About the Year of Light

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On 20 December 2013, The United Nations (UN) General Assembly 68th Session proclaimed 2015 as the International Year of Light and Light-based Technologies (IYL 2015).

This International Year has been the initiative of a large consortium of scientific bodies together with UNESCO, and will bring together many different stakeholders including scientific societies and unions, educational institutions, technology platforms, non-profit organizations and private sector partners.

In proclaiming an International Year focusing on the topic of light science and its applications, the United Nations has recognized the importance of raising global awareness about how light-based technologies promote sustainable development and provide solutions to global challenges in energy, education, agriculture and health. Light plays a vital role in our daily lives and is an imperative cross-cutting discipline of science in the 21st century. It has revolutionized medicine, opened up international communication via the Internet, and continues to be central to linking cultural, economic and political aspects of the global society.

An International Year of Light is a tremendous opportunity to ensure that international policymakers and stakeholders are made aware of the problem-solving potential of light technology. We now have a unique opportunity to raise global awareness of this.

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# Why Light Matters

On the most fundamental level through photosynthesis, light is necessary to the existence of life itself, and the many applications of light have revolutionized society through medicine, communications, entertainment and culture. Light and photonics are poised to become key enabling technologies of the future.

## What is Photonics

Photonics is the science and technology of generating, controlling, and detecting photons, which are particles of light. Photonics underpins technologies of daily life from smartphones to laptops to the Internet to medical instruments to lighting technology. The 21st century will depend as much on photonics as the 20th century depended on electronics. This page will contain links and resources to let you learn about photonics and understand its impact on the world.

Photonics is the science of light. It is the technology of generating, controlling, and detecting light waves and photons, which are particles of light. The characteristics of the waves and photons can be used to explore the universe, cure diseases, and even to solve crimes. Scientists have been studying light for hundreds of years. The colors of the rainbow are only a small part of the entire light wave range, called the electromagnetic spectrum. Photonics explores a wider variety of wavelengths, from gamma rays to radio, including X-rays, UV and infrared light.

It was only in the 17th century that Sir Isaac Newton showed that white light is made of different colors of light. At the beginning of the 20th century, Max Planck and later Albert Einstein proposed that light was a wave as well as a particle, which was a very controversial theory at the time. How can light be two completely different things at the same time? Experimentation later confirmed this duality in the nature of light. The word Photonics appeared around 1960, when the laser was invented by Theodore Maiman.

Even if we cannot see the entire electromagnetic spectrum, visible and invisible light waves are a part of our everyday life. Photonics is everywhere; in consumer electronics (barcode scanners, DVD players, remote TV control), telecommunications (internet), health (eye surgery, medical instruments), manufacturing industry (laser cutting and machining), defense and security (infrared camera, remote sensing), entertainment (holography, laser shows), etc.

All around the world, scientists, engineers and technicians perform cutting edge research surrounding the field of Photonics. The science of light is also actively taught in classrooms and museums where teachers and educators share their passion for this field to young people and the general public. Photonics opens a world of unknown and far-reaching possibilities limited only by lack of imagination.

## Energy

The energy from our sun that reaches the Earth can be converted into heat and electricity, and governments and scientists worldwide are working to develop affordable and clean solar energy technologies. Solar energy will provide a practically-inexhaustible resource that will enhance sustainability, reduce pollution and lower the cost of mitigating climate change. This page will contain links and resources to let you learn about the various technologies underlying solar energy, and its benefits for the world and our planet.

Solar energy is produced by harnessing heat from the sun's rays using technologies like solar heating, solar photovoltaics (solar panels) and solar thermal electricity, amongst others. The use of solar energy has increased dramatically over the past decade to pave the way for a cleaner, more sustainable energy future. This technology is used in residential, commercial, agricultural, and even rural areas. Solar energy is becoming a crucial investment for our Earth's future as we face climate change and natural resource shortages worldwide.

Below are several different ways solar energy is utilized.

### Architecture & Urban Planning

Passive solar architecture is used to create well-lit spaces at comfortable temperatures. By orienting buildings properly based on climate and implementing a low surface area to volume, solar architects create energy-efficient homes that rely on almost exclusively on energy from the sun.

### Agriculture & Horticulture

In agriculture and horticulture, solar energy helps to make better use of the sun's energy. Mass storage of solar energy is not just used in large-scale thermal power plants. Greenhouses are the most common application of solar energy in this category and are used to convert solar light to heat in order to grow crops that are not suited to the natural climate in certain areas.

### Transportation

Solar-powered cars are a long-anticipated technological development, but are not yet a reality for the general public. This is not to say that solar-powered cars do not exist. The North American Solar Challenge, for example, has hosted teams competing in designing, building, and driving solar-powered cars for over 20 years. Solar energy is also used in vehicles for auxiliary power applications to reduce fuel consumption.

Passenger boats, aircrafts, and other forms of transportation are also incorporating solar energy. Already, extensive trips (including a 54 hour flight) have been made using solar technology, showing that the future of completely solar-powered transportation is not far off.

### Desalination & Water Recycling

Climate change and droughts, paired with a rapidly increasing world population is driving a rising global demand for freshwater. Water.org estimates that almost 800 million people lack access to clean water. Thermal desalination (ridding seawater and brackish water of salt and impurities) by way of PV systems is one viable option is creating more readily-available freshwater. Solar PV systems can also be used to purify and reuse water. Although reverse osmosis using electrically power pumps is still the preferred method, these applications of solar power are crucial in meeting the needs of our current exponential population growth.

### Solar Thermal

Thermal energy generated by the sun can be used for a multitude of tasks, from cooking to cooling and more. These applications of the sun's energy are both low-tech and very useful.

Solar hot water heaters are used around the world to heat residential homes and especially pools. In residential and commercial areas, solar thermal can be used to supply thermal energy in the form of heating, cooling, and ventilation year-round. Other applications of solar thermal energy include water treatment and solar cookers, both of which are becoming increasingly important in the economic development in rural, off-grid communities.

### Solar Energy & Climate Change

The need for alternative energy has become more and more apparent as the imminent threat of climate change becomes a reality. According to the International Energy Association, technologies such as photovoltaic panels and solar water heaters have the potential to provide up to a third of the world's energy by the year 2060. This projection, which is both bold and plausible, would require international participation in reducing greenhouse gas emission through increased usage of solar energy and decreased reliance on fossil fuels.

Concentration solar power (CSP) systems use mirrors or lenses to concentrate a large area of sunlight onto a small area. The solar thermal energy collected is then converted into heat, which typically powers an electrical power generator. The demand for CSP systems, namely in commercial industries, is on the rise. Despite their hefty price tag, these systems are desirable due to their ability to store electricity.

Developments in photovoltaic (PV) technology and the ability to generate, store, and use electrical energy locally without long-range transmission is bringing about transformational changes in electricity infrastructures. With proper education and financial resources, electricity generation by photovoltaics (solar panels) has the potential to transform the infrastructure in underdeveloped, emerging, and developed economies.

The low cost and reliability of PV is leading to its dominance over other alternative forms of electricity, such as wind energy and concentrated solar power (CSP). However, installation of such alternatives are also increasing rapidly worldwide.

## Economic Impact

Businesses in the field of photonics and light-based technologies work on solving key societal challenges, such as energy generation and energy efficiency, healthy ageing of the population, climate change, and security. Photonic technologies have major impact on the world economy with a current global market of 300 billion EUR and projected market value of over 600 billion EUR in 2020. Growth in the photonics industry more than doubled that of the worldwide GDP (gross domestic product) between 2005 and 2011. This page will contain links and resources to let you learn about the important role that photonics plays in driving economic growth internationally.

### 2013 Photonics Industry Report

The Photonics Industry Report 2013, released by photonics21.org, highlights key industry metrics and changes from 2005 to 2020. It aims to show that the photonics industry is an increasingly important industry on both national and global scales.

Insights for worldwide photonics are shown below. View the downloadable PDF to see the full comprehensive report, including analysis by country and region.

Also view the Multiannual Strategic Roadmap towards 2020, including implementation timelines.

### EU Supporting Photonics (Horizon 2020)

With nearly 80 billion EUR in funding available from 2014-2020, Horizon 2020 is the largest EU Research and Innovation programme ever. Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at creating an innovation-friendly environment that creates economic growth and jobs in the EU. Through a Public Private Partnership (PPP), there is potential to implement in photonics in Horizon 2020. The overarching objectives in implementing a photonics PPP are to foster photonics manufacturing, job and wealth creation in Europe, accelerate Europe's innovation process and time to market, and to mobilize public and private resources. This initiative would address market sectors where the European photonics industry is strong, including materials, equipment, component and devices, integrated systems, and products and solutions.

## Light in the Built Environment

Lighting represents almost 20% of global electricity consumption (International Energy Agency). The future development of society in both developed countries and emerging economies around the world are intimately tied up with the ability to effectively light our cities, homes, schools and recreation areas. This page contains links and resources to let you learn about the innovative lighting solutions that will guide the future of the world.

Lighting provides safety and security, provides access to education, enhances architecture, and improves quality of life. We take it for granted and often notice it only by its absence. As cities worldwide develop, however, it becomes essential to employ new and innovative lighting design techniques and technologies that improve energy efficiency cost and control, and can be adapted easily to local needs. Use the resources below to explore the power of light and it's role in the built environment.

Philips - Learn more about how lighting innovation is improving the quality of people's lives and the environment.

International Association of Lighting Designers - Lighting designers are a resource for innovative, practical and economically viable lighting solutions. Learn more about lighting design and careers in lighting

Global off-Grid Lighting Association - Over one-quarter of the world's population lives without access to electricity. Off-grid lighting addresses this challenge by providing light to those in need. For more information on how GOGLA is helping rural communities, see Study after Sunset.

