The Laser has been one of the most significant developments in the field of light. Today laser devices have become such an important part of our lives that we cannot imagine our life without it. From CDs and DVDs to laser printers, barcode readers and fibre optics communication there are innumerable laser applications in our day to day life. The invention of Laser is one of the most important milestones in history and a precursor to the development of several light-based equipments.

Light is not only the visual light that humans can see but it is a vast area of the entire electromagnetic spectrum. Even if we cannot see the entire electromagnetic spectrum, visible and invisible waves are part of our everyday life. We live in an envelope of light and it is not possible to think of life without light.

Today, light is also finding unusual avenues of employment.

### Light in Agriculture Technology

All plants have a unique combination of photoreceptors - pigments that use specific frequencies of light. These pigments trigger different behaviours in the plant, such as leaf growth, flowering, rooting or even speeding up and slowing down stem and shoot growth. If different light-based techniques were employed by growers, the result would be durable plants that yield more fruit.

By monitoring the photosynthesis process carefully, through a procedure known as Indoor Farming we can grow vegetables two-and-a-half times faster than in an outdoor farm. Special LED fixtures have been developed that emit light at wavelengths optimal for plant growth. Purple lighting is used to mimic night, while the white lights are adjusted slowly throughout the day to mimic a sun moving through the sky. The environment is also monitored including temperature, humidity and irrigation.

Greenhouse Farming Technology is also employed to convert solar light to heat in order to grow crops that are not suited to the natural climate in certain areas. Greenhouse Farming Technology is the technique of providing favourable environmental conditions to the plants. It is used to protect plants from adverse climatic conditions such as wind, cold, precipitation, excessive radiation, extreme temperature, insects and diseases.

Satellite remote sensing and GIS technologies have helped to overcome the limitations of the manual system. In this technology sensors are used to measure the amount of electromagnetic radiation existing in an object or geographic area from a distance and then extracting valuable information from the data. The technology based on high resolution satellite crop images, enables monitoring of vegetation, soil temperature, humidity and also helps to reveal problem areas on the field. This has also helped to monitor natural calamities like floods and droughts.

Today, we also have optical crop-sensing systems where light sensors are used to analyse in-season plant health. Healthy plants absorb more red light and less healthy plants take in less. Sensors measure the reflected light as...
the systems go through the field and the software instantaneously predicts crop yield potential and crop response to additional nitrogen. The systems can also produce crop health maps, which are generated during fertiliser application.

Agricultural Drones are today playing an increasing role in the increase of yields, reduction of crop damage and prevention of weeds by spraying pesticides. They are also equipped with an autopilot, GPS and a standard point-and-shoot camera controlled by the autopilot all of which help to monitor the crop.

There is also an optical spray or weed detector technology that uses advanced optics and computer circuitry to sense the presence of a weed. When a weed enters the sensor’s field of view it signals a spray nozzle to deliver a precise amount of herbicide to that weed only.

**Light in Human Health Care**

The most extensive use of optics in health care is in the fabrication of eyeglass frames, lenses and contact lenses. Optics has enabled surgery with the help of laser, optical diagnostic techniques and visualization of the interior part of the body. The use of light in the area of health care has evolved into a field of photonics called Biophotonics.

Today biomedical technology has increased the ability of the physicians to diagnose diseases with the help of optics and imaging. Development of advanced microscopes has allowed discoveries in microbiology which determined that germs are the underlying cause of most of the infectious diseases. The observation of bacteria and microbial parasites led to the development of antibiotics.

Minimally-invasive procedures have been enabled by the advance of various medical technologies with the help of optics. Minimally-invasive surgery refers to surgical techniques that limit the size of incisions needed and so it lessens wound healing time, associated pain and risk of infection. Modern optical endoscopes provide a close-up view of organs and also a method for implementing laser surgery.

Refractive eye surgery is used for the correction of visual defects such as near-sightedness, astigmatism and farsightedness by correcting refractive errors or changing focus of the eye. There are various surgical procedures for correcting or adjusting the eye’s focusing ability. The most widely performed type of refractive surgery is LASIK (laser-assisted in situ keratomileusis) where a laser is used to reshape the cornea.

Light has also found use in Photodynamic Therapy (PDT) or the activation of drug by light. This activated drug in turn transfers its energy to molecular oxygen, which can then destroy the infected tissue. Cancer therapy was the initial application for PDT. Some noncancerous applications
include destruction of abnormally growing blood vessels in the eye that can lead to blindness, treatment of the skin disease psoriasis, treatment of rheumatoid arthritis, etc.

Radiation therapy uses high-energy radiation to shrink tumours and kill cancer cells. X-rays, gamma rays and charged particles are types of radiation used for cancer treatment. It uses radioactive substances, such as radioactive iodine, that travel in the blood to kill cancer cells.

Medical imaging is the process of creating visual representations of the interior of a body for further medical analysis. Common applications include CT (computed tomography) scans, MRIs (magnetic resonance imaging) and X-rays. Lung diseases such as emphysema, lung cancer and tuberculosis are also detected using CT and X-ray imaging.

**Light in Communication**

Fibre-optic communication systems have played a major role in the advent of the Information Age. It is a method of transmitting information from one place to another by sending pulses of light through an optical fibre. It is unique because it can carry high bandwidth signals over long distances without degradation.

Copper can also carry high bandwidth, but only for limited distances and after that distance the signal begins to degrade and the bandwidth narrows. Optical fibres have enormous information carrying capacity and possess immunity from the many disturbances that can affect electrical wires and wireless communication links. Because of their advantages over electrical transmission, optical fibres have largely replaced copper wire communication in the developed countries. Now telecommunication companies are using optical fibre to transmit telephone signals, Internet communication and cable television signal. Cable television operators are also installing fibre-ring architecture that improves the reliability of their network.

