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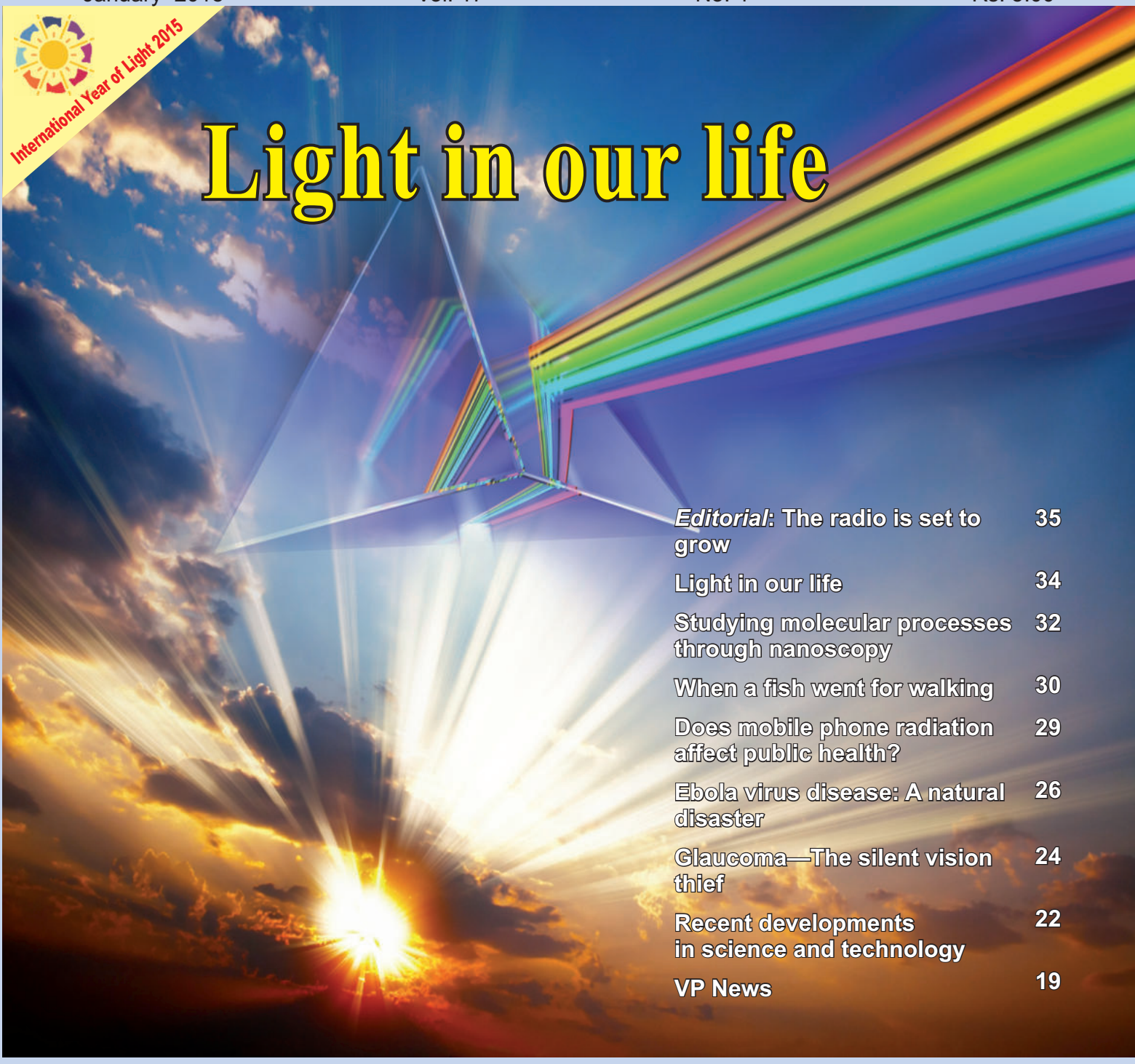

... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

The radio is set to grow

Dr. R. Gopichandran

Natural disasters create a compelling opportunity for battery-based radio communication. This is especially so when other modes do not help establish robust communication due their own special constraints. A recent analysis by Robson & Templeman (2014)[1] stresses the need for focussed communication in the pre-, during and post-disaster phases with equal consistency. They cite the post-Hurricane Katrina circumstances and present the case of the Yellow Bird alert system – a unique adaptation through technology convergence.

