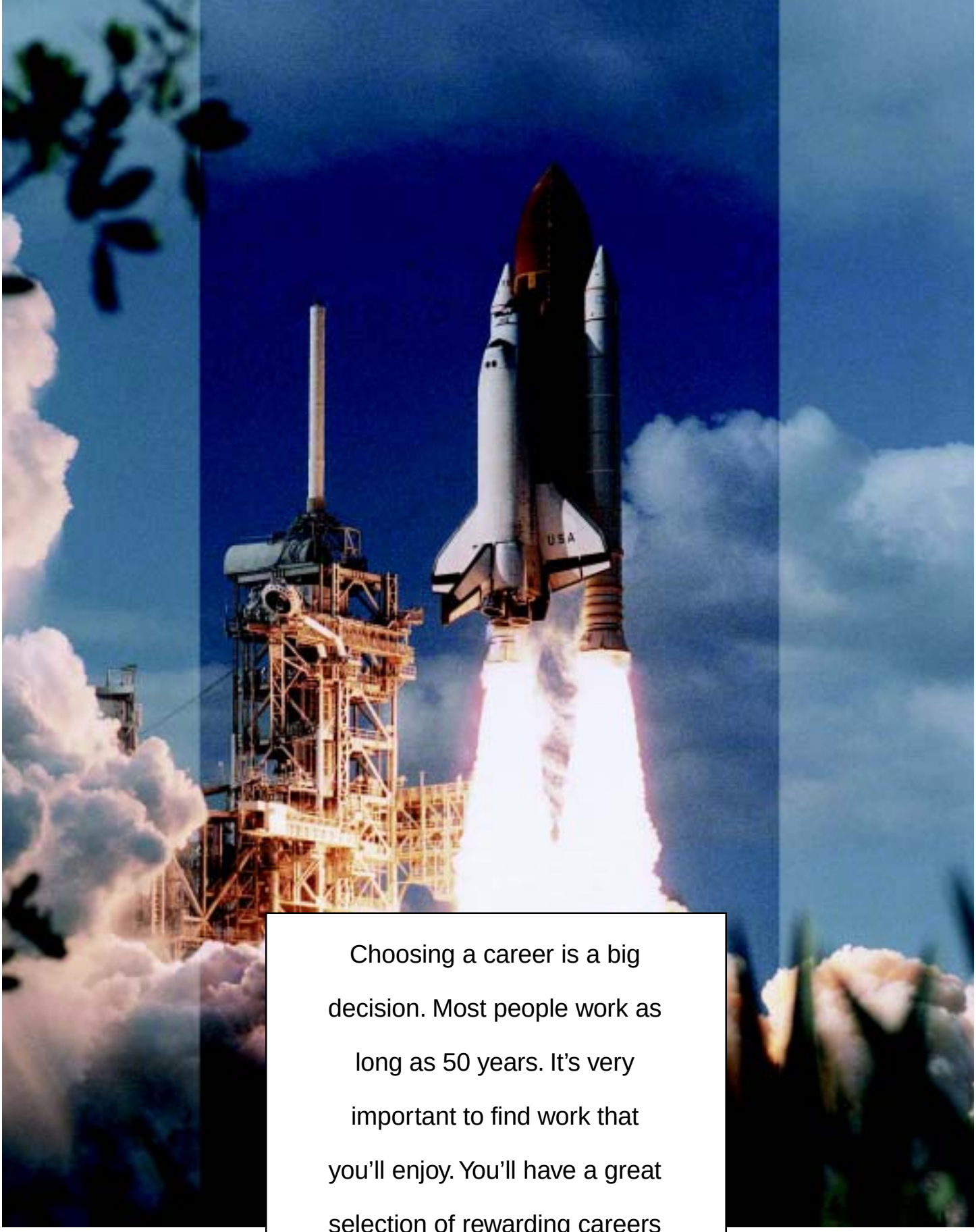
BY DINAH L. MOCHÉ, PhD

FOR THE APS COMMITTEE

ON THE STATUS

OF WOMEN IN PHYSICS

AMERICAN PHYSICAL SOCIETY



Choosing a career is a big decision. Most people work as long as 50 years. It's very important to find work that you'll enjoy. You'll have a great selection of rewarding careers to choose from if you study math and science. This booklet describes some of your possibilities.

Photo by NASA

Cover photos by (clockwise) Neil Schneider, NASA, Argonne National Lab, Angela Seckinger, Neil Schneider, John T. Consoli and Ray Manning

PHYSICS IS THE BASIS OF SCIENCE AND TECHNOLOGY

It deals with how and why matter and energy act as they do.
The laws of physics precisely describe force and motion, gravity, electricity, magnetism, sound, light and heat. They help you understand the physical world and develop products that meet human needs.
Mastering physics is challenging. You must work with other people as well as alone. You learn how to solve problems, observe things carefully, make measurements and keep accurate records. You can use these valuable skills the rest of your life. They open doors to many good jobs. Physicists ask questions about the physical world and try to find exact answers. They are creative and persistent. Some do basic research. Their aim is to increase our knowledge of the universe. Others do applied research. They use basic knowledge to solve human problems such as food and energy supply, environmental protection, transportation, communication and defense.