Undersea fibre systems have become the major information arteries between continents. The old submarine cable system used coaxial cables and carried information in analog form. The new fibre system uses digital system, which provides a considerable improvement in quality. TAT-8 was developed as the first undersea fibre optic link between the United States and Europe. It went into operation in 1988.

Fibre-to-the-home (FTTH) is the delivery of communications signal over optical fibre from the operator’s switching equipment to a home or business, thereby replacing existing copper infrastructure such as telephone wires and coaxial cables. It is best for high-speed networking, high speed data transfer, digital television and telephone service to residences using fibre optic cables.

Satellite communication used extensively today also depends in large measure on optical systems. Inter-satellite cross-links can be either optical or radio frequency. The shorter wavelength of optical systems allows modest telescope sizes and transmission at a high data rate. Space agencies are working to develop Laser-based space communications systems, which will be the key to ensuring rapid and accurate transmission of information from spacecraft around the solar system.

**Light in Manufacturing**

Modern manufacturing is also being revolutionised by the use of optics. Light can be used to process or probe materials remotely. Numerous optical techniques are used throughout industry and are critical to not only the manufacture of such diverse and basic products as semiconductor chips and chemicals but also construction of roads and tunnels.

The use of high-power lasers for materials processing functions such as cutting and welding has now become routine in numerous automobile manufacturing applications. Machine vision systems are being used in a wide range of applications in automotive manufacturing thus improving quality by generating information used to adjust and optimise manufacturing processes.

The semiconductor integrated circuit manufacturing industry is powered by optics, optical systems, and optical materials. Photolithography is a key enabling technology for the industry and is the single most significant application of optics in industrial manufacturing.

Today optical techniques in the chemical industry are used to provide information for process control which allows up-to-the-second evaluation of chemical streams during the manufacturing process, in turn allowing real-time process control. This ability to maintain optimum operating conditions in real-time to meet specific customer requirements results in a measurable reduction in waste, which in turn leads to a desirable reduction in environmental degradation and a reduced need for waste management.

Airplane manufacturers have similar needs featuring accurate location and alignment or layout of mating three-dimensional structures over large distances. Laser and other modern electro-optic systems are being effectively and routinely employed to save time and cost. The Laser Tracker...
Instrument is a real-time coordinate measurement system for accurately mapping large structures.

Construction projects typically require the acquisition and assessment of a lot of data. Optical techniques can make this process faster and cheaper by reducing the need for expensive labour or making it more efficient. Design and construction tools include optical image scanners, laser guidance systems for construction equipment, geodetic measurements including fly-over and satellite-based mapping systems, and laser tools for precision cutting and welding of construction materials or monitoring of shifting structures and stresses.

A strong drive toward shorter production times and just-in-time printing closer to the end user is forcing the printing industry to move from older technologies to digital techniques, where the information to be printed is provided as digital input directly to the press. Digital platemaking used for low-volume, high unit price applications, and digital printing used for high-volume applications, are predominantly optical processes.

**Light in Security and Defence**

Optical technologies have played and continue to play an indispensable role in national defence and security. The sophisticated satellite surveillance systems are a keystone of intelligence gathering. The other applications include perimeter security, range-finding, target illumination, monitoring of hazardous gases, and illumination.

“Night Vision” is technology that provides vision in total darkness and improvement of vision in low-light environments. The most common applications include night driving or flying, night security and surveillance, wildlife observation, sleep lab monitoring and search and rescue.

Light is one of the means of chemical detection too. Surface Enhanced Raman Spectroscopy (SERS) is a sensing technique used to identify chemical and biological molecules in a wide range of fields. When a powerful laser interacts with chemical and biological molecules, it can produce photons that have a different frequency from the laser light.

X-ray baggage inspection system is a highly sophisticated security system. It is designed to analyse components within the baggage effectively and efficiently by using X-ray radiation. Then there is CCTV (close circuit television) that uses security cameras to observe places or people and deliver signals to a particular destination for surveillance.

**New Developments in Photonics**

Printing new skin for patients is an option for the near future. Laser technology has been developed in such a way that it is able to print live cells by Laser-assisted Bio Printing (LaBP). 3-D skin printing is making a huge impact in the medical field.

A group of scientists have discovered that placing gold nanoparticles within the leaves of trees causes them to give off a luminous reddish glow. From there has grown the idea of using trees to replace street lights: not only would it save on electricity costs and cut carbon dioxide emissions, but it could also greatly reduce light pollution in major cities.

Wearable technology is defined as a computing-based advanced electronic technology to wear directly on body or introduce them into users’ clothing or accessories. Current applications in the wearable industry are in medical and health care (blood pressure monitors, heart rate monitors, hearing aids), Fitness (activity monitors, fitness monitors), Infotainment (smart watch, smart glass, smart clothes, Bluetooth headsets), Industrial (smart glasses, smart clothing), and Military (hand worn terminals, heads up display).

A new advance in piezoelectricity may lead to self-powering cell phones and other electronic devices that can convert sound waves produced by the user into the energy it needs to keep running.

Near Field Communication, abbreviated NFC, is a form of contactless communication between devices like smartphones or tablets. Contactless communication allows a user to wave the smartphone over a NFC compatible device to send information without needing to touch the devices together or go through multiple steps setting up a connection. Apart from the diverse applications of light, light also affects our mood often even regulating our thoughts and feelings. So, optics is not only just a subject for researchers and scientists but also deeply influences our daily lives.

Ms Hemlet Guria is an Electrical Engineer and Curator, National Council of Science Museums, 33, Block-GN, Sec-V, Salt Lake, Kolkata-91; Email: guriancsm@gmail.com