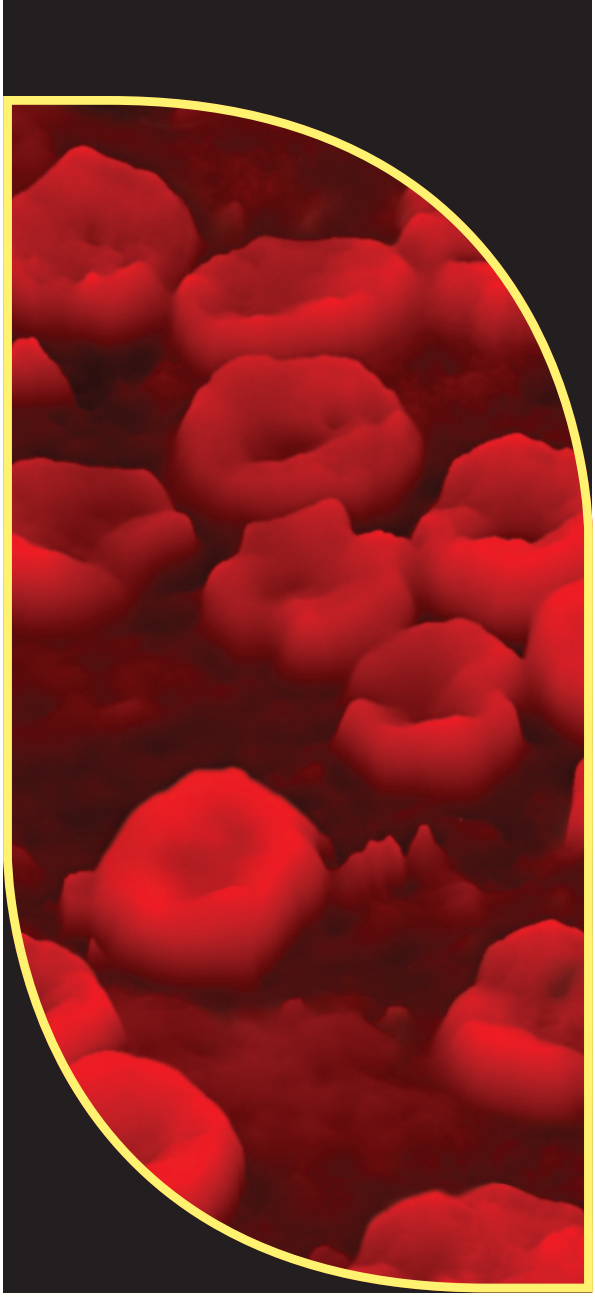


BIOMEDICAL OPTICS

OSA Educational Resources … *Exploring the Science of Light*

OSA®
Optical Society of America

Optical Society of America (OSA)

Founded in 1916, OSA brings together optics and photonics scientists, engineers, educators and business leaders. OSA is dedicated to providing its members and the scientific community with educational resources that support technical and professional development. OSA's publications, events and services help to advance the science of light by addressing the ongoing need for shared knowledge and innovation. The Society's commitment to excellence and continuing education is the driving force behind all its initiatives.

OSA's Education Outreach

Education outreach is one the most important and significant ways OSA supports and inspires young scientists. A variety of materials and programs have been developed to address the needs of students from elementary school through 12th grade. We invite you to explore the education resource pages at www.osa.org and welcome your comments and suggestions. Contact OSA's educational programming staff at opticseducation@osa.org.

The OSA Foundation

Inspiring the next generation of scientists and engineers

The future's great scientists are among the children of today and tomorrow. These children live and study around the world. Some have the resources and support needed to succeed, but many others do not. The OSA Foundation believes all students should have access to quality education resources and everyone should have the opportunity to explore scientific studies and career paths.

The Foundation focuses on advancing youth science education by providing students with access to science educators and learning materials through interactive classroom and extracurricular activities. To learn more about the Foundation and its funded programs or to request support for your program, please visit www.OSA-Foundation.org, e-mail foundation@osa.org or call +1.202.416.1421.

This poster series was created by the Education Subcommittee of the OSA Membership and Education Services Council.