Over 40,000 physicists work in industry, educational institutions, government, and medical centers today. Most are active scientists and engineers. They do research, development, administration, and teach. The rest use their physics background in work such as publishing, sales, law, accounting and medicine. Salaries for beginning physicists are generally good, although it depends on their education, type of employer, and responsibilities. You can get the latest salary information from the American Institute of Physics at http://www.aip.org/statistics/. You've probably seen TV shows and movies that have influenced your thoughts about scientists. Now meet some real people who are physicists. Find out what they actually do and what kind of people they truly are. Then see if you can picture yourself with a career in science.

START TO PLAN YOUR FUTURE

Think about how your career will fit into the life style you want.
Talk to your science and math teachers, advisors and parents about the opportunities physics can open to you.
Go to your public library. You'll find popular books, magazines, and websites that tell about current topics of interest in science. Ask physicists about their work. Companies, universities, and museums often let people see their facilities and meet their staff. Call to find out when you can visit. Get suggested websites and more information from the Committee on the Status of Women in Physics, of the American Physical Society (see http://www.aps.org/educ/cswp/index.html) For more information about how physics is part of your world, go to PhysicsCentral, http://www.physicscentral.com/.

YOUR OWN GOALS AND TALENT

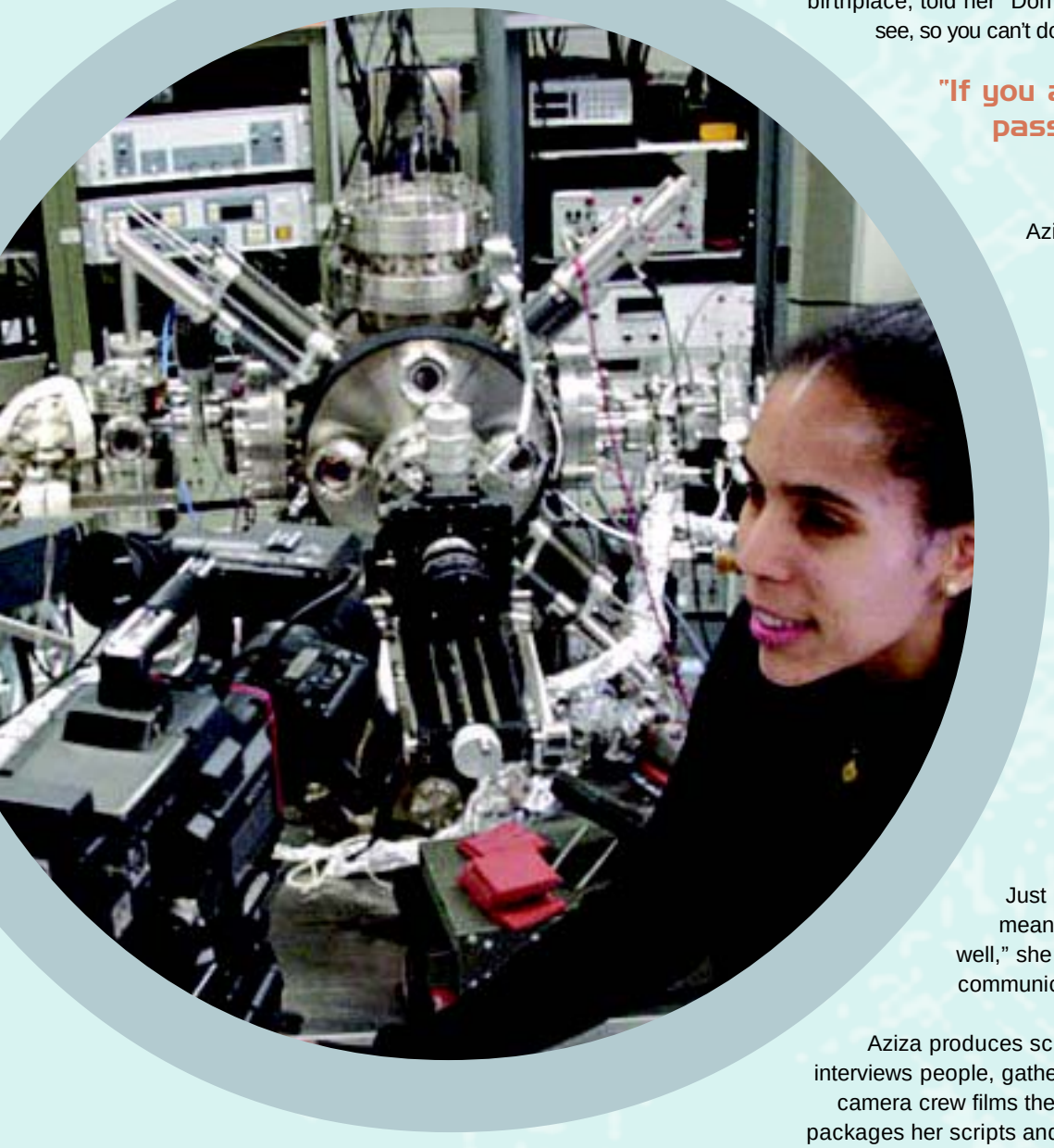
Your own goals and talent will determine how much more science and math you study after high school. If you want to be a physicist, you must at least graduate from college with a degree in physics. The most interesting jobs usually require a degree from graduate school.