The International Commission on Illumination - also known as the CIE from its French title, the Commission Internationale de l´Eclairage - is devoted to worldwide cooperation and the exchange of information on all matters relating to the science and art of light and lighting, colour and vision, photobiology and image technology.

UL (Underwriters Laboratories) – UL is a global independent safety science company with more than a century of expertise innovating safety solutions, from the public adoption of electricity to new breakthroughs in energy efficiency and performance testing. Dedicated to promoting safe living and working environments, UL helps safeguard people, products and places in important ways, facilitating trade and providing peace of mind.

## Connecting the World

Social media, low cost telephone calls, video conferencing with family and friends – these are three examples of how the internet allows people around the world to feel connected in a way that has never before been possible in history. And all of this technology is because of light! This page will contain links and resources that will let you understand how it is ultrashort light data pulses propagating in tiny optical fibers the width of a human hair that have created the modern communications infrastructure and the internet that we all use every day.

### What are fiber optics?

Optical fibers are extremely thin, flexible, transparent fiber made of silica or plastic. These hair-like fibers transmit light signals from one end to the other, and over long distances when conjoined end-to-end. Most commonly used in telecommunications, the use of light in fiber optics has revolutionized the way humans interact in the 21st century.

### Why do we use fiber optics?

Unlike wire cables, optical fibers permit transmission over long distances at high bandwidths. Fibers are also used because signals travel through them with less loss than in metal wires, and they are unaffected by electromagnetic interference.

### Uses of fiber optics

Communication: We have optical fibers to thank for providing us the ability to use social media, texting, video-conferencing,the internet itself, and so many other forms of modern communication. When bundled as cables, the fibers allow for long-distance communication because light easily proliferates with little depletion.

Sensors: Optical fibers have many uses in remote sensing. They can be used as sensors to measure strain, temperature, pressure, and other qualities by modifying a fiber so that the property to measure modulates the intensity, phase, polarization, wavelength, or transit time of light in the fiber. Fiber optics sensing is most commonly found in security systems. By placing optical fibers along a boundary such as a fence or property line, a signal monitors disturbances and will trigger an alarm if an intrusion occurs.

Other: Fiber optics is used in many other lesser-known applications. For example, optical fibers can be used to transmit power using a photovoltaic cell to convert light into electricity. They are also used for decorative purposes in signs, art, toys, and artificial Christmas trees.

### History of Fiber Optics - Charles Kao

In 1965, the then young scientist Charles Kao doing an early experiment on optical fibers at the Standard Telecommunication Laboratories in Harlow, U.K.

Charles K. Kao, also known as the "Father of Fiber Optics", is highly regarded for the discovery of fiber optics as a telecommunication medium in the 1960s. Before his pioneering work, glass fibers were widely believed to be unsuitable as a conductor of information. Through his research efforts at Standard Telecommunications Laboratories (STL) in England, Kao and his team discovered that silica glass of high purity is an ideal material for long-range optical communication. Over the years, he has published more than 100 papers, been granted over 30 patents, and received numerous awards. In 2009, Charles Kao was awarded the Nobel Prize in Physics "for groundbreaking achievements concerning the transmission of light in fibers for optical communication".

"The International Year of Light 2015 is a very exciting development. With such huge changes that optical fibers has made to lifestyles and well-being globally in these last fifty years, it is timely to celebrate all the consequences. My husband Charles Kao pushed for many of the same aims of the International Year of Light decades ago, and the timing is now ripe to celebrate his success and the success of the entire field."

Charles' wife, Mrs. Gwen Kao, speaks on IYL2015 and her husband's success

For more information on Charles Kao's contributions to optics and to learn about his background, view his biography.

"Ideas do not always come in a flash, but by diligent trial-and-error experiments that take time and thought."

# Learn About Light

Light is everywhere. It allows to go about our daily activities and provides us with entertainment, security, technological advancements, and healthcare, amongst other things. Discover the different roles light and its applications play in our everyday lives.

## Lasers

Daily activities, from scanning items at a grocery store checkout to playing your favorite CD, require the very precise light lasers provide. This page will contain links to resources that will allow you to explore how laser light differs from regular light, browse a timeline of laser science milestones, and learn about the Nobel Prize winning contributions of the many scientists that made the laser possible.

A laser is an optical amplifier - a device that strengthens light waves. Some lasers have a well-directed, very bright beam with a very specific color; others emphasize different properties, such as extremely short pulses. The key feature is that the amplification makes light that is very well defined and reproducible, unlike ordinary light sources such as the sun or a lamp.

In the fifty years since its discovery, the laser has become an indispensable tool in our daily lives. The laser's many uses stem from its unique properties; for example, the ability to achieve high power while being focused to a pinpoint makes the laser ideal as a precision scalpel in medicine or as a means to slice through thick plates of steel. Other industries reliant on lasers include telecommunications, medical diagnostics, manufacturing, environmental sensing, basic scientific research, space exploration and entertainment. Learn about all the incredible laser innovations over the last 50 years here.

Scientists and engineers continue to find new uses for the laser everyday. Some wide-reaching areas on the horizon for laser technology include improved cancer diagnoses, faster Internet speeds, clean sources of energy, black hole exploration and much more.

Learn more about lasers, their history, and their future at LaserFest.org.

## Lightsources of the world

Light is a key ingredient for large scientific research facilities known as synchrotrons and Free Electron Lasers (FELs). At the heart of one of these giant machines is a particle accelerator which is used to create an incredibly bright light. This light is so intense it can reveal the atomic and molecular detail of the world around us, and is used by scientists the world over for fundamental and applied research into almost every scientific research field imaginable. There are now more than 60 synchrotrons and FELs around the world dedicated to applications in physics, engineering, pharmacology, and new materials, to name but a few. You can browse these pages for information and links to resources that will allow you to explore the remarkable properties of these magnificent machines.

### Revealing the world around us

Scientists use synchrotron light to study a vast range of subject matter, from new medicines and treatments for disease to innovative engineering and cutting-edge technology.

Whether it is fragments of ancient paintings or unknown virus structures, scientists can study their samples using a machine that is 10,000 times more powerful than a traditional microscope.

Synchrotrons are amongst the most advanced scientific facilities in the world, and their pioneering capabilities are helping us to find answers to some of the most challenging problems facing us today.

Find out where synchrotron light can make a difference...

### A spectrum of possibilities

'Light' refers to the breadth of the electromagnetic spectrum, which includes visible light, as well as light with wavelengths that we cannot see such as: radio waves, microwaves, infrared, ultraviolet, X-rays, and gamma rays. These different types of light are used in everyday life, however. For example, airport scanners use X-rays to inspect the contents of your suitcase.

The right kind of light and the right equipment can help us see things in much finer detail than the human eye could possibly make out. This capability holds the key to answering some of the fundamental questions about the world around us, such as: what is our planet made from? What are the processes that sustain life? How can we conquer viruses?

These questions can only be answered at the molecular level, and this is where lightsources come in.

### Where in the world?

Visit lightsources.org to find your nearest light source. This dedicated website is the result of collaboration between communicators from light source facilities around the world, and is a regularly updated global resource providing information and updates about light sources, and opportunities for international collaboration.

### What are they used for?

The light produced by synchrotrons can be used in almost any field of scientific research. Its high brilliance, high intensity, sharp focus and tunability gives it advantages over conventional techniques. In the pages below you will find a wide range of applications and case studies where synchrotron light has played a key role in discovery.

Göttingen-based scientists working at DESY's PETRA III research light source have carried out the first studies of living biological cells using high-energy X-rays. The new method shows clear differences in the internal cellular structure between living and dead, chemically fixed cells that are often analysed. "The new method for the first time enables us to investigate the internal structures of living cells in their natural environment using hard X-rays," emphasises the leader of the working group, Prof. Sarah Köster from the Institute for X-Ray Physics of the University of Göttingen.

#### Researchers find novel approach for controlling deadly C. difficile hospital infections

Using data collected at the Canadian Light Source, researchers have revealed the first molecular views showing how antibodies derived from llamas may provide a new method for controlling the highly infectious disease C. difficile, common in health-care facilities.

One of the most problematic hospital-acquired infections worldwide, C. difficile (Clostridium difficile) is an opportunistic bacterial pathogen that causes extreme diarrhea and potentially fatal colon inflammation. This new research provides exciting opportunities for creating a new generation of engineered antibodies that will be more effective at preventing the toxins from damaging the intestine during the normal course of the disease.

#### The interaction of asbestos and iron in lung tissue revealed by synchrotron-based scanning X-ray microscopy

Asbestos fibres are known as a potent carcinogen associated with malignant mesothelioma and lung cancer, but the reasons for their toxicity and carcinogenic mechanisms are still unclear. Most often, the toxicity is ascribed to the specific physico-chemical characteristics of asbestos and, in particular, to its ability to adsorb iron that may cause an alteration of iron homeostasis in the tissue.

Using a combination of advanced synchrotron-based X-ray imaging and micro-spectroscopic methods representative tissue samples from ten patients exposed to asbestos (from shipyard workers in Monfalcone) have been studied obtaining important correlative morphological and chemical information for the chemistry of asbestos body formation and other changes in the surrounding lung tissue that cannot be obtained using conventional techniques.

#### Energy

Synchrotrons are a vital tool in helping to meet global energy challenges, offering scientists a vast portfolio of the latest R&D techniques and innovations to tackle a wide range of energy research. With our reserves of fossil fuels in decline, we must learn how to use them more efficiently and effectively in industry, domestic applications and transport systems. Additional challenges include producing cleaner, safer and more affordable energy from renewable alternatives such as biofuels, solar and nuclear power, and developing novel materials and technologies for carbon-capture and fuel-gas storage systems. Meeting these challenges is vital both to help us achieve a low-carbon energy economy and to conserve our natural resources and protect our environment.