The UNDP *et al.* in 2011[2] highlighted the benefits derived by initiatives in Nepal, Philippines, Liberia and Egypt with sector-specific information support extended to stakeholders with implications for development. Significant insights on the dynamics of community radio can be derived from the Consultation Paper issued by the Telecom Regulatory Authority of India[3] in May 2014. This was on the premise that radio is a popular, highly mobile medium for communication in India and can be afforded. The paper lays special emphasis on the use of radio systems in emergencies, citing its use in other countries too. A comparable initiative is published by the White House Office of Science and Technology Policy July 2014[4] with a special focus on innovation in communication strategies for disaster related response and recovery. An excellent overview of the roles perceived and played by several stakeholders is defined in this context. The World Disasters Report with a focus on culture and risk[5] also provides interesting insights into the dynamics of communication, duly recognising the potential of radio based systems in optimising outcomes.

Diligent efforts by Vigyan Prasar has over the years produced a significant number and variety of programmes broadcast through radio. Sincere thanks to All India Radio in particular, it has been possible to develop theme specific modules in several Indian languages and English; delivered through AIR's stations across the country. A network of dedicated listeners is also developed in many cases that helps provide additional learning materials. While such wide a variety of themes as mathematics, atom, innovations, etc., are covered, the principles and methods of science that pervade these areas are highlighted. Responses from listeners help connect with them once again. Detailed analyses of logical frameworks that need to guide and enable convergence of tools for large scale communication with radio are in progress. It will be useful to focus on disasters related aspects as part of the way forward.

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Light in our life

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Light plays a central role in all living beings. Light is required for photosynthesis – hence, at the most fundamental level, existence of life itself is dependent on light.

Since ancient time people have wondered about light – be it natural source of light from Sun, lightning, forest fire, light emitted by firefly or light from a candle or electric lamp. Scientists have been studying light for hundreds of years and debated its nature and characteristics. Understanding of the true nature of light came only in the 20th century.

Newton, Huygens, Maxwell, Hertz, Einstein and a number of prominent physicists have done research on light throughout their life. Their ground-breaking discoveries have shaped the future course of research in many interdisciplinary areas. Today light based technologies are essential in healthcare, space explorations, advanced modes of tele-communication and hold the promise of limitless possibilities. Researches on light-based technologies are essential for sustainable use of natural resources, renewable energy and energy efficiency and in turn, hold the key of future development.

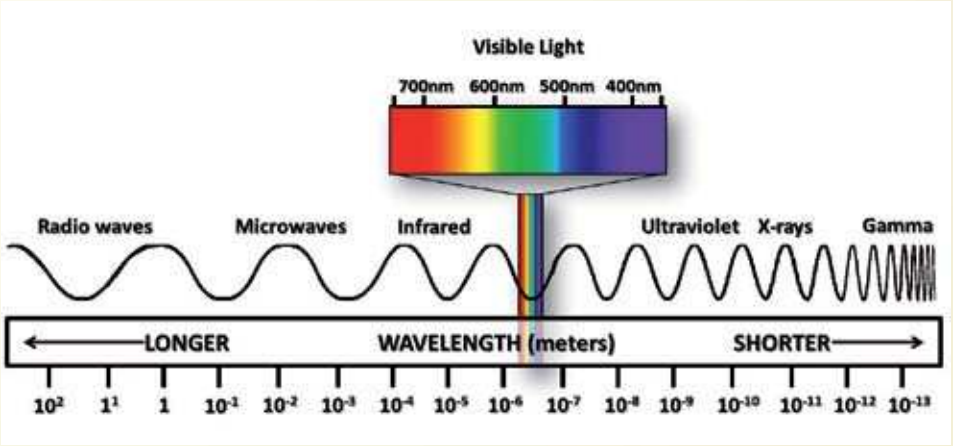
Recognising the importance of light and light-based technologies in the lives of the citizens of the world and for the future development of global society on many levels, the United Nations proclaimed the year 2015 as International Year of Light and Light-based Technologies.