ACT NOW TO KEEP YOUR CAREER OPTIONS OPEN

Take all the math and science you can. Math is the language of physics and computers are the main tools for calculations. Understanding high school science will prepare you to enter college and be a good citizen in any job. Join a science or computer club in your community or start one yourself. You'll find other people who enjoy solving puzzles, exploring nature, doing projects, and sharing ideas. Work on your own projects. If your school has a science fair, try to participate in it. Get experience with computers, tools, electronics and machinery. You may take shop and industrial arts courses or build and repair things on your own.

Photo of Elaine Fu by John T. Consoli, University of Maryland College Park. (top)
Photo of Alice White by Bell Labs Lucent Technologies (bottom)

"WITH MENTAL ABILITY AND COMMITMENT, ANYONE CAN DO SCIENCE"



"I've been passionate about science since I was a little kid," declares Aziza Baccouche. When she was eight years old, Aziza fell on her head at camp and lost her sight. Middle school advisors in Tunisia, her birthplace, told her "Don't even think about science. You can't see, so you can't do science." But Aziza refused to give up.

"If you are committed, if you are passionate about something, you'll find a way to get it done," Aziza emphasizes. "The most important thing is your mindset. I was really passionate about physics because I really loved math and I really loved science" in high school. Physics combines both of those subjects. Aziza's physics teacher in Fairfax, Virginia inspired and encouraged her.

Now in graduate school, Aziza focuses on nuclear physics and theoretical research. She studies properties of special kinds of subatomic particles called heavy baryons, such as protons and neutrons. She loves to figure out a result and make predictions about how things work.

"Science offers you flexibility. Just because we excel in science doesn't mean that we can't do other things equally well," she notes. "I'm equally passionate about communicating science to the general public."

Aziza produces science news stories for television. She interviews people, gathers information and writes the story. A camera crew films the people and their activities. An editor packages her scripts and the tapes into a video to broadcast.

After she earns her PhD degree, Aziza will continue her work as a science correspondent for television. She has a production company to make science videos for high tech companies and TV. She aims to "expand the classroom so that I'm talking to the whole world about science and its remarkable impact on our lives."

Aziza wants *all* kids to gain the skills and knowledge that science offers. She speaks at schools and special conferences on science and education. Her message is "Hey, this is something you can do. This is a possibility - you can do science."

anyone can do it

Photo of Aziza Baccouche, University of Maryland College Park by Sheldon Smith

PHYSICS MAKES OUR LIVES MORE COLORFUL

The colors on this page look different if you view them in the online version at http://www.aps.org/educ/cswp/index.html. Object, screen, and printer colors never match exactly. Dr. Karen M. Braun is a color scientist. She improves color images.

The differences occur because computers and printers produce color images in different ways.

Each can reproduce colors in only a specific range. None can reproduce all colors. Computer displays *add* and printers *subtract* red, green, and blue light to make all other colors. “Look at the colors printed on this page with a magnifying glass,” suggests Karen. “All you’ll find is cyan, magenta, yellow and black dots. But together these dots produce all the colors you see on the page.”
Although she mostly works independently at her computer, Karen often brainstorms with others about how to get high-quality color images from one device to another. They develop digital imaging software and hardware to compensate for differences among devices.

Karen tests human perception of color and color preferences.

The same color can look different under various viewing conditions. Kids prefer more colorful images with more contrast than adults do.

“If I have colors that are outside what a printer can make, I look for the best way to reproduce those colors with that printer”, Karen says. “I aim to make the images better for people who are looking at them.”

She writes algorithms (instructions) to translate colors faithfully from a computer to a printer.

Software designers incorporate her algorithms. “A fun day is when I’ve worked on my algorithm all day and I’m ready to pull my hair out, but at the end of the day I get it to work”, smiles Karen.

Research is most useful when people compare an image that was produced with Karen’s algorithm to one without her algorithm. “I take images and display colors in a way that makes people say, ‘Wow, that’s a lot better’!”