##### Watching Solar Cells Grow

For the first time, a team of researchers at the HZB has managed to observe growth of high-efficiency chalcopyrite thin film solar cells in real time and to study the formation and degradation of defects that compromise efficiency. To this end, the scientists set up a novel measuring chamber at the Berlin electron storage ring BESSY II, which allows them to combine several different kinds of measuring techniques. Their results show during which process stages the growth can be accelerated and when additional time is required to reduce defects. Their work has now been published online in Advanced Energy Materials.

##### Making more efficient fuel cells

Using high-brilliance X-rays, researchers track the process that fuel cells use to produce electricity, knowledge that will help make large-scale alternative energy power systems more practical and reliable.

##### Scientists discover how to build cheaper, more efficient fuel cells

Using the Canadian Light Source (CLS) synchrotron, researchers have discovered a way to create cheaper fuel cells by dividing normally expensive platinum metal into nanoparticles (or even single atoms) for use in everything from automobiles to computers.

A team led by Western University, and in collaboration with McMaster University, the CLS synchrotron, and Ballard Power Systems Inc., has developed a method of utilizing atomic layer deposition (ALD). This surface science technique is used for depositing chemical compounds, to create single atom catalysts. This is a major boon for the three-headed battle against global energy demands, depletion of fossil fuel reserves, and environmental pollution problems.

##### Postcards from the Photosynthetic Edge

Photosytem II utilizes a water-splitting manganese-calcium enzyme that when energized by sunlight catalyzes a four photon-step cycle of oxidation states (S0-to-S3). When S3 absorbs a photon, molecular oxygen (O2) is released and S0 is generated. S4 is a transient state on the way to S0.

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A crucial piece of the puzzle behind nature's ability to split the water molecule during photosynthesis that could help advance the development of artificial photosynthesis for clean, green and renewable energy has been provided by an international collaboration of scientists. Working at SLAC's Linac Coherent Light Source (LCLS), the world's most powerful x-ray laser, the researchers were able to take detailed "snapshots" of the four photon-step cycle for water oxidation in photosystem II, a large protein complex in green plants. Photosystem II is the only known biological system able to harness sunlight for the oxidation of water into molecular oxygen.

##### Solar cell degradation observed directly for the first time

Researchers of Technische Universität München have, for the first time, watched organic solar cells degrade in real time. This work could open new approaches to increasing the stability of this highly promising type of solar cell.

Organic solar cells, especially those based on polymers are inexpensive to produce on a large scale. Thanks to their physical flexibility, they can open up new applications of photovoltaics not possible today. Moreover, they can convert light into electricity at an efficiency of more than ten per cent and could contribute significantly to a large-scale power supply based on renewable sources. However, the efficiency of organic solar cells still rapidly declines and they have a shorter service life than conventional silicon cells.

#### Environmental Sciences

Synchrotron based techniques have made a major impact in the field of environmental science in the last ten years. High resolution allows the study of ultra-dilute substances, the identification of species and the ability to track pollutants as they move through the environment. Synchrotrons are playing an important role in monitoring and predicting the effects of human activities on local and global environments. This knowledge will enable the development of strategies to reduce our overall environmental impact.

##### What amphibians tell us about arsenic levels in the environment

Amphibians living in an old mine tailings site near Upper Seal Harbour, Nova Scotia, show high levels of arsenic after being tested using synchrotron light, leading scientists to believe these animals could be the canary in the coal mine for monitoring fresh water sites and understanding health concerns with arsenic in the environment.

Groundwater arsenic contamination is an international health concern. Many countries including Bangladesh, India, Nepal, and China are dealing with widespread contamination issues in their population.

In this study, samples were collected from two different species of frogs and toads, as well as water samples from the Nova Scotia site, to find out how arsenic is absorbed in the environment.

##### X-rays Track Tree-Ring Growth Anomalies

Experts Charlotte Pearson and Sturt Manning, from the Cornell Tree-Ring Laboratory, worked with CHESS staff using X-ray fluorescence to record the chemical composition of individual tree-rings for historical data. Samples of Juniper wood were borrowed from the Aegean Dendrochronology Project archives to study the growth anomalies seen at relative ring 854. X-ray maps of sulfur and zinc concentrations provide direct evidence, for the first time, that the growth anomaly might be caused by volcanic activities attributed to the Minoan eruption of Thera mid-late 17th century BC. The timing of this eruption is important because it is believed to be a key event leading to the rise of ancient Greece.

##### Volcanoes can damage the ozone layer

In the 1980s, atmosphere researchers discovered that the ozone layer in the stratosphere was very thin in some areas. The cause for this "ozone hole" was ozone depleting hydrochlorofluorocarbons manufactured in large amounts for several industrial products, and released into the atmosphere. However, there are ozone killing sources also in nature. Scientists from GEOMAR Helmholtz Centre for Ocean Research Kiel and DESY in Hamburg found that giant volcanic eruptions may have large amounts of ozone depleting gases.

#### Life Sciences

Pharmaceutical companies and academic researchers are making increasing use of a synchrotron technique called macromolecular crystallography, which is used to solve the 3D structure of important biomolecules such as proteins. Chemists and structural biologists use this method to work together in the development of promising compounds into drug candidates.

Synchrotrons can also help us to better understand diseases which involve a change in the fold of a protein, so that the protein becomes pathogenic (for example Creutzfeld-Jacob-Desease (CJD), Alzheimer's Disease, BSE).

##### New foot-and-mouth vaccine signals huge advance in global disease control

Scientists have developed a new methodology to produce a vaccine for foot-and-mouth disease virus (FMDV). Because the vaccine is all synthetic, made up of tiny protein shells designed to trigger optimum immune response, it doesn't rely on growing live infectious virus and is therefore much safer to produce.

Furthermore, these empty shells have been engineered to be more stable; making the vaccine much easier to store and reducing the need for a cold chain. This is important research because it represents a big step forward in the global campaign to control FMDV in countries where the disease is endemic, and could significantly reduce the threat to countries currently free of the disease. Crucially, this new approach to making and stabilising vaccine could also impact on how viruses from the same family are fought, including polio.

##### Research Reveals Rapid DNA Changes that Act as Molecular Sunscreen

The molecular building blocks that make up DNA absorb ultraviolet light so strongly that sunlight should deactivate them - yet it does not. Now scientists have made detailed observations of a "relaxation response" that protects these molecules, and the genetic information they encode, from UV damage. The experiment at the U.S. Department of Energy's SLAC National Accelerator Laboratory focused on thymine, one of four DNA building blocks. Researchers hit thymine with a short pulse of ultraviolet light and used the LCLS' powerful X-ray laser to watch the molecule's response: A single chemical bond stretched and snapped back into place within 200 quadrillionths of a second, setting off a wave of vibrations that harmlessly dissipated the destructive UV energy.

##### The malaria parasite under a super microscope

An international team of scientists has decoded two key proteins of the malaria parasite Plasmodium, using DESY's bright X-ray source PETRA III and other facilities. The results shed light on the workings of Plasmodium's structural proteins actin I and actin II, without which the parasite cannot infect human cells. The project led by Prof. Inari Kursula from the new Centre for Structural Systems Biology (CSSB) on the DESY campus may contribute to the development of tailor-made drugs against malaria.

##### Fatty Acid Biosynthesis Caught in the Act

Fatty acids are key components of a variety of biological functions ranging from cellular membranes to energy storage. In addition, they are of great interest as potential "green" biofuels and targets in the development of novel antibiotics. In order to fully exploit their potential, researchers must first understand in detail how organisms synthesize fatty acids. However, due to the dynamic nature of the process, structural and functional studies of fatty acid biosynthesis are very challenging. A team of scientists has recently made a giant leap forward by determining the structure of a protein-protein complex that represents a snapshot of fatty acid biosynthesis in action.

#### Engineering

Facilities unique in the world are available for the detailed study of engineering and manufacturing. Synchrotron light allows for detailed analysis and modelling of strain, cracks and corrosion as well as in situ study of materials during production processing. This research is vital to the development of high performance materials and their use in innovative products and structures.

##### Brighter LED Displays

Collaborative work between researchers from the Chemistry Department of the University of Florida and the Cornell High Energy Synchrotron Source (CHESS) at Cornell University has resulted in novel way to make colloidal superparticles from oriented nanorods of semiconducting materials. The resultant superparticles exhibit enhanced light emission and polarization, features that are important for fabrication of LED televisions and computer screens. The nucleated superparticles can further be cast into macroscopic polarized films. Using currently available manufacturing techniques, these films promise to increase efficiency in polarized LED television and computer screen by as much as 50%.

##### Scientists watch nanoparticles grow

With DESY's X-ray light source PETRA III, Danish scientists observed the growth of nanoparticles live. The study shows how tungsten oxide nanoparticles are forming from solution. These particles are used for example for smart windows, which become opaque at the flick of a switch, and they are also used in particular solar cells.

##### Electron beam instrumentation for FELs

Frontier fast dynamics science is strongly founded on accelerator-based pulsed photon sources. The longitudinal electron bunch properties play a crucial role to guarantee high performance of the most advanced accelerator-based facilities. Advanced instrumentation have been designed to control picosecond and sub picosecond electron bunch duration. The simplest and most robust bunch length diagnostics are based on the measurement of coherent radiation power and they are used in existing accelerators to measure the relative variation of the bunch length non-destructively and shot by shot. The resulting information is used in bunch length control feedback loops. The drawback is that for an absolute estimation of the bunch length, external instrumentation like a transverse RF deflecting cavity is usually needed.

#### Palaeontology

Synchrotron light has been long used in paleontology. Many fossils are analyzed with X-ray microscope to view the interior of precious specimens without cracking them. Three-dimensional tomography can be reconstructed to visualize the details inside these fossils.