The resolution adopted by the UN general assembly emphasised importance of raising global awareness and better education about how light-based technologies promote sustainable development and provide solutions to global challenges in energy, education, agriculture and health, as well as help improve the quality of life.

What is light?

Light, by default, implies visible light. However, visible light is only a small part of electromagnetic spectrum that consists of radio wave, microwave, infrared, visible light, ultraviolet rays, X-rays, and gamma rays.

Scientists have long debated the nature of light – whether light is wave or consists of particles. A number of experiments suggested that light behaves as wave. Similarly, a number of other experiments suggested light should consist of energy particles. Today it is well established fact that light behaves both as wave as well as particles – it all depends on the situation.

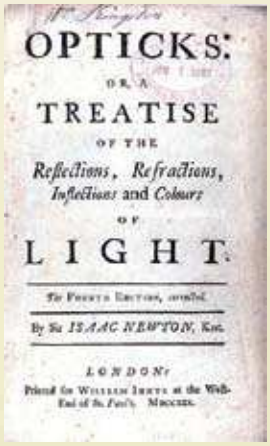


Electromagnetic spectrum

Light travel through space as electromagnetic radiation. In vacuum, light and radiations covering the entire electromagnetic spectrum travel at a speed of nearly 300 million kilometres per second. Surprisingly, speed of light in vacuum is the same for all observers, regardless of the motion of the light source or the observer. This signifies that even if the source of light is moving, the speed of light from that source measured by a stationary as well as a moving observer will be the same. This was originally proposed in 1905 by Albert Einstein in his special theory of relativity.

A brief history of light

Isaac Newton (1642-1726) did a series of experiments to understand the nature of light and constituent colours of visible light. Newton proposed a particle theory of light. He argued that the geometric nature of reflection and refraction of light could only be explained if light was made of particles. He referred to light particles as corpuscles.


OPTICKS:
OR A
TREATISE
OF THE
Reflections, Refractions, Inflections and Colours
OF
LIGHT.
By Sr ISAAC NEWTON, Knt.
LONDON:

In 1704 Newton published *Opticks* – his second major book on physical science after *Principia*. The book was largely a record of experiments on reflection, refraction, other optical phenomena and the deductions made from those experiments. It is considered one of the great works in optics.

The major significance of Newton's work was that it overturned the dogma attributed to Aristotle or Theophrastus that "pure" light (such as the light coming from the Sun) is fundamentally white, and is altered into colour by mixture with darkness caused by interactions with matter. Newton showed light is composed of different spectral hues (he describes seven — red, orange, yellow, green, blue, indigo and violet), and all colours, including white, are formed by various mixtures of these hues.

Around the same time, during 1678, Dutch mathematician and scientist Christiaan Huygens (1629-1695) did a number of experiments on visible light and proposed a wave theory of light. He said speed of light is

finite and it propagates like wave from the source that generates the light. However, his theory was not accepted in general due to Newton's particle theory of light.

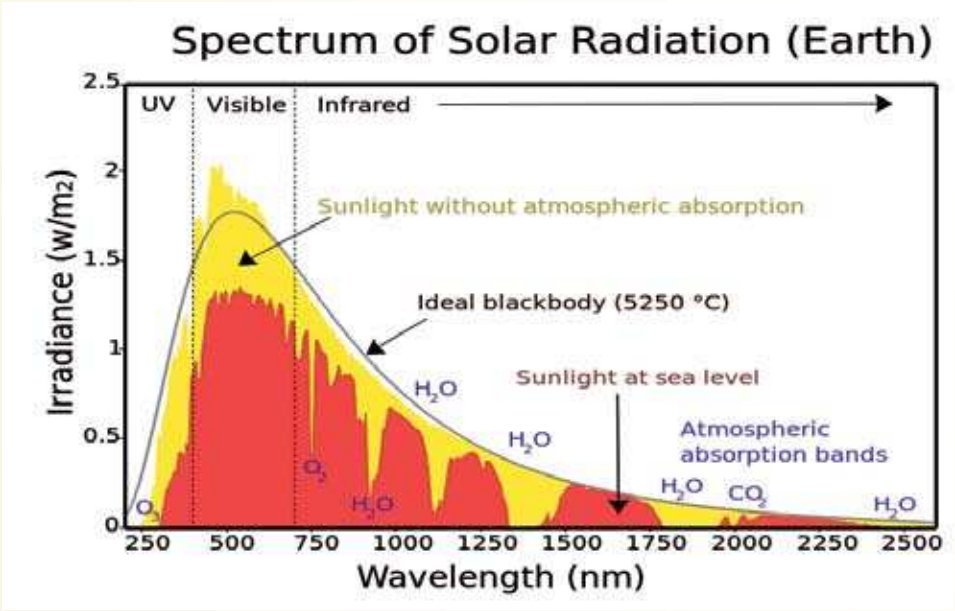
In 1801, English scientist Thomas Young (1773-1829) again established the wave theory of light by his famous double-slit experiments to demonstrate interference of light. In Young's double-slit experiment, alternate bright and dark bands are observed when light from two coherent sources are superimposed on each other. This phenomenon could not be explained by particle theory of light.