“I thought about becoming a psychology major when I was graduating from high school in upstate New York,” Karen says. “Physics and psychology seemed so separate. In graduate school I discovered that imaging science combines them.”

making life colorful

Photo of Karen Braun, Xerox Corp., Webster, NY by Larry McKnight, Information Technology Solutions

PHYSICS HELPS SOLVE MEDICAL MYSTERIES

Millions of people of all ages suffer pain or learning disabilities. Dr. Susan Bowyer applies physics to reveal exactly where the trouble is in the brain .

How does Susan map the brain at work?

Her system is nicknamed MEG, for *m*agneto*e*ncephalo*g*raphy. “We stimulate your fingers, face, or toes with pulses of air. In response, tiny electrical currents move in your brain. They generate weak magnetic signals which tell us where the stimulus triggers electrical activity in your brain,” she explains. “We hope to locate cognition and memory soon.”

Susan designs, sets up, and runs research studies in the hospital MEG lab. A giant magnetometer dominates a room that keeps out stronger magnetic signals from power lines, electric motors, and elevators. The equipment looks amazing.

MEG is a totally safe way to image the brain.

Susan calms nervous patients: “I’ll be able to pinpoint where things are going on without doing *anything* to your brain. A magnetometer just picks up signals - like a car antenna does.”

A technologist collects the data. When a problem occurs, Susan must figure out why. Sometimes equipment breaks. Other times a patient simply forgets to remove earrings or underwear that cause interference.

After the patient leaves, Susan analyzes the data. She also supervises graduate students who work with her. They process the measurements with a computer. They produce a map of the precise regions of the brain where activity occurred in response to the stimuli.

Doctors can look at Susan’s maps and easily see active and abnormal areas. They can diagnose problems more accurately and plan the best possible treatments. Surgeons can plan operations that minimize damage to basic senses such as seeing, hearing, and feeling.

Travel is a fun part of the job.

Susan presents her cutting-edge MEG research at medical conferences all over the world. “Colleagues are always interested in what MEG is and how they can use it”, she beams.

Susan and her son Michael, 7, work and play together. She coaches his soccer team. He helps in her research. Michael is her first subject when she studies children. “Michael draws cute pictures of the magnetometer measuring his teddy bear’s brain,” smiles Susan.

Photo of Susan Bowyer, Henry Ford Hospital, Detroit, MI, by Ray Manning, Media Resources

SHE DISCOVERS PLANETS CIRCLING DISTANT STARS

People have always wondered if space creatures exist. Perhaps billions of planets house alien life. Dr. Debra Fischer, who hunts for these planets, finds astonishing clues. “I spend 40 to 70 nights a year at the telescope collecting data,” she says. Debra cannot see planets circling distant stars. They are much too small and faint. She focuses sensitive instruments on visible stars that seem most likely to have planets.

Debra deduces the presence of unseen planets by observing a slight wobble in a star's motion.

Single stars race straight through space. The tug of a circling planet makes a star bob back and forth a bit instead.

“I love going to the Observatory,” Debra says. “It is both peaceful and a time of concentrated effort.” She analyzes data, writes computer software, and tests new equipment in her office. **“**The best part of my job is conferring with colleagues and students. They are amazing, lively people who are passionate about their work,” Debra notes. “We fit pieces of a great puzzle together. We undo previous misconceptions, construct theories, and make predictions that drive new experiments and observations.”

Discovering multiple planet systems thrilled the team most.

Giant planets close-in to their stars were discovered first. Their strong gravity tugs hardest and they circle quickest. “They jump up and down waving their arms to get our attention,” smiles Debra. But nothing can live on these hot gas worlds. With ever-improving measuring techniques, Debra is collecting data on hundreds of stars. “We will find out soon if our solar system is extraordinary. More likely, planets like Earth - with liquid water and atmospheres - circle out in the livable zones around nearby stars,” she says.

People are very enthusiastic about the work Debra does.

She shares the excitement in articles and speeches. “I receive E-mails from kids and adults around the world who thank me. That is an inspiring experience that keeps me going when things get tough.”