##### Revealing the healing of Dino-sores

Scientists have used state-of-the-art imaging techniques to examine the cracks, fractures and breaks in the bones of a 150 million-year-old predatory dinosaur.

The University of Manchester researchers say their groundbreaking work sheds new light, literally, on the healing process that took place when these magnificent animals were still alive.

The research took advantage of the fact that dinosaur bones occasionally preserve evidence of trauma, sickness and the subsequent signs of healing. Diagnosis of such fossils used to rely on the grizzly inspection of gnarled bones and healed fractures, often entailing slicing through a fossil to reveal its secrets. But the synchrotron-based imaging meant the team could tease out the chemical ghosts lurking within the preserved dinosaur bones.

##### Diving Deep Into Dinosaur Pigment

For the first time, scientists have decoded the full-body color patterns of a dinosaur. Scientists are hoping to use this improved knowledge of dinosaur coloration to better understand how some prehistoric animals behaved and why feathers evolved in the first place.

The subject of this study—the 155-million-year-old Anchiornis huxleyi—turns out to have looked something like a woodpecker the size of a chicken, with black-and-white spangled wings and a rusty red crown.

The team behind the new study determined the feather colors by analyzing the shape and density of melanosomes within fossil feathers. Melanosomes are nanoscale, pigment-bearing organelles within feathers.

##### Organic Remains in Fossil Embryo of a Dinosaur

Synchrotron light has been used to discover the earliest fossil embryos from China. The specimin was confirmed as the oldest evidence of preservation of organic remains in situ in a fossil.

The fossil was found in a monotaxic bone bed near Dawa, Lufeng County, Yunnan Province, China. Such a monotaxic bone bed allows scientists to study the development and growth of a single species. The bone bed is dated from the Early Jurassic (Sinemurian) period, about 190-197 million years ago, temporally equivalent to the oldest known dinosaurian embryos preserved in South Africa.

#### Chemistry

Synchrotron light has a wide range of applications in chemical research. In the investigation of new materials, the finely tuned X-ray beams are able to accurately determine the structure of single-molecule crystals. This is a crucial factor not only in the characterisation of a new compound but it is also for our understanding of the properties of a material.

Solid state chemistry is beginning to be explored under extreme conditions at synchrotron facilities, helping to predict new materials and their properties.

Synchrotrons also allow the study of the microstructural changes that occur on deformation of polymers. By studying the behaviour of the material at different stages of degradation we are able to map the relationships between microstructure, degradation and ultimate mechanical response. This enables rational design of microstructure for desired properties.

##### Scientists Take First Dip into Water's Mysterious 'No Man's Land'

Scientists at the Department of Energy's SLAC National Accelerator Laboratory have made the first structural observations of liquid water at temperatures down to minus 51 degrees Fahrenheit, within an elusive "no man's land" where water's strange properties are super-amplified.

The research, made possible by SLAC's Linac Coherent Light Source (LCLS) X-ray laser and reported June 18 in Nature, opens a new window for exploring liquid water in these exotic conditions, and promises to improve our understanding of its unique properties at the more natural temperatures and states that are relevant to global ocean currents, climate and biology.

##### Salty surprise - ordinary table salt turns into "forbidden" forms

High-pressure experiments with ordinary table salt have produced new chemical compounds that should not exist according to the textbook rules of chemistry. The study at DESY's X-ray source PETRA III and at other research centres could pave the way to a more universal understanding of chemistry and to novel applications.

#### Material Science

Material Science represents a wide field of research and the micro-structural characterisation of materials is needed in order to better understand the main phenomena that occur during the forming or during the use of a material. The microstructure characterisation must be carried out at the relevant scale, depending on the scientific problem. Synchrotron X-ray techniques are unique to achieve spacial resolution below the micron. The prediction of the performance of building materials exposed to aggressive environments is economically and technically important. Only by understanding the mechanisms behind the degradation can the right curative or preventive action be taken.

##### Stronger than steel: Scientists spin ultra-strong cellulose fibres

A Swedish-German research team has successfully tested a new method for the production of ultra-strong cellulose fibres at DESY's research light source PETRA III. The novel procedure spins extremely tough filaments from tiny cellulose fibrils by aligning them all in parallel during the production process.

"Our filaments are stronger than both aluminium and steel per weight," emphasizes lead author Prof. Fredrik Lundell from the Wallenberg Wood Science Center at the Royal Swedish Institute of Technology KTH in Stockholm. "The real challenge, however, is to make bio based materials with extreme stiffness that can be used in wind turbine blades, for example. With further improvements, in particular increased fibril alignment, this will be possible."

##### Scientists Watch High-temperature Superconductivity Emerge out of Magnetism

Scientists at SLAC National Accelerator Laboratory and Stanford University have shown for the first time how high-temperature superconductivity emerges out of magnetism in an iron pnictide, a class of materials with great potential for making devices that conduct electricity with 100 percent efficiency.

The results are an important step toward understanding how high-temperature superconductors work – information scientists need to realize their dream of engineering superconductors with more useful properties that operate at close to room temperature for a variety of practical applications.

##### Temperature Driven Reversible Rippling and Bonding of a Graphene Superlattice

Graphene on Ir(100), a support with square symmetry, provides a remarkable model for investigating the intriguing physics of the metal-graphene interface. In our study on this system, we discovered distinct flat and buckled graphene phases on that coexist at room temperature, forming stripe-shaped domains which relieve the strain accumulated after cooling the film below growth temperature. In the buckled phase, a small fraction of the carbon atoms chemisorbs to the substrate, originating a textured structure with exceptionally large one-dimensional ripples of nm periodicity. Our results unravel the complex interplay between film and support, disentangling the effects of the film configuration and substrate interaction on the quasi-particle dispersion.

#### Earth Science

Synchrotrons are increasingly useful in Earth Science applications. The high energy X-rays enable the study of the physics and chemistry taking place in the extreme conditions that occured during the formation of the solar system and in the interior of planets. Microfocus spectroscopy on samples such as meteorites and comet dust provide information on the environment in which they formed. Powder diffraction studies enable the mineralogical community to investigate the behaviour of naturally occurring materials and the subtle responses of known structures to changes in temperature, applied stress and chemical variations.

##### X-rays reveal inner structure of the Earth's ancient magma ocean

Using the world's most brilliant X-ray source, scientists have for the first time peered into molten magma at conditions of the deep Earth mantle. The analysis at DESY's light source PETRA III revealed that molten basalt changes its structure when exposed to pressure of up to 60 gigapascals (GPa), corresponding to a depth of about 1400 kilometres below the surface. At such extreme conditions, the magma changes into a stiffer and denser form, the team around first author Chrystèle Sanloup from the University of Edinburgh reports in the scientific journal Nature. The findings support the concept that the early Earth's mantle harboured two magma oceans, separated by a crystalline layer. Today, these presumed oceans have crystallised, but molten magma still exists in local patches and maybe thin layers in the mantle.

##### Advancements in Uranium-driven Energy

Clean electricity generated from uranium is estimated to reduce carbon dioxide emissions by 2.5 billion tonnes a year. Now, scientists working at the Canadian Light Source are working to make uranium use even cleaner.

Uranium today provides almost a fifth of the world's electricity, and it is an incredibly useful element . Saskatchewan is at the hub of the world's uranium production, and hosts the largest mine in the world at McArthur River.

Ensuring that mining sites and their surroundings remain clean and healthy is an important focus for Saskatchewan mining companies and researchers alike. Luckily, natural wetlands at many mining sites may help sequester uranium tailings. Researchers are interested in understanding and enhancing this process in order to make nuclear power generation even cleaner and safer for the environment.

##### Illuminating the Puzzle of Asteroid Itokawa

Researchers have uncovered the dramatic early history of the small asteroid Itokawa by analyzing tiny granular samples returned to Earth by JAXA's Asteroid Explorer Hayabusa. The team analyzed 38 tiny grains of Itokawa samples brought back to Earth, using X-ray diffraction and high-resolution electron microscopy. Major minerals identified in Itokawa samples are: olivine, low-Ca pyroxene, high-Ca pyroxene, and plagioclase. Less abundant but common minerals are: troilite, taenite, and chromite. This suggests that Itokawa is similar in mineral composition to chondrite meteorites, the oldest and most primitive material in the solar system.

#### Physics

Determining the properties and morphology of buried layers and interfaces is an important area in solid-state science with synchrotrons being the meeting ground of state-of-the-art theory and high-precision experimental results. The wolrd's first dedictaed synchrotron was used to help study giant magneto-resistance (GMR), which is now used in billions of electronic devices worldwide.

##### Superconductor discovery an advancement for technology

Scientists have discovered a universal behavior in copper-based (cuprate) superconductors, paving the way for a crucial advancement in understanding and development of these fascinating materials that will have implications on everything from producing smaller, more efficient MRI machines to making better power lines.

The international team found that the so-called charge-density-waves – spatial modulations of the electronic density in a crystal – are the same in all cuprate compounds.

##### Emerging research suggests a new paradigm for "unconventional superconductors

Superconductivity in so-called unconventional superconductors, for example copper-oxide, iron-arsenide and iron-selenide high-temperature superconductors, is nearly always found in the vicinity of another ordered state, such as antiferromagnetism, charge density wave (CDW), or stripe order. This suggests a fundamental connection between superconductivity and fluctuations in some other order parameter.

A team of scientists has reported that emergence of superconductivity in the CDW system TiSe2 coincides with a quantum critical point (QCP) at which the CDW phase transition temperature goes to zero, suggesting TiSe2 exemplifies the universal phenomenon of superconductivity emerging near suppression of an ordered state.