In 1865 Scottish mathematical physicist James Clerk Maxwell (1831-1879) said that electromagnetic waves travel at the speed of light. He concluded that light is also a kind of electromagnetic wave.

During 1888 German physicist Heinrich Hertz (1857-1894) performed a series of experiments that supported James Clerk Maxwell's conclusion that light is an electromagnetic wave. During the next 50 years many other types of electromagnetic radiations (X-ray, gamma ray) were discovered.

In 1900, German theoretical physicist Max Planck (1858-1947) theorised that electromagnetic radiation is emitted in discrete packets of energy. This was the beginning of theories now called 'quantum mechanics'.

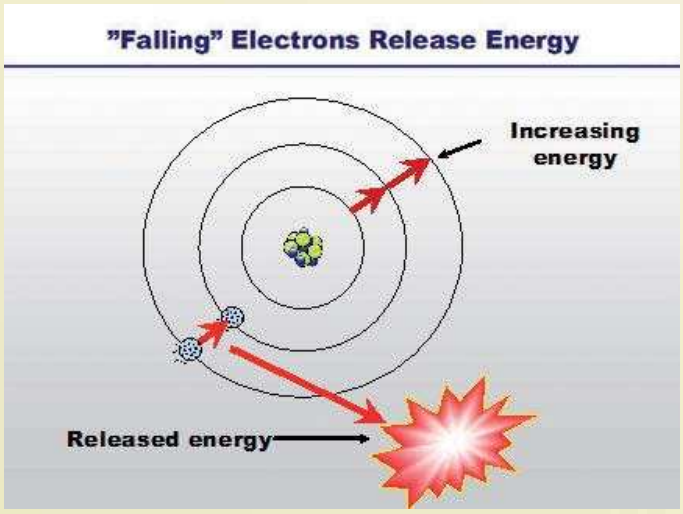
In 1905, Albert Einstein explained photoelectric effect by describing light as composed of discrete quanta rather than continuous waves. This discovery led to the quantum revolution in physics and earned Einstein the Nobel Prize in Physics in 1921.



Sources of light

Visible light or any part of the electromagnetic spectrum may be considered as packets of energy called photons. Newton referred to these particles as corpuscles. Energy of a photon of any radiation is dependent on the frequency of that radiation. Frequency of visible light is less than frequency of gamma-rays. Hence energy of visible light is less compared to gamma ray photon. Further, visible light consists of seven colours, each with a different frequency, red having the lowest and violet having the highest frequency. Hence energy of red light photon is less compared to that of violet light.

In simplest terms, primary source of visible light (or any other electromagnetic radiations) is release of energy when electron jumps from its excited state to the stable state. Depending on the energy released, different types of radiations are generated.



All atoms consist of nuclei and orbiting electrons. When any material is heated, electrons of individual atoms in inner orbits get excited and jump to outer orbits. However, when these excited electrons jump back to their stable state energy is released. For example, if an iron rod is heated, it emits invisible infrared radiation. If the rod is heated further it becomes red. This means energy released by excited electrons correspond to red light wavelength. If the iron rod is continuously heated more, the colour changes from red, orange and yellow to bright white. Similarly, a common incandescent bulb emits light when its tungsten filament is heated by electric current.

In case of fluorescent lights and CFLs, light is produced by a combination of electric discharge through a gas and fluorescence. In case of light emitting diodes (LEDs), light is emitted on account of energy released during recombination of electrons and holes (electron holes).