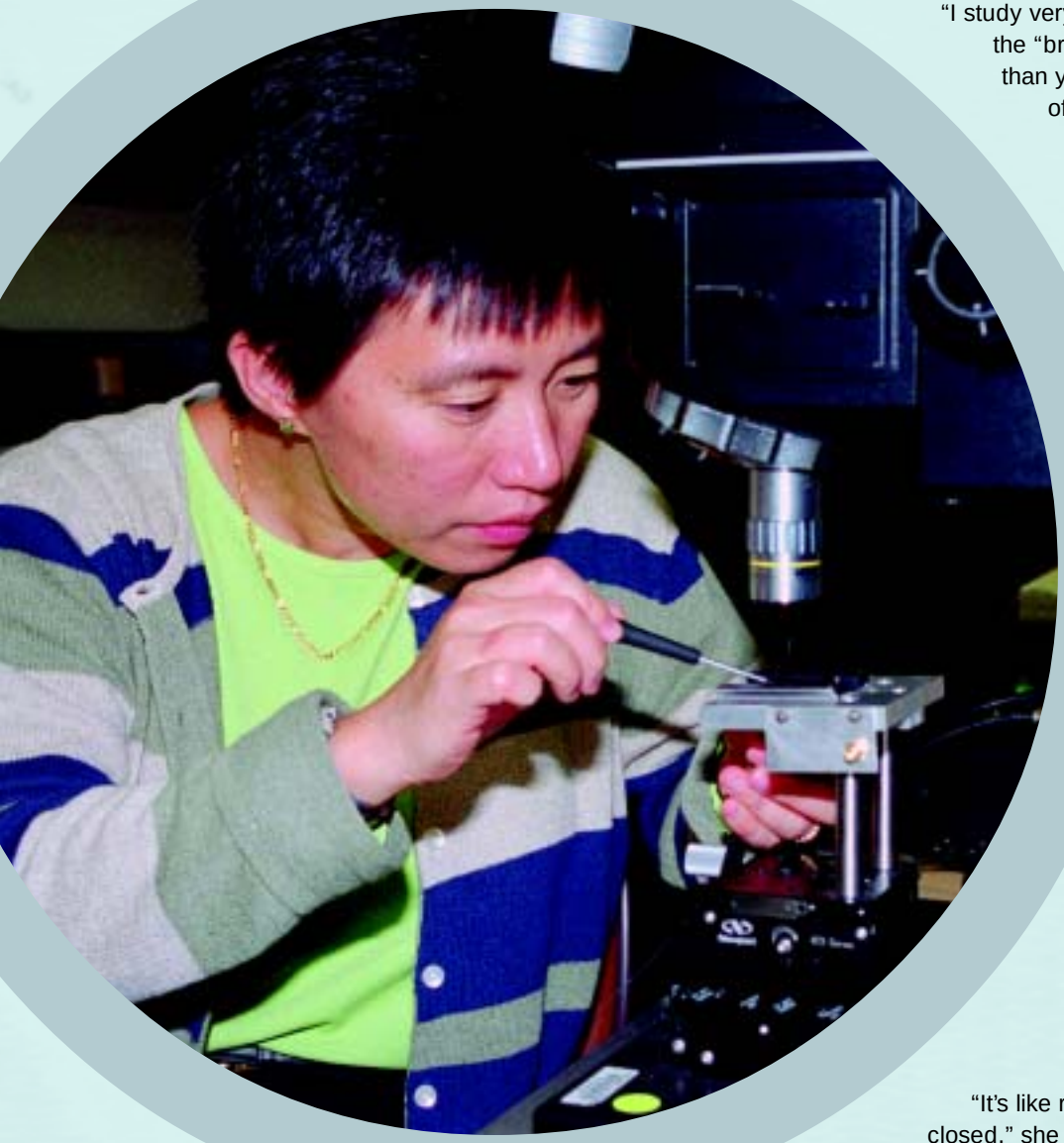
Debra became interested in science when she was growing up in Des Moines, Iowa. “In the fifth grade, I sat in a tree in our back yard and read science fiction books. I imagined myself as a mad chemist pouring smoking concoctions from one vial to another,” she laughs. She studied a wide range of science and finally majored in physics in college. There her first astronomy course hooked her for life.

discover planets

Photo of Debra Fischer, University of California Berkeley by Noah Berger

MATERIALS RESEARCH IS MAKING OUR LIVES BETTER

People want ever smaller, faster, and better electronic and optical devices. Superior new models - computers, CD players, cell phones, internet access – require improved materials. Dr. Julia W. P. Hsu aims to find some.



Julia examines candidate materials.

"I study very tiny features," she says. Computer chips, the "brain cells" of electronic devices, are smaller than your fingernail. These chips hold thousands of circuit elements that manipulate and store information. To shrink and improve chips further requires a clear image of minute features that are smaller than a human hair's width!

Julia also examines physical properties of candidates. Will the material conduct electricity? Does it give off light? What happens to it near a magnet?

Tiny irregularities, called defects, are important. Julia tries to understand how the defects affect the material's ability to conduct electricity or to emit light. She targets a material, collects data, analyzes it, and reports her results.

People who make materials use her findings. They try to figure out how best to alter the materials to make them most useful. Inventors could use Julia's data in the future to make devices that we cannot even imagine.

How does Julia examine properties she cannot see?

"It's like running your finger on a wall with your eyes closed," she says." "Try it. You will find out many things. Is the wall rough or smooth? Hot or cold? You can tap it to find out if it's hard or soft."