##### First laser-like X-ray light from a solid

Researchers have for the first time created an X-ray laser based on a solid. The method developed at DESY's free-electron laser FLASH opens up new avenues of investigation in materials research, as reported by the team of Prof. Alexander Föhlisch of the Helmholtz Zentrum Berlin (HZB) in the British scientific journal "Nature." "This technology makes it possible to analyse sensitive samples that otherwise are quickly destroyed by intense X-ray light," notes co-author Prof. Wilfried Wurth of the University of Hamburg and the Hamburg Center for Free-Electron Laser Science (CFEL), a collaborative effort by DESY, the Max Planck Society and the University of Hamburg.

##### One pulse good, two pulses better

Two-pulse two-colour free-electron laser provide a self-standing source for pump-probe experiments.

Understanding the exotic properties of matter driven to extreme non-equilibrium states by interaction with very intense VUV/X rays, has become possible with the advent of ultrabright free electron lasers (FEL). Development of different photon correlation schemes, with temporal and spatial resolution determined only by the FEL pulse duration and wavelength, are key steps towards accessing ultra-fast dynamic phenomena.

The dynamics is initiated by the first "pump" pulse, which generates carriers at time scales shorter than carrier diffusion and electron-phonon scattering. The evolution of the transient states is then monitored by a second "probe" pulse arriving at variable and defined time delay. Tuning the pulse wavelengths to atomic resonances opens an unprecedented opportunity to add selectively elemental sensitivity to the mesurement, which is essential for exploring ultrafast processes in morphologically complex multicomponent materials.

### How do they work?

Lightsources can be compared to a 'super microscope', by providing intensely bright forms of X-ray, infrared and ultraviolet light, which enables research on samples in the tiniest detail. Each range of light is suited to a particular job.

To 'see' atoms, we need to use a form of light that has a much shorter wavelength than visible light. As a general rule, short-wavelength (hard) X-rays are most useful for probing atomic structure. Again as a general rule, long-wavelength (soft) X-rays and ultraviolet light are good choices for studying chemical reactions. Infrared is ideally suited to studying atomic vibrations in molecules and solids, and at its very long wavelength end (terahertz waves), it is also useful for certain types of electronic structure experiments. The identification of elements in samples is the province of X-rays.

This range of the electromagnetic spectrum is known as 'synchrotron light', as it is produced by a dedicated synchrotron machine. A synchrotron light source typically begins with an electron gun, containing a manmade material, to which an electrical and thermal current is applied. This results in electrons 'lifting off' and beginning their journey by being propelled down a linear accelerator (linac). They then enter a circular-shaped booster ring, where they are accelerated to relativistic speeds. Finally they enter another ring, often called a 'storage ring', where they circulate for hours. The electrons will travel in a straight line, so at points around the ring, special 'bending' magnets help them keep to their circular path. As the electrons circulate, powerful magnets keep them bunched together and focused.

Synchrotron light is produced when the electrons change direction around the ring. In synchrotrons, this happens when they are manipulated by bending magnets, or as they pass through insertion devices. At the points where the electrons change direction, they emit a fan of radiation (known as synchrotron light). This radiation branches off the storage ring, and enters laboratories, or 'beamlines'. Here it is refined with devices such as monochromators and mirrors, before it is shone on the sample, enabling researchers to obtain detailed data about the sample's structure and behaviour.

The moving graphic below (courtesy Diamond Light Source) gives a demonstration of the electrons (in red) starting in the linac and speeding around the booster synchrotron and storage ring, where the synchrotron light (in blue) is produced. The team at the Swedish synchrotron, MAX IV Laboratory, have created a friendly animation to help explain how synchrotron light is created: watch the video.

### Where did they come from?

The history of synchrotrons can be traced back to 1873, when James Clerk Maxwell published his theory of electromagnetism; this theory changed our understanding of light. Some years later in 1895, Wilhelm Rontgen expanded on Maxwell's theory and identified X-ray light, and by 1906 Charles Barkla had discovered that X-rays could be used as a tool to determine the elements present in gases. In 1912 Max von Laue found another use for X-rays: the beams could help to identify the structure of very small matter, like atoms, based on their crystal structure. In 1913, William Henry and Lawrence Bragg, a father and son team, solved the formula for determining an object's structure based on the pattern formed by X-rays passing through it. The Braggs' discovery opened up the field of crystallography, making it possible to investigate the atomic nature of our world.

The first synchrotron, built in 1946, was designed to study collisions between high energy particles. In this role they were very successful, and the Large Hadron Collider at CERN is still dedicated to this purpose. But scientists soon noticed that these machines also had a by-product: they generated very bright light.

In 1956, the first experiments were carried out using synchrotron light siphoned off from a particle collider at Cornell in the USA. Over the years, the number of experiments using synchrotron light increased, but the scientists still had to use the light that was a by-product of particle collider machines; there was no dedicated synchrotron light source. This changed in 1980, when the UK built the world's first synchrotron dedicated to producing synchrotron light for experiments at Daresbury in Cheshire, UK. Now there are over 40 large synchrotron light sources around the world. These scientific facilities produce bright light that supports a huge range of experiments with applications in engineering, health and medicine, cultural heritage, environmental science and many more.

## Light in Nature

From sunsets to rainbows, from the blues and greens of the ocean to the remarkable range of colors of plants and animals, our first experiences of light and color are through what we see in the natural world. This page will contain resources and links to images so that you can see for yourself the wonderful range of light and color in the natural world and understand the science behind it.

### Rainbows

A rainbow is a beautiful natural phenomena that occurs when drops of rainwater meet sunlight. The multi-color arch is produced by a fundamental process called refraction, or the "bending" of light. In optics, refraction is a phenomenon that often occurs when waves travel from a medium with a given refractive index to a medium with another at an oblique angle.

### Sunsets

Perhaps one of the most frequently occurring visual displays of light in nature, sunsets are also a result of refraction. In astronomy, sunset is the point when the trailing edge of the Sun's sphere disappears below the horizon. The brilliant array of colors that appear in the sky during sunset are created by scattered airborne particles passing through rays of white sunlight traveling through the atmosphere. Because the evening air contains more particles than morning air, sunsets are typically more radiantly colored than sunrises.

### Photosynthesis

The process that converts energy in sunlight to chemical energy used by green plants and other organisms is called photosynthesis. Although it is performed differently by different species, the process always begins when energy from light is absorbed by proteins called reaction centers that contain green chlorophyll pigments. A seemingly simple process, photosynthesis is actually quite complex and is the basis by which we grow all of our food and produce important resources such as fossil fuels.

### Northern Lights

Also known as the Aurora Borealis, the Northern lights is a natural light display that occurs in the sky in the arctic (northernmost) region on Earth. In fact, auroras be seen all over the world, but occur most frequently in high altitude regions. Caused by the collision of solar wind and magnetospheric charged particles with the high altitude atmosphere, most auroras occur in a band known as the auroral zone.

## Art and Culture

Paintings and murals in all cultures of the world show how artists have used light and shade and color to illustrate mood and create atmosphere. Modern technological possibilities allow artists to use light in new ways in entertainment and performance, and large scale lighting installations can dramatically highlight the beauty of architecture. This page will provide resources to allow you to see the many different ways in which light impacts on art and culture, and it will also describe how the scientific uses of light provide new insights into the study of our past.

### Laser Light Shows

From concerts to theme parks, laser light shows entertain audiences of all ages. The precision and strength of lasers allow for light to illuminate crowds, create designs on infrastructures, and can even be seen in the night sky.

### Stained Glass

One of the oldest example of light in art, stained glass dates back to the fourth century. This form of art relies on natural light to illuminate it's brilliance and great detail. Most commonly, stained glass windows include art depicting biblical stories and can be found in churches and other significant buildings.

### Photography and Cinematography

Light is essential in producing photos and film. In photography, lighting can be the difference between an incredible shot and a terrible one. It can also be used to produce photographs in darkrooms, wherein photographers can manipulate light during exposure and use processing chemicals to create a desired effect.

In cinematography, light is necessary to create an image exposure on a frame of film or on a digital target. The art of lighting for cinematography goes far beyond basic exposure, however, into the essence of visual storytelling. Lighting contributes considerably to the emotional response an audience has watching a motion picture.

### Theater and Dance

In live performances, effective lighting is so important that it typically warrants a working crew, commonly known as lighting technicians. Stage lighting in performance arts pieces not only allows the audience to see what's happening on stage, but can also be used to set the tone, direct focus, or alter one's position in time and space.

Lighting design is a highly technical field and involves manipulating luminaires to find the appropriate intensity, color, direction, focus, and position. In both theater and dance, light plays a tremendous role in developing the plot of performances and evoking emotion within the audience.

### Architectural Illumination

With advancements in LED technology, building illumination has become a common form of light art. Displays on buildings and even major landmarks are executed for both celebratory and advertising purposes. These spectacular visuals involve digitized images shown on a building's surface and may range anywhere from 2D to 4D. Building illumination may also refer to the decorative or functional lighting of any architectural structure. For more information on this, see Light in the Built Environment.

### Art Restoration

The semi-controversial process of art restoration and conservation involves using various methods to preserve the artwork for posterity. Because art is a strong link to history and cultures of the past, this process involves following international ethical guidelines so as not to tarnish or destroy any works of art. Modern conservation laboratories use light-based scientific equipment such as microscopes, spectrometers, and x-ray instruments to better understand object and their components. The data collected from such inspections help in deciding the conservation treatments necessary.

## Light in Life

Through photosynthesis, light is at the origin of all life. Photonic technologies provide new tools for doctors and surgeons, new developments in optometry and vision science improve quality of life, and light-based technologies are used every day in medical diagnostics in ways that we are often unaware of. This page will contain links to resources that will allow you to understand how light science and light technologies impact on medicine, vision and life sciences in general.