The brightest source of light for our Earth is the Sun, which gives us light and heat that make life survive on Earth. The source of energy of the Sun is fusion reaction in which two hydrogen atoms are fused to form one helium atom and release energy. The Sun produces radiation covering almost the entire electromagnetic spectrum - from radio waves to gamma rays. However, gamma rays do not reach the surface of the Sun due to absorption in the core. X-ray form a small part of the solar radiation. Main constituents of solar energy are infrared, visible light and ultraviolet. These electromagnetic radiations travel through space. On reaching Earth, most of the ultraviolet radiations are absorbed in the atmosphere and we see mainly the visible part of the spectrum. ■

Studying molecular processes through nanoscopy

Biman Basu
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For a long time physicists had believed that optical microscopes can never attain a better resolution than half the wavelength of light because of a fundamental law of optics known as the 'diffraction limit', also known as the 'Abbe limit', after the German physicist Ernst Abbe who demonstrated in 1873 that the resolution of an optical microscope is limited by, among other things, the wavelength of the light. As a consequence, it was believed, how small an optical microscope can see is limited by the wavelength of light and the smallest object that can be resolved is about 0.2 millionths of a metre. Smaller objects such as bacteria, viruses and proteins cannot be resolved by an optical microscope. A technique called electron microscopy can resolve far smaller details than can optical microscopy, but it must take place in a vacuum; it is suitable only for samples that are dead, or that were never alive.

This year's Nobel laureates found a way to work round the diffraction – by making parts of the molecules glow. Eric Betzig of the Howard Hughes Medical Institute in Virginia, USA; Stefan W. Hell of the Max Planck Institute for Biophysical Chemistry in Germany; and William E. Moerner of Stanford University in California, USA, were able to bring "optical microscopy into the nano-dimension," enabling scientists to "study living cells in the tiniest molecular detail". The trio won the prize for overcoming what had seemed to be an insurmountable barrier to using microscopes to see features in biological cells that are smaller than a few hundred nanometres across. The methods developed by them have come to be known as super-resolution microscopy or 'nanoscopy'.

To overcome the problem of the diffraction limit, the scientists followed different routes. Hell took one approach to solving the problem, while Betzig and Moerner took a somewhat different route.

William E. Moerner

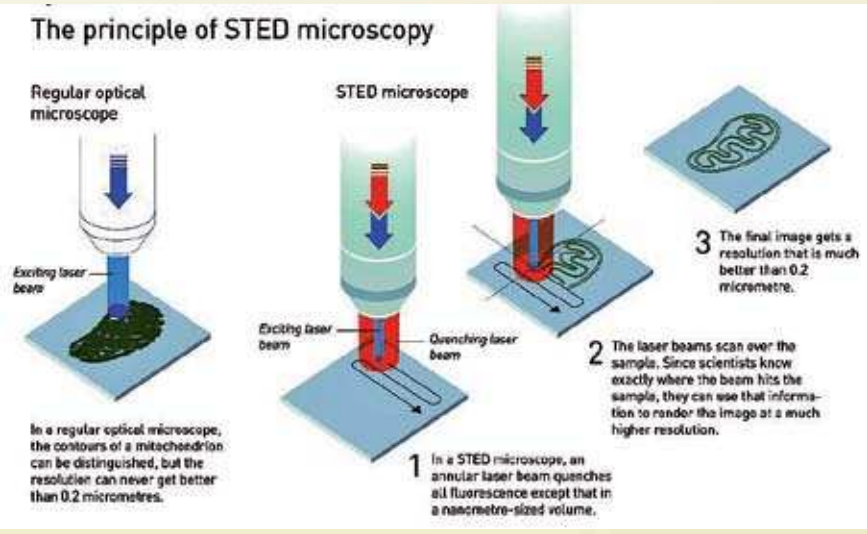
Eric Betzig

Stefan W. Hell

Both techniques, however, involve "tagging" a relatively large biological molecule of interest with much smaller fluorescent molecules that glow briefly (or "blink") after being illuminated with a pulse of laser light.