Julia's "finger" is the tip (probe) of a scanning probe microscope. She runs the tip on a bit of test material to map out (scan) physical properties. "I like to measure things that no one else ever has," she says. If the equipment she needs doesn't exist, she designs and builds it.

When did Julia decide to be a physicist?

"Probably In middle school," she recalls. "I had a great teacher who gave me projects to do. I've always liked working with equipment and people." Julia grew up in Taipei, Taiwan. She was ready for twelfth grade when she moved to New York City at age 16. "I arrived here very well prepared in science and math. I had been learning English ever since seventh grade. Of course the slang was new to me, " she smiles.

making lives better

Photo of Julia Hsu, Bell Labs-Lucent Technologies by Neil Schneider

PHYSICS PROMISES AN AMAZING FUTURE

Dr. Cherie R. Kagan pictures a computer that you roll up and put in your knapsack. Cherie is a materials scientist. She demonstrated a revolutionary new process. “We deposited a very thin coating - thinner than a human hair - of semiconductor materials from solution onto plastic at low temperatures,” Cherie explains. “We made a new transistor by this process.”

Transistors are the basic building blocks of electronic products. They switch electric current on and off to make the products work. Today transistors are made out of rigid semiconductor materials. The new transistor could be used for flexible electronics.

"The days I spend in my lab and confer with colleagues are my best,"

Cherie says. “We make materials, measure their electronic and optical properties, and create better, flexible, cheaper electronic devices. Right now if I dropped my laptop it would be pretty bad,” Cherie says. “I would love to have a pocket computer that I could sit on and not have to worry about breaking it.” Manufacturers could use this process to produce flexible, lightweight displays for digital watches, calculators, and cell phones. They could make electronic paper, a flexible plastic sheet that would electronically display text and images.

Cherie imagines future computers that will be faster, smaller, more powerful, and cheaper than any we have today. Her materials can’t reach the speeds necessary for the microprocessors of your computer now. Small as they are, the thin films are made up of many, many stacked molecules. They are three-dimensional.

Molecular electronics may do the job.

Here the semiconductor coating is just a single layer of molecules or less. Cherie is working on it. “Wow, it would be fantastic if some day we could build the function of a whole device into just a single molecule!”

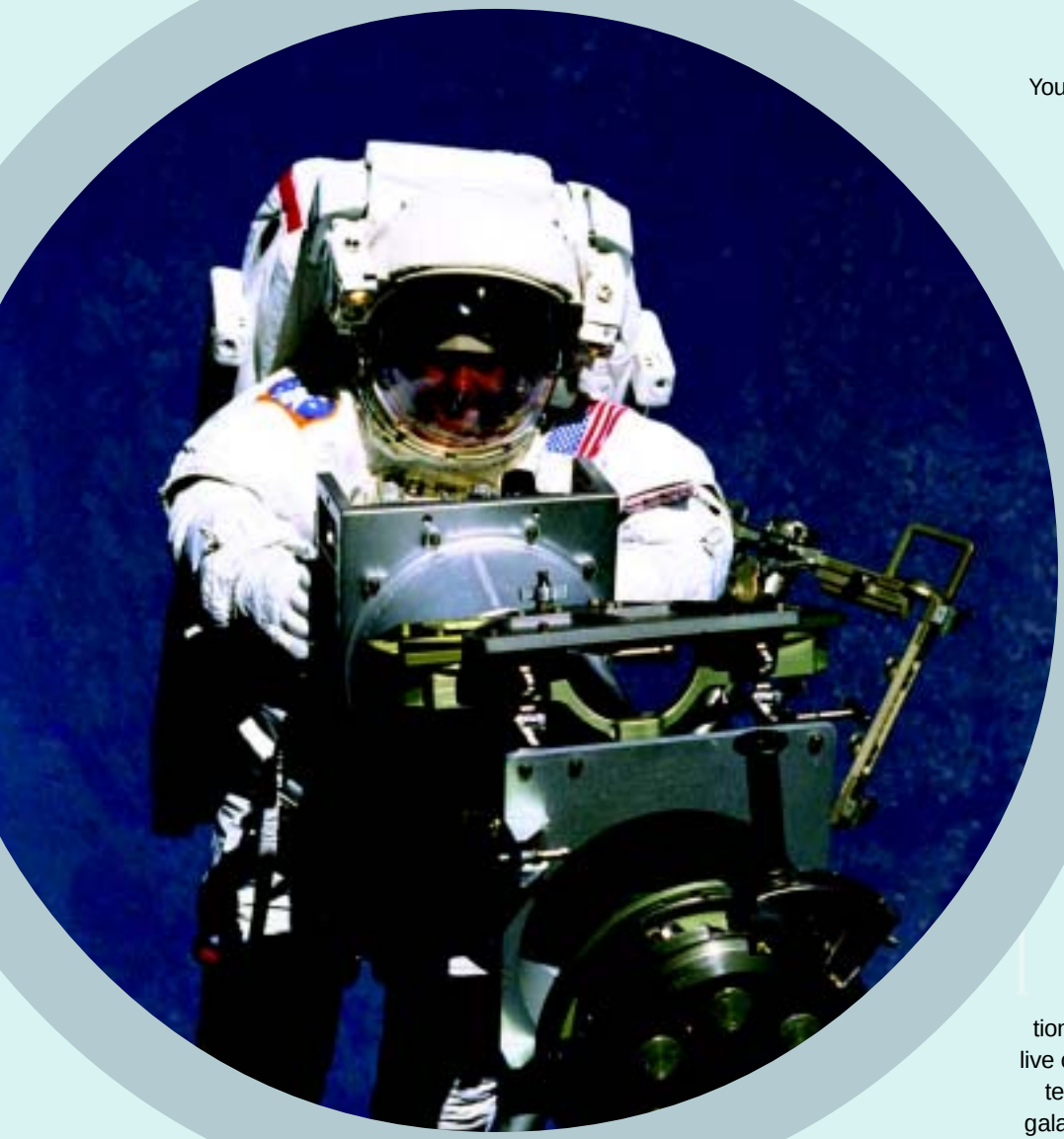
“Although I always wanted to do science, my family didn’t know exactly what scientists do,” she says. Cherie grew up on Long Island, New York. “I found out in college that I really liked doing research.” She got a degree in electronic materials, which combines physics and chemistry. “It gives me many opportunities for different types of jobs.”