### Medicine

Breakthroughs in light technology continue to revolutionize the medical industry. Medical imaging, surgical procedures, and even diagnoses rely upon the use of light.

Medical imaging is the process of creating visual representations of the interior of a body for further medical analysis. Such imaging is generally used in medical fields such as neuroscience, cardiology, psychiatry, and psychology, amongst others. Common applications include CT (computed tomography) scans, MRIs (magnetic resonance imaging), ultrasounds, and X-rays (a form of radiography).

With the invention of the laser just over 50 years ago, the role of light in medical procedures has grown immensely. Lasers are especially crucial in dermatology (skin), ophthalmology (eyes), and dentistry due to their precision and high power density. In fact, lasers are now widely used for common procedures such as tumor, tattoo, hair, and birthmark removal. Eye surgery and other surgical procedures now also use the power of lasers rather than invasive methods of the past.

More recently, light applications - specifically lasers - have been used in medical diagnosis due to their non-invasive properties. Routine diagnostics such as tissue oxygenation, early detection of tumors by fluorescence, and early detection of dental cavities are all performed by laser-based medical apparatus.

### Life sciences

Light is crucial in exploring the fundamentals of life and our surrounding environment. The overarching fields of physical and natural sciences rely on photonics technology to explore and better understand our world.

Physical science includes physics, astronomy, chemistry, and earth science, and has led to our understanding of far-reaching concepts such as matter, gravity, origins of the Universe, molecular structure, and meteorology. Natural sciences, on the other hand, explore nature's phenomena and how the Universe works. Branches of natural science include biology, chemistry, physics, astronomy, and earth sciences. Biology especially depends on light sciences to further research concepts such as molecular biology.

Across the board, instruments developed through light technology are used frequently in life sciences. Found both in both research labs and classrooms, microscopes are used for viewing objects too small to be seen by the naked eye. On the other end of the spectrum, telescopes are instruments that help us to see distant objects in space in order to view and understand the Universe. Technology such as high resolution cameras, laser microdissection, and molecular probe development all aid in the understanding of our natural environment.

### Vision

It is said that the eyes are the windows to the soul; however, it is optics and photonics that play a major role in studying the eye. Optics and vision go together and optical and photonics technologies are used to examine, correct, and test normal and abnormal vision. These include the whole gamut from simple eyeglasses all the way to laser correction, photodynamic therapies, low vision aids and retinal implants to enable the blind to see. Optics and photonics has enabled the development of sophisticated devices such as optical coherence tomography, photorefraction, LASIK techniques, etc.

There is also a great need for mobile technologies – that is using inexpensive smartphone technologies and building inexpensive, lightweight optics/photonics based attachments to detect air pollution levels, malaria in blood cells, allergens in food, etc. In terms of vision it is possible to devise apps and add-on devices to detect /diagnose blinding diseases such as age related macular degeneration, refractive correction, and other abnormalities in the field, especially in developing countries and be able to perform telemedicine.

To learn more about how optics and photonics are shaping the way we live and see, view the following resources:

* Smartphone Add-On for Eye Tests
* Smartphones Set to Revolutionize the Medical World
* Pocket Diagnosis: App turns any smartphone into a portable medical diagnostic device
* iPhones for Eye Surgeons
* Smartphones in Ophthalmology
* Lasers in Medicine

# Hands On Involvement

There are many ways for you to get directly involved in IYL 2015, whether that's giving a presentation, educating a young student, or just putting your smartphone to good use. Here you'll find cool science articles, links to educational materials, and some ready-made presentations to make it easy for you to participate. And don't forget to submit your best pictures to the IYL Photo contest!

## LightTALKS!

Organizing local events will be one of the key ways that the international scientific community can spread IYL2015's message about the importance of light and light-based technologies in our world. Find resources in the form of lightTALKS, collections of informative videos on interesting topics related to IYL2015.

### Optical Illusions Show How We See

Beau Lotto's color games puzzle your vision, but they also spotlight what you can't normally see: how your brain works. This fun, first-hand look at your own versatile sense of sight reveals how evolution tints your perception of what's really out there.

### A Light Switch for Neurons

Ed Boyden shows how, by inserting genes for light-sensitive proteins into brain cells, he can selectively activate or de-activate specific neurons with fiber-optic implants. With this unprecedented level of control, he's managed to cure mice of analogs of PTSD and certain forms of blindness.

### Playing with Space and Light

In the spectacular large-scale projects he's famous for (such as "Waterfalls" in New York harbor), Olafur Eliasson creates art from a palette of space, distance, color and light. This idea-packed talk begins with an experiment in the nature of perception.

### Why Light Needs Darkness

Lighting architect Rogier van der Heide offers a beautiful new way to look at the world — by paying attention to light (and to darkness). Examples from classic buildings illustrate a deeply thought-out vision of the play of light around us.

### Magic Bullets

Dr. Rox Anderson talks about "Magic Bullets," specialized light-energy treatments that can remedy skin abnormalities and help kids lead normal lives.

### Science Unplugged – What is Light?

World Science University provides hundreds of short video answers to a wide range of scientific questions, like this one on "What is Light."

### Folding Objects with Light (Courtesy of Inside Science)

Chemical engineers developed a way to transform two-dimensional patterns into three-dimensional objects using only light.

### Invisible Touch Screen (Courtesy of Inside Science)

Computer scientists and engineers at Texas A&M University use crisscrossing beams of invisible light to create a virtual air touchpad computer interface.

### Smart Drug Delivery System (Courtesy of Inside Science)

Inside the body, a smart material changes from a gel to a solid and an optical device allows researchers to see dye in the material through the skin.

## Smartphone Science

The smartphone that many of us use every day is one of the most advanced photonics devices ever made with state-of-the-art imaging and communications built-in. The links below show how smartphones are used by scientists as measuring instruments in applications from air pollution and light pollution, to adaptation as a microscope for measuring bacteria. Find out how you can use your own smartphone to perform scientific measurements with simple apps and add-ons.

### Scientific Uses

#### Compact Microscopes for Your Smartphone

"Two winners of the 2009 Vodafone Wireless Innovation Project were compact microscopes that interface with a cell-phone camera. There is also a nanosensor-based detector for airborne chemicals that plugs into an iPhone. Although envisioned for field use, these devices highlight the possibilities of the technology."

#### DIY Foldable Smartphone Spectrometer

The foldable paper mini-spectrometer folds up in minutes to transform your smartphone into a compact, simple, yet powerful experimental tool - a visible/near-infrared spectrometer, also known as a spectroscope or spectrophotometer.

#### SciSpy: Spy on Nature, Contribute to Science

For certain apps, like SciSpy, mobile devices allow users to take pictures of what they observe, stamped with the time, date, and even GPS coordinates. This is incredibly useful for researchers that need to compile large amounts of data for things like bird migration patterns, species concentration, and seasonal trends.

#### Smartphone Apps Illuminate Science of Space, Earth and Sea (September 2012)

"The school year is back in full swing and students are studying a variety of scientific topics, from biology, to astronomy to chemistry. Using smartphones and tablets, apps are helping illuminate a wide range of sciences for students, researchers and enthusiasts alike."

#### NASA, Scripps Use Technology Used In Smartphones To Boost Early Warnings Of Natural Calamities Like Floods, Earthquakes (December 2013)

"A new technology, similar to the one used in smartphones, can help scientists get early and more accurate warnings about extreme weather systems, tsunamis and earthquakes, researchers said."

#### Scientific Breakthrough Transforms Smartphones Into Cancer-Detecting Microscopes (May 2014)

"Smartphones have emerged as a tool not just for selfies and communicating on the go, but also for science. Australian Researchers recently invented a new kind of lens that transforms a smartphone camera into a microscope that's detailed enough to diagnose skin cancer."

### Citizen Scientists

#### iSPEX: Measure Aerosols With Your Phone

iSPEX is an instrument that measures atmospheric aerosols with your smartphone. Although invisible to the naked eye, we inhale tens of billions of aerosols every time we inhale. Aerosol groups include sulfates, organic carbon, black carbon, nitrates, mineral dust, sea salt, or a combination of these elements. Despite their small size, they have a huge impact on our health and climate. The iSPEX smartphone attachment is revolutionary because it allows the general public to learn more about the presence of aerosols and their impact on the immediate environment.

#### 10 Ways You Can Use Your Smartphone to Advance Science (July 2012)

"When almost everyone has an Internet connection, a camera, and a GPS unit right in their phone, almost anyone can gather, organize, and submit data to help move a study along. Here are 10 projects and apps that will turn you into a citizen scientist."

#### 10 Ways Scientists Are Using Your Smartphone To Save The World (October 2013)

"Smartphones allow us to be always connected to the greatest collection of information ever put together. The fact that everyone has their own mini supercomputer hasn't escaped scientists, who have come up with a number of novel ways to use smartphones to change the world."

#### 8 Apps That Turn Citizens into Scientists (November 2013)

"App-equipped wireless devices give users worldwide the ability to act as remote sensors for all sorts of data as they go through their daily routines—whether it's invasive garlic mustard weed in Washington State or red-bordered stinkbugs in Quintana Roo, Mexico."

# Cosmic Light

The importance of light reaches far beyond life on Earth. Through major scientific discoveries and technological advancements, light has helped us to see and better understand the universe. Discover breakthroughs in Astronomy, view stunning images of the cosmos, and learn more about dark skies.

## Einstein Centenary

In 1915, the theory of General Relativity developed by Einstein showed how light was at the center of the very structure of space and time. There will be many events worldwide focusing on this seminal theory of the universe, and this page will provide specific links so you can get involved, and will also provide other resources so that you can learn about Einstein and his many contributions to physics and cosmology.