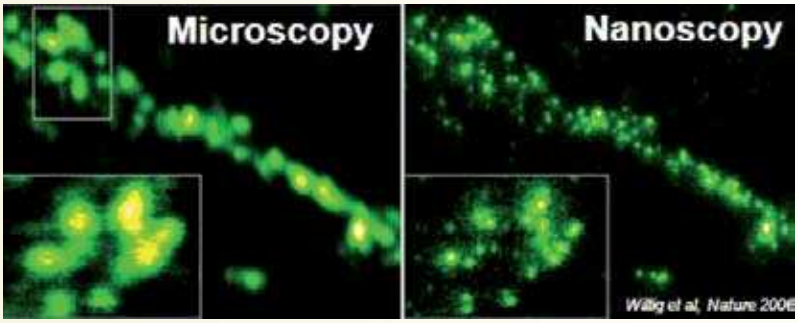
Hell has been using fluorescence microscopy, in which scientists use fluorescent molecules to image parts of the cell. For instance, fluorescent antibodies are used to couple specifically to cellular DNA (deoxyribonucleic acid). To do this, antibodies are excited with a brief light pulse, making them glow for a while, and when they couple to the DNA they will radiate from where the molecule is located in the cell nucleus. But this technique only allowed them to locate clusters of molecules, such as entangled strands of DNA. The resolution was not good enough to discern the individual strands.

Hell thought that if he could devise some kind of nano-flashlight that could sweep along the sample, a nanometre at a time, he could quench all the fluorescent molecules through stimulated emission except the one of interest in the middle. By delivering precisely calibrated pulses of energy, lasers can be used to make certain molecules glow temporarily in a process called fluorescence. Such fluorescence can be suppressed by light of another colour. In 2000, Hell developed a technique called stimulated emission depletion (STED) microscopy, which uses laser beams to home in on fluorescently glowing molecules, scanning a sample nanometre by nanometre to produce a high-resolution image. The STED microscope collects light from a multitude of small volumes to create a large whole. Hell used two combined beams, one designed to induce fluorescence and another designed to quench it over the same area – except a tiny part in the centre. The effect of overlapping these two beams is the emission of fluorescent light from a central region that is smaller than the diffraction limit. Indeed, the size of the region can, in principle,



STED microscopy

be made arbitrarily small by adjusting the relative intensities of the two lasers. By sweeping the paired beam across a sample and measuring the light emitted by the few remaining central molecules, features much smaller than the diffraction limit can be resolved.



Nanoscopy provides unprecedented optical resolution not attainable by conventional optical microscopy

Working separately, Betzig and Moerner paved the way for single-molecule microscopy, in which interspersed molecules are fluoresced on and off such that, when the same area is imaged multiple times, superimposition of the resulting images results in nano-level resolution.

It was in 1989 that Moerner became the first scientist in the world to measure the light absorption of a single molecule. Eight years later he took the next step towards single-molecule microscopy, building on the previously Nobel Prize-awarded discovery of the green fluorescent protein (GFP). He discovered that the fluorescence of one variant of GFP could be turned on and off at will. When he excited the protein with light of wavelength 488 nanometres the protein began to fluoresce, but after a while it faded. Regardless of the amount of light he then directed at the protein, the fluorescence was dead. It turned out, however, that light of wavelength 405 nanometres could bring the protein back to life again. When the protein was reactivated, it once again fluoresced at 488 nanometres.

Moerner dispersed these excitable proteins in a gel, so that the distance between each individual protein was greater than Abbe's diffraction limit of 0.2 micrometres. Since they were sparsely scattered, a regular optical microscope could discern the glow from individual molecules – they were like tiny lamps with switches. By this discovery Moerner demonstrated that it is possible to optically control fluorescence of single molecules.

Inspired by Moerner, among others, Betzig had already detected fluorescence in single molecules using near-field microscopy. He began to ponder whether a regular microscope could yield the same high resolution if different molecules glowed with different colours, such as red, yellow and green. The idea was to have the microscope register one image per colour. If all molecules of one colour were dispersed and never closer to each other than the 0.2 micrometres stipulated by Abbe's diffraction limit, their position could be determined very precisely. Next, when these images were superimposed, the complete image would get a resolution far better than Abbe's diffraction limit, and red, yellow and green molecules would be distinguishable even if their distance was just a few nanometres and thereby Abbe's diffraction limit could be