OSA would like to thank the following volunteers for donating their time and expertise to this project:
Daniel Eversole, Univ. of Texas at Austin, USA; Irene Georgakoudi, Tufts Univ., USA; Halina Rubinsztein-Dunlop, Univ. of Queensland, Australia, and Ali Serpenguzel, Koç Univ., Turkey.

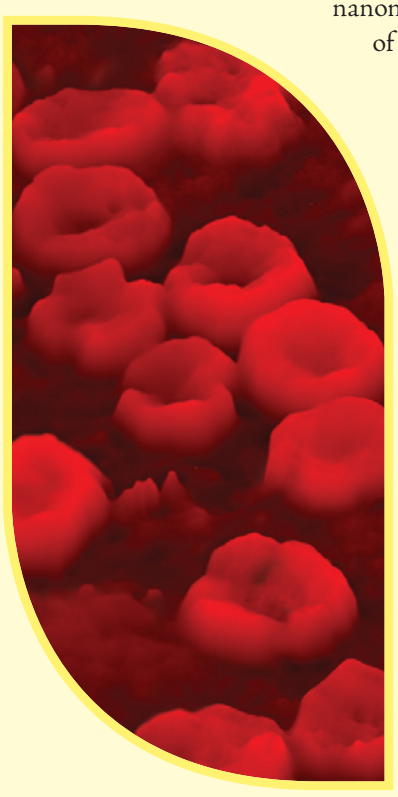
OSA would like to thank the following organizations for their support of this project:
The National Center for Optics and Photonics Education, www.op-tec.org
The American Institute of Physics, www.aip.org

BIOMEDICAL OPTICS

Scientists, engineers and doctors around the world are working to develop the next generation of devices that will allow physicians and medical researchers to understand, detect and treat human diseases in a painless and non-invasive way. This exciting field of work is known as biomedical optics.

One example is an imaging method that allows for a highly detailed examination of the structure and characteristics of red blood cells. Why is this important? Red blood cells are the most common type of cell in our blood. They deliver oxygen and nutrients to our tissues. To accomplish this task they need to be incredibly elastic so they can squeeze through 96,500 kilometers of tiny blood vessels in our body.

Recently, researchers have developed an imaging technique that allows them to visualize tiny vibrations that constantly occur along the membranes of red blood cells. This method uses an optical phenomenon known as interference, one of the interactions that occurs between light waves. As one light wave passes through a cell it is compared to another wave that doesn't pass through. Combining these two light waves causes an interference pattern forming an image of individual cells that is sensitive to variations on the nanometer scale. A nanometer is a billionth of a meter!



The biomedical optics poster you are looking at was created using this very technique. Similar approaches are used to acquire images of exquisite detail from tissues throughout our bodies simply by shining light on them and collecting the light that scatters back out of the tissue. Other approaches involve shining light through the tissue and looking for refraction or absorption effects. Such images allow doctors to detect tiny changes that occur when diseases such as cancer or atherosclerosis (heart disease) are forming, without the need to perform a biopsy and without any side-effects.

Definitions

Absorption
The process by which the energy of a photon is taken up by an object. For example, an object is red because is absorbs the energy from blue, green and yellow lightwaves but scatters the energy from the red lightwave.

Interference
The result of waves impinging on one another. Constructive interference occurs when the waves are nearly in phase, or when their "peaks" combine; destructive interference occurs when the waves are nearly 180° out of phase, or when the "peaks" cancel out the "troughs" of the waves.

Refraction
When a light ray slows down and changes direction as a result of passing through different mediums – such as water or air.

Scattering
A physical process where light is forced to deviate from a straight trajectory. It occurs when light encounters a rough surface, causing it to be sent off in many different directions.

Wavelength
The distance from the peak of a wave crest to the peak of the subsequent wave crest, or from one trough to the next trough, expressed in units of distance (e.g. km, m, cm, micron, nm).

EXPERIMENTS Want to see how light interacts with your body?

1. Filtering Light with your Finger

What You Need

- Flashlight
- Red, green and blue LED lights (many holiday lights or key chains have colored LED's)
- Room with adjustable lighting

What To Do

1) Darken the room.
2) Place the flashlight under your hand or in your mouth. What do you observe about the resulting glow?
3) Place a finger on each of the LED's. What colors shine through? Is the intensity the same for each color?