2015 marks an important milestone in the history of physics: one hundred years ago, in November 1915, Albert Einstein wrote down the famous field equations of General Relativity. General Relativity is the theory that explains all gravitational phenomena we know (falling apples, orbiting planets, escaping galaxies...) and it survived one century of continuous tests of its validity. After 100 years it should be considered by now a classic textbook theory, but General Relativity remains young in spirit: its central idea, the fact that space and time are dynamical and influenced by the presence of matter, is still mind-boggling and difficult to accept as a well-tested fact of life¹.

The development of the theory was driven by experiments that took place mostly in Einstein's brain (that is, so-called "thought experiments"). These experiments centred on the concept of light: "What happens if light is observed by an observer in motion?" "What happens if light travels in the presence of a gravitational field?" Naturally, several tests of General Relativity have to do with light too: the first success of the theory and the one that made the theory known to the whole world, was the observation of the light deflection by the Sun. Eddington in 1919 was able to observe, during an eclipse, the effect of the Sun on the light coming from a far away star. The observed deflection was in perfect agreement with Einstein's theory while the prediction of the old theory of Newton was off by a factor of 2: a triumph for Einstein! Nowadays, light deflection by astrophysical objects (that is optics with very massive lenses!) is a tool successfully used to explore the Universe: it is called gravitational lensing².

Light remained central even in subsequent tests of the theory. For example in the so-called gravitational redshift³: light changes frequency when it moves in a gravitational field, another predictions of General Relativity, experimentally tested since 1959. Actually, the happy marriage between light and General Relativity is important every time we use a GPS device: general relativistic effects are crucial to determine our position with the required accuracy!

But the most amazing prediction of General Relativity has not to do with light, but rather with its absence! Black holes are objects so dense that even light cannot escape their strong gravitational field!⁴. Again it is not science fiction: black holes are by now standard objects that we (indirectly!) observe and study.

On much larger, cosmological scales, the gravitational redshift of light from galaxies and exploding stars (supernovae) constitutes the basic tool that allows us to "map" the Universe and study its "geometry". It is through these tools that we realized that the Universe is expanding, i.e. all Galaxies are moving away from each other. Even more recently it became clear that this expansion is in fact accelerating! As a consequence we realized that there is new form of (dark) energy present in our Universe!⁵ It is worth underlying that all these amazing and surprising discoveries were made possible by studying the light coming from distant astrophysical in the framework of General relativity.

From cosmology comes another connection between light and General Relativity, related to the early moments in our Universe. General Relativity predicts that our Universe comes from a very energetic state, the Big Bang, and a sign of this is imprinted in the so called Cosmic Microwave Background: CMB. The CMB is the light produced in the hot Early Universe in the moment when its decreasing density finally allowed photons to travel freely. This very same light we can see today and provides us with precious information of how the Universe looked like when its age was only 1/30000th of its age today!

What about the future discoveries? We are eagerly waiting (in 2015?) for the first detection of gravitational waves, i.e. "ripples" in the space-time fabric, another fascinating prediction of General Relativity, so crazy that not even Einstein believed in it.

Those produced in the early stages of the history of the Universe could be detected, indirectly, as peculiar patterns in the polarization of the CMB light. Such detection could provide us with invaluable information on the very Early Universe, pushing further back in time our "sight".

## Dark Skies Awareness

In most large cities of the world, it is no longer possible to appreciate the beauty of the night sky. Inefficient public lighting both wastes energy and causes "light pollution" that hides our universe from us. This page will provide links and resources to explain the adverse impacts of lighting on local environments and provide information on how you can help, and where you can go to see a dark sky near you.

### What is Light Pollution?

"Light Pollution" is a form of environmental degradation in which excessive artificial outdoor lightings, such as street lamps, neon signs, and illuminated sign boards, affect the natural environment and the ecosystem. The wasteful light emitted directly upwards or reflected upwards from poorly-designed artificial light sources can be scattered by clouds, fog, and pollutants like suspended particulates in the atmosphere. The night sky is thus brightened, leading to a reduced number of stars visible in the sky due to a decrease of the light contrast.

## A Universe of Images

From our nearest planetary neighbors to the most distant galaxies, the cosmos is a wonder to behold, and we are incredibly lucky in the 21st century to be able to see so many remarkable and beautiful images taken from telescopes and satellites. This page will provide many samples and links that are truly inspiring!

## Galileoscope

The Galileoscope is a high-quality, low-cost telescope kit developed by a team of leading astronomers and science educators. No matter where you live, with this easy-to-assemble kit, you can see the celestial wonders that Galileo Galilei first glimpsed over 400 years ago including lunar craters and mountains, four moons circling Jupiter, the phases of Venus, Saturn's rings, and countless stars invisible to the unaided eye. This page will provide information on how you can obtain a Galileoscope yourself.

Galileo Galilei, more commonly known by just his first name, was a late 16th/early 17th century physicist, mathematician, astronomer, and philosopher who made great contributions towards the scientific revolution. In 1609, he constructed the first known complete astronomical telescope, which revolutionized the way we view outer space from Earth. Through this invention, Galileo made many important observations and discoveries that helped to solidify a basis for our knowledge of the Universe today.

### What Is Galileoscope?

The Galileoscope is:

* An advanced educational telescope kit designed by a team of experts.
* An educational program to accompany the kit.
* A professional-development program for teachers.
* A Cornerstone Project of the International Year of Astronomy 2009, a worldwide effort in more than 145 countries, led by the U.S. Galileoscope team.

### What can you see with the Galileoscope?

The best views are of the key objects that Galileo observed and that influenced his views on astronomy. The Galileoscope is optimized to provide high-quality views of…

Mountains and craters on the Moon, which revealed to Galileo that the Moon is a craggy world like Earth, not a smooth heavenly sphere.

Four moons circling Jupiter, which revealed to Galileo that there can be more than one center of motion in the universe, and that a planet can move through space without losing its satellites.

More stars in the Pleiades and Beehive star clusters than can be seen with the unaided eye, which revealed to Galileo that nature is filled with wonders never before imagined — literally more than meets the eye.

Saturn's rings, which perplexed Galileo because his telescope wasn't strong enough to show them clearly. (In its 50-power configuration, the Galileoscope will reveal Saturn's rings in all their splendor.)

Venus going through a complete set of phases, like the Moon, which showed Galileo that Venus orbits the Sun, not the Earth.

### How to order Galileoscope?

To order your own Galileoscope, visit galileoscope.org, and be sure to view other optics and photonics kits available for home and education use.

## The Big Bang

In 1965, Bell-labs scientists Arno Penzias and Bob Wilson discovered the Cosmic Microwave Background, an electromagnetic echo of the origin of the universe. The Big Bang has now entered into popular culture, but most people have no idea really what it means for cosmology. This web page will explain the history behind the 1965 measurements, and provide resources and links so you can learn what it all means!

The Cosmic Microwave Background (CMB) is the cooled remnant of the first light that could ever travel freely throughout the Universe. This 'fossil' radiation, the furthest that any telescope can see, was released soon after the 'Big Bang'. Scientists consider it as an echo or 'shockwave' of the Big Bang. Over time, this primeval light has cooled and weakened considerably; nowadays we detect it in the microwave domain.

The CMB radiation was discovered by chance in 1965 when two radio astronomers in the United States, Penzias and Wilson, registered a signal in their radio telescope that could not be attributed to any precise source in the sky. It apparently came from everywhere with the same intensity, day or night, summer or winter. They concluded that the signal had to come from outside our Galaxy; from the origin of the Universe.

# Light For Development

All over the globe, people are using light to discover solutions for society's most pressing problems. From 3-D printing to bringing energy solutions to developing regions, light is key in driving economies and encouraging the development of civilization. Discover how international organizations are encouraging research, education, and advancement of light in communities worldwide.

## Study after Sunset

For over 1.5 billion people around the world, night-time means either darkness or the dim glow of an unhealthy kerosene lamp or candle. Such poor-quality lighting has dramatic impact and health and educational opportunities, and an important aim of the International Year of Light will be to promote the use of portable solar-powered high-brightness LED lanterns in regions where there is little or no reliable source of light. This page will provide resources explaining this problem, explain how we are planning to address it, and show how you can get involved.

In developing and third-world countries without access to electricity, 1.3 billion people depend on kerosene for light. The burning of kerosene lamps leads to the death of 1.5 million people every year. Inhaling kerosene smoke is the equivalent of smoking 4 packs of cigarettes a day, and commonly induces respiratory illnesses such as asthma, bronchitis, pneumonia, and cancer in tens of millions of people. The open flame of kerosene lamps also pose as an obvious danger to households. Moreover, impoverished families spend up to half of their income on kerosene which not only provides inadequate illumination but also emits extremely harmful black carbon into the Earth's atmosphere. Kerosene lamps contribute to a vicious cycle of poverty that needs to be broken.

Providing clean, efficient forms of energy to developing communities is not only important for health reasons - it is also vital for productivity. Families in rural communities rely on work to provide for the most basic needs of their family, and are currently limited in hours due to scarce lighting after sunset. The majority of children in developing countries are also expected to work during the day to help provide for their family. With no or inadequate light at night, these youth are unable to read or write, and thus deprived of an education. Possibly the most pressing issue of all is access to healthcare. Hospitals are able to care for patients during the day but shut down operations at night because they do not have adequate lighting. With limited health care professionals and increasing levels of illnesses and disease in developing countries, it is crucial that these hospitals receive new means of lighting.

Difficulty convincing these off-grid communities that sustainable, high-tech lighting alternatives is the reason many are still using kerosene lamps. There are countless organizations that devote their efforts towards providing clean lighting in the form of solar and LEDs, but it is not always an easily executed task. As the price of LED and photovoltaic technology decreases, however, implementing these technologies will become increasingly actionable.