an amazing future

Photo of Cherie Kagan, IBM, Yorktown Heights, NY by Neil Schneider

SHE RISKS HER LIFE IN SPACE TO DO UNIQUE RESEARCH

Dr. Tamara “Tammy” Jernigan has flown 1,512 hours in space. She was a mission specialist and payload commander who managed equipment and experiments aboard space shuttles. Space shuttles transport people, material and equipment to and from Earth orbit.



Living 225 miles up is very different from home.

You’re in zero-G, a state where you can’t detect the pull of gravity. Everything floats — even astronauts. “I love feeling weightless and really free,” says Tammy. Space has no air to breathe, great heat (250 °F in direct sunlight) and cold (-250 °F in the dark), deadly radiation, and micrometeoroids, (bits of rock that can hit you like bullets). Tammy usually works inside an airtight crew cabin. She wears shorts and a golf shirt. “My favorite space food is spaghetti and meat sauce,“ she reveals. For an exterior construction job, Tammy wore a life-supporting 300-pound space suit for almost 8 hours. “I felt exhilarated to be outside of my space ship. Continents, oceans, and whole cities looked awesome!”

Tammy researches important questions in space and life sciences and astronomy.

She does experiments to find out how humans, animals, plants and cells change and grow in zero-G. We need this information before people can take long space trips or live on the Moon and Mars. Tammy uses special telescopes to study very hot stars and distant galaxies from space. She operates the remotely controlled robot arm to lift cargo in and out of the shuttle. She delivers supplies and equipment to the International Space Station, a spacecraft that circles Earth every 90 minutes endlessly. Between flights Tammy is busy. Astronauts help design, maintain, and operate spacecraft. They perform science experiments and test hardware and software. They also appear on television, radio and in person worldwide to share the excitement of space exploration with everyone.

What results are most exciting?

“First, a better understanding of how weightlessness weakens our bodies – heart, blood vessels and bones,“ Tammy says. “Second, observing primordial helium, left over from the Big Bang.” This ancient gas is valuable evidence of how our universe began billions of years ago.

If you want to be an astronaut, you need a college degree in engineering, science or math, and excellent health.

Tammy was prepared. She grew up in Santa Fe Springs, California. “I got into physics in high school, then majored in physics in college. I loved understanding and predicting how things work.” She also competed in all sports, especially volleyball, track and field, and soft ball.

Photo of Tamara Jernigan, by NASA

YOUR CHANCE OF SUCCESS IS GREATER TODAY THAN EVER BEFORE

KATHARINE GEBBIE

(above)

Dr. Katharine Gebbie directs the physics laboratory at the U.S. National Institute of Standards and Technology (NIST). Researchers at this laboratory develop new physical standards, measurement methods and data, and collaborate with industry to commercialize inventions and discoveries.
Katharine enjoys encouraging other scientists in their work. “I get joy and thrills from building a first class laboratory”, she says.

MILDRED DRESSELHAUS

(top small photo)

Policy makers in government, industry, education, and science often seek advice from MIT physics professor Dr. Mildred Dresselhaus. She is known worldwide as a researcher on exotic forms of carbon and as a leader in promoting opportunities for women in science. Millie enjoys working with students. She says, “I like to be challenged. I welcome the hard questions and having to come up with good explanations on the spot.”