Fast Fact

Flashlights give off all the colors of the rainbow, plus some light we cannot see. Why does the glow of the light from your hand look orange/red? What happened to the other colors? Think about all the amazing things in your hand like blood, water, bone, cells, DNA, proteins, fats, sugars and more. Each has specific ways in which it interacts with different colors of light.

By starting with colors we know (red, green and blue), we can reflect them off or pass them through different components of the body and see how the light reacts or changes – the differences tell us something about the tissues. So what can we do with that? Well, we can make very useful tools that quickly and non-invasively tell us about what is going on in our bodies!

2. Passing Infrared Light Through Your Finger

What You Need

- Digital camera with an LCD screen
- TV remote control
- Room with adjustable lighting
- Parent or friend

What To Do

1) Darken the room.
2) Turn on and position the camera so you can see the LCD screen.
3) Hold the remote about 2 inches from camera and push a button. Try pushing different buttons.
4) What do you see? You should see a flash on the LCD corresponding to the location of the LED on your remote.
5) Have your friend put their finger over the LED light on the remote and push a button.
6) What did you observe this time?

Fast Fact

Doctors use a tool called a pulse oxymeter to pass red light and near infrared light, like that coming from your remote control, through your finger. This allows them to measure how much oxygen is in your blood as well as your heart rate. Now, the heart-rate is not that impressive, but telling you the oxygen level sure is! The pulse oxymeter replaced a very painful exam while dramatically decreasing the risk of dying from lack of oxygen on the operating table!

These experiments were provided by Marco Molinaro, Ph.D., Center for Biophotonics Science and Technology, Univ. of California at Davis, http://cbst.ucdavis.edu.

Career Profiles
PEOPLE CHANGING OUR WORLD

Rebecca Richards-Kortum, Ph.D., Rice University, USA

Dr. Rebecca Richards-Kortum specializes in the development and use of laser spectroscopy for diagnosing diseases in human tissue, specifically the early detection of cancer. "We are looking at how well patients and providers accept this technology, and seeing what impact the devices actually have," she says of her research, which currently is focused on finding pre-invasive cervical cancer, and head and neck cancers.

A professor of biomedical engineering and associate chair for research, Richards-Kortum's work grew from a burgeoning interest in math, physics and biochemistry, and her own undergraduate introduction to lab research, first as a freshman and later as a junior at the University of Nebraska.

"I thought I was going to be a high school math teacher, but when I was a freshman, the chairman of the physics department went out of his way to make a spot for me in his lab," she recalls. "I got to do research for a year. It was basic semiconductor physics work. Even though I liked that research, I wanted to do something that would impact humanity in a much more direct way."

"Later, I got the opportunity to work in biochemistry. I wanted to do something that could blend the two, so when I heard about the field of biomedical engineering, I realized that was exactly what I wanted to do," she adds.

As an Howard Hughes Medical Institute Professor, she hopes to give undergraduates the same early exposure to research that influenced her own career, opportunities she believes are rare today in undergraduate education. Moreover, understanding the field of medical technology development is important in order to make informed decisions about personal health care and to contribute to debates about public policy, she says.

Dr. Richards-Kortum is the Stanley C. Moore Professor and Chair of Bioengineering at Rice University. Previously, she held the Cockrell Family Chair in Engineering and was a Professor of Biomedical Engineering at the University of Texas at Austin, where she was also a Distinguished Teaching Professor. After receiving a B.S. in Physics and Mathematics from the University of Nebraska-Lincoln in 1985, she continued her graduate work at the Massachusetts Institute of Technology, where she received an MS in Physics in 1987 and a PhD in Medical Physics in 1990. That same year, she began her academic career at The University of Texas in the Electrical and Computer Engineering Department as an Assistant Professor, (1990), Associate Professor (1995) and Professor (1999). She joined the Department of Biomedical Engineering at UT Austin when it formed in 2001.

More profiles and details on exciting biomedical optics research can be found by visiting the Science News Education section of Howard Hughes Medical Institute website www.hhmi.org.

Nirmala Ramanujam, Ph.D., Duke University, USA

Breast cancer is the most common malignancy among women in the western world and the second leading cause of cancer related deaths among women in the United States. Most patients diagnosed with breast cancer will have surgery with or without radiotherapy to control local disease.