The Global Off-Grid Lighting Association (GOGLA) is especially active in contributing to the further development of the off-grid lighting sector through several ongoing projects. In their words, "positioning off-grid lighting outside the philanthropic arena as a fully recognized industry in an important and growing market". GOGLA is constantly working with businesses in developing countries to reduce barriers and increase opportunity for sustainable lighting alternatives.

To help contribute to GOGLA's efforts in expanding the off-grid lighting market, participate in an upcoming event or become a member .

## Active Learning

ALOP (Active Learning in Optics and Photonics) – a UNESCO's International Basic Sciences Programme (IBSP) flagship activity – is based on the simple idea of using hands-on optics and photonics lessons to teach teachers more about science, and encourage them to share their knowledge with other teachers as well as their students. Activities involve simple, inexpensive materials that, whenever possible, can be fabricated locally. Optics is ideal as subject matter because it provides a basis for many wider educational topics in science and technology, and is adaptable to research and education in many developing countries. This page will provide links to active learning programs in optics and photonics worldwide.

The ALOP program began in 2004, and has since hosted workshops for over 1,000 teachers from 55 developing countries in Africa, Asia, and Latin America. With continuing support from UNESCO, ICTP, and SPIE, the goal of the program is to strengthen the learning environment by providing professional development workshops for teachers. Based on UNESCO's ALOP Training Manual, educators learn six optics and photonics modules; Geometrical Optics, Lenses and Optics of the Eye, Interference and Diffraction, Atmosphere Optics, Optical Data Transmission, and Wavelength Division Multiplexing. During workshops, they are also provided hands-on applications using low-cost materials and learn how to assess student knowledge using the Light and Optics Conceptual Evaluation (LOCE).

Today, the training manual has been translated from English to several international languages which allows for a wider range of accessibility. The program is led by professors from universities in the US, Tunisia, Canada, Philippines, and Australia, with each member of the team bringing a unique set of experiences and talents to the table. ALOP aligns with UNESCO's mission to enable youth scientifically, and will continue to bring high-quality education to developed and developing countries across the globe. Looking forward, the hope is to develop ALOP-like workshop curricula in other topic areas in order to improve secondary and higher education as a whole.

## UNESCO's actions

The International Basic Sciences Programme of UNESCO is an international multidisciplinary programme established by UNESCO Member States in order to strengthen national capacities in the basic sciences and science education. This page will allow you to learn about the many activities of this programme on this page, and the success stories in encouraging new partnerships and activities worldwide.

Created in 1945, UNESCO (United Nations Educational Scientific and Cultural Organization) aims to establish a lasting peace between all members regarding political and economic agreements. Since then, UNESCO has consistently worked towards their overarching objectives of creating a culture of peace and sustainable development through conferences, education centres, partnerships, and much more.

The International Basic Sciences Programme (IBSP) focuses on fostering major region-specific actions that involve a network of national, regional and international centres of excellence or benchmark centres in the basic sciences. Since the programme was established in 2005, more than 40 projects have been executed. These projects focus on capacity building in key areas of physical and biological sciences and on promoting experimentation in science education by using Microscience kits for the instruction of basic science disciplines. New initiatives for the multidisciplinary programme are continually discussed and implemented between Member States and partner organizations.

By supporting the International Year of Light 2015, IBSP will contribute to achieving the goals of the UNESCO in strengthening science, technology and innovation (STI) systems and policies as well as in the advancement of science and technology for sustainable development. It will also play a major role in harnessing international cooperation of science and technology capacity-building.

## Astronomy for Development

One of the strong legacies left by the 2009 International Year of Astronomy was the establishment of an Office of Astronomy for Development whose mission is to use astronomy to make the world a better place. The office was set up by the International Astronomical Union (IAU) in partnership with the South African National Research Foundation. This page will highlight its actions in supporting universities and research; children and schools; and public outreach.

Astronomy has been an important driver for the development of advanced technology, such as the most sensitive detectors of light and radio waves and the fastest computers. The need to study the faintest objects requires sophisticated electronics and extreme-precision adaptive optics as well as state-of-the-art engineering. Astronomy has also played an important role in the development of space technology that has opened up the Universe for study across the whole electromagnetic spectrum. Modern optics and radio telescopes are among the most advanced machines ever built and are outstanding educational vehicles for introducing the latest complex technology

### Office of Astronomy for Development

Mobilizing more volunteers and implementing new programs cannot be achieved without professional management and coordination. For this reason the IAU Office of Astronomy for Development (OAD) was created in partnership with the South African National Research Foundation following the International Year of Astronomy 2009 (IYA2009). Through the office in Cape Town, projects that help to realize the vision of the IAU Strategic Plan have the opportunity to be reviewed and receive funding. Special projects of the OAD include AstroEDU, AstroVARSITY, AstroComputing, and AstroSense.

## African Optics and Photonics

Supporting advanced training in Africa is a priority for UNESCO, and the International Year of Light has a special aim to create as a legacy of 2015, a sustainable African Optics and Photonics Society. This page will allow you to follow this exciting project, and to explore the impact of such a society on the photonics industry in Africa. It will also touch on the initiatives occurring throughout Africa to implement sustainable research with sufficient human capacity development and governmental support.

Optical sciences and light-based technologies have remained at the forefront of advances in various fields of human endeavour and continue to play leading roles in the development of science and technology in Africa. IYL2015 presents an opportunity for greater awareness of the solutions that optical sciences and light-based technologies could present in order to foster greater collaboration among different fields and sectors for the sustainable development of Africa.

### Aims and Goals

To create greater awareness of the potential of light-based technologies for solving many of the challenges facing the continent.

To expand interaction between academics, industries and professionals in using optics and photonics concepts in tapping developmental strategies for communities, with the view to enable policy makers appreciate the relevance of science for economic advancement.

To attract young innovators to the study and application of light-based technologies for the benefit of the continent.

### Expected Outcomes

It is expected that IYL2015 will lead to the:

* Expansion of educational opportunities in optical sciences and technology for capacity and industrial building.
* Establishment of sub-regional centres of excellence in light-based technologies for the promotion of optics and photonics.
* Expansion of research infrastructure to uphold new consciousness in optics and photonics for the emerging economies towards nation-building.
* Increase in the number of young innovators in optics and photonics, particularly, in the areas of medicine, communication, agriculture and energy applications relevant to the various national needs.
* Need for Africa to make a mark in optics to unravel the potentialities needed to solve our numerous challenges.

### Resources

Beginning with more than 20 African countries, the African Laser, Atomic, Molecular, and Optical Sciences (LAM) Network was created in 1991. Currently, the LAM Network is supported by the International Centre for Theoretical Physics (ICTP) and the International Science Program (ISP). Physics of Laser Atoms and Molecules is becoming increasingly vital to development in countries that need access to higher education, health, agriculture production and communication. The LAM Network helps to build interconnectedness between universities and research facilities in Africa, and also to emphasize the development of cooperation between those structures.

The African Physical Society is a non-governmental association legally incorporated under the law of the Republic of Ghana, along with the African Association of Physics Students as a subsidiary organization. The organization was created to to bring global awareness of research and education in physics, also to promote relations between physics students from all over the world.

The African Spectral Imaging Network was created to research, collaborate, and innovate on the topic of microscopic imaging systems. Through workshops, networks, and support from universities, the network is able to share expertise to open new areas for investigation and support each other to solve problems in spectroscopy.

Sponsored by OSA and SPIE, the Tunisian Optical Society actively performs research in the fields of optical fibre communications, optoelectronics, quantum communications, and photonics components for telecommunication-based applications. The activities hosted in Tunisia by the Optics & Photonics Student Chapter aim to diffuse the knowledge of optics while promoting research and connecting with industry leaders.

The Council for Scientific and Industrial Research (CSIR) in South Africa is one of the leading scientific and technology research, development, and implementation organizations in Africa. Focusing on areas such as laser technology, built environment, biosciences, and defence, CSIR undertakes directed research and development for socio-economic growth.

Created by the CSIR, the African Laser Centre (ALC) aims to develop much-needed laser research capacity, infrastructure, technology transfer and applications throughout Africa. Objectives of the ALC include promoting the research and training programs of major laser research facilities in Africa, ensuring technology transfer of laser knowledge throughout the industry, and improving the quality of life for all African citizens.

The African Network for Solar Energy (ANSOLE) focuses on decreasing the exploitation of our Earth's natural resources by exploring the potential of solar energy in Africa. It serves as a platform to connect stakeholders who are devoted to seeking the use of renewable energy forms to address the acute energy problem in Africa.

# Partner Platforms and Centers

AAPT  
American Association of Physics Teachers

ALC  
African Laser Center

BPHOT  
B-PHOT Brussels Photonics

CIE  
the Commission Internationale de l´Eclairage

CILA  
Centre for International Light Art

CXRC  
Chandra X-Ray Center

DLS  
Diamond Light Source

ECOP  
European Centers for Outreach in Photonics

ECSITE  
The European Network of Science Centres and Museums.ELRI  
Laserlab Europe Integrated Initiative of European Laser Research Infrastructures

EPIC  
European Photonics Industry Consortium

ESP  
the European Society for Photobiology

ETOP  
Education and Training in Optics Conference

ETPP  
European Technology Platform Photonics 21

IAPS  
International Association of Physics Students

ICFO  
the Institute of Photonic Sciences

ICUIL  
the International Committee on Ultra-High Intensity Lasers

IOR  
Institute of Optics Rochester

ISPRS  
the International Society for Photogrammetry and Remote Sensing

LAM  
African Laser, Atomic, Molecular and Optical Sciences Network

LSFN  
The Lightsources source facility network

Museum on Light  
Museo de la Luz

SESAME  
Synchrotron-light for Experimental Science and Applications in the Middle East

UNAM  
Universidad Nacional Autónoma de México

UNESCO-ICTP  
International Center for Theoretical Physics