SHIRLEY ANN JACKSON

(middle small photo)

President of RPI, Dr. Shirley Ann Jackson has served on many U.S. government task forces and has been an advisor to major companies. Shirley was one of the first African-American women to get a PhD degree in physics, and the first to win the Black Engineer of the Year Award by U.S. Black Engineer & Information Technology magazine (Feb. 2001). She says, “My priorities are my family and my career.”

CHERRY MURRAY

(bottom small photo)

Dr. Cherry Murray was the first female vice-president for physical science research at the big communications technologies company where she works, Bell Labs-Lucent Technologies. She made fundamental contributions to physics research on colloids (particles that neither dissolve nor settle when suspended in a liquid) that may be used in future optical and optoelectronic systems. Cherry loves to spend personal time with her family and encouraging middle school students to pursue careers in physics.

Photos by NIST, MGM Group website, Mark McCarty RPI, and Bell Labs Lucent Technologies

MYRIAM SARACHIK

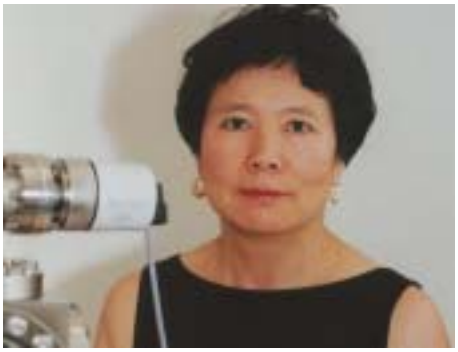
(above)

Dr. Myriam Sarachik is famous for her experiments explaining how electric and magnetic properties of materials can be controlled. She enjoys sharing her ideas with her students at the City College of New York and loves to talk about the pleasures that a career in physics can bring. Myriam was born in Belgium and attended primary school in both Belgium and Cuba.

HELEN QUINN

(left, top small photo)

Dr. Helen Quinn has won many awards and honors for her research in particle physics. She enjoys making physics exciting for students at the Stanford Linear Accelerator (SLAC). SLAC is a facility where electrons and positrons are smashed together to produce energy; the energy then turns into other particles and anti-particles to reveal secrets about the ultimate nature of matter.



CHA-MEI TANG

(middle small photo)

The scientific and business challenges of running her own technical company in Maryland motivate Dr. Cha-Mei Tang. She founded a successful company to develop diagnostic and analytical tools for use in healthcare and environmental practice. “Understanding physical principles is the key to technical innovations”, she says.

SALLY RIDE

(bottom small photo)

When Dr. Sally Ride rocketed into space in 1983 she made history as the first American woman ever to go there. A mission specialist for NASA, she ran experiments on two space shuttle flights. Sally earned her PhD degree in physics. Since leaving the astronaut corps, Sally has taught physics at the university level, written children’s books on space, and developed educational materials.

Photos by The City College New York, SLAC, Julie Hui, and NASA.

Math and science are demanding. They require solving problems and doing laboratory experiments. Think of the effort and time you spend as an investment in your future. Your rewards will be new skills, self-confidence, friends, and career possibilities.

Photo of Jessica Clark, College of William and Mary by Sugata Tripathi

“Physics in Your Future” introduces physics and careers in physics to young people, their parents, teachers and advisors.

Although physics is often not taught until the last years of high school, the necessary mathematical preparation begins at the middle school level. The purpose of this booklet is to inspire students who might otherwise avoid technical subjects to take all the mathematics and science courses they can. The American Physical Society (APS) is dedicated to the advancement and communication of the knowledge of physics. The Society publishes scholarly journals and organizes scientific meetings. It establishes committees, such as the Committee on the Status of Women in Physics (CSWP) to consider issues of concern to APS members.

The CSWP sponsors a variety of projects including events and career booklets, a newsletter, a roster of women physicists and many symposia at APS meetings. (http://www.aps.org/educ/cswp/index.html)

Author Dinah L. Moché, PhD is a professor of Physics and Astronomy at Queensborough Community College of the City University of New York. Dr. Moché is the author of numerous books and articles that make science accessible and exciting for everyone.

Photo by SLAC

CSWP Coordinator: Dr. Beverly K. Berger
Staff Liaison: Suzanne Otwell
Graphic Designer: Kim Quigley

The American Physical Society gratefully acknowledges the generous support of

We thank Cynthia Kahlenberg and Jessica Kahlenberg of Pyle Middle School, Bethesda, MD for editorial assistance, the American Astronomical Society for providing press releases and fact sheets, and Ernest Holzberg, Esq. for counsel.

ISBN 0-7354-0076-8 print
ISBN 0-7354-0077-6 online version
Library of Congress Cataloging-in-Publication Data

Moché, Dinah L.
Physics in Your Future

Published by the American Physical Society
Printed in the United States of America
The American Physical Society
One Physics Ellipse
College Park, MD 20740