An associate professor in the Department of Biomedical Engineering, Dr. Nirmala Ramanujam is working on optical technologies that will aid in the early detection and excision of breast cancer. By studying and understanding the way light moves through human tissue, she and her team are developing noninvasive optical-based tools to image and characterize human tissue as either "normal" or "cancerous."

Dr. Ramanujam completed all of her educational studies at the University of Texas, Austin, earning a B.S. and M.S. in mechanical engineering, and a Ph.D. in biomedical engineering.

Kevin Rodgers, President, Precision Laser Specialists, USA

Kevin Rodgers is the president of Precision Laser Specialists. Like many people, he was always fascinated by light and optics, and turned that fascination into a career. He began his work in optics and photonics 12 years ago when he graduated from Camden County College (CCC) in Blackwood, New Jersey, with an Associate of Applied Science degree in photonics.

After college, Kevin began working as an optics technician at Quantronics, where he learned the ins and outs of the photonics industry. Today, as president of his own company, he works with diagnostic and treatment laser systems for medical purposes. Kevin's company's focus is on the safety, performance and service of medical and surgical lasers. They have a state-of-the-art, in-house training program that ensures all their technicians have the highest level of knowledge on all lasers that they service.

With Ernie Longo, his fellow CCC graduate and vice president, Kevin spends time traveling, meeting clients and developing new techniques to solve problems in the medical technology field. When asked about his career as an optics technician Kevin says "I feel good about being able to help solve problems with medical systems so that the doctors who use them can in turn help people. I feel like my work is making a difference in the medical world."

Additional OSA Resources for Students, Teachers and Parents

OPTICS: Light at Work

This 15 minute DVD is geared toward 12 and 13 year old students, and is a great resource for raising awareness of optical science, along with its applications and many career opportunities. In addition to introductory information about the science of optics, the video highlights real world applications of optical technology, from everyday items like remote controls, cell phones and bar code scanners, to space exploration, innovations in solar energy and new frontiers in medicine. A variety of career options are highlighted through clips from a diverse group of scientists currently working in the field. Helpful advice and encouragement to students is included throughout.

Laser Technology: Changing Daily Life, Forging New Opportunities

This 42-minute CD-ROM traces the fast-paced history of the laser and includes exciting visual depictions of laser applications. Targeted to high school and post-secondary students, the CD focuses on the characteristics of diode, solid-state and gas lasers and the properties that make them useful in a variety of applications including telecommunications, entertainment, biomedicine and the military.

Optics Discovery Kit

The Optics Discovery Kit provides educators with classroom tools and optics lessons. The kit features 11 experiments that demonstrate basic principles of optics. Components include: lenses, color filters, polarizers, optical fibers, a mirror, a hologram, a diffraction grating and an anamorph. Also included are teacher and student guides. The new updated version will be available January 2008.

Terrific Telescopes Kit

Terrific Telescopes is an education packet based upon the Hands-On Optics (HOO) program. The kit's activities give students the opportunity to learn about the properties of lenses such as the focal length and the "flippoint". The lessons and materials also demonstrate how to use a single lens and other household objects as magnifiers. Students are encouraged to discover how to combine two lenses together to create a simple refracting telescope. The educator-led activities include demonstrations of how light bends and how lenses are used to create colorful images. A teacher's guide with step-by-step instructions is included with the kit.

Optics Suitcases

Developed by the OSA Rochester Local Section, the Optics Suitcase is an innovative, interactive presentation package designed to introduce middle school students to a variety of science concepts. The suitcase provides students with packets of materials that can be taken home to show to friends and family members as a reinforcement of the classroom lessons. To view the Suitcase Teaching Guide, and to read articles about outreach programs that have successfully used these materials, visit: www.opticsexcellence.org.

Educational Website

OSA hosts an educational website for students, teachers and parents. All material is designed to spark students' interest in science. The site features optics experiments, tutorials, demonstrations, games, optical illusions, career profiles, reference materials and more. Visit www.opticsforkids.org to continue your exploration of optics.

For more information about ordering any of these products please contact opticseducation@osa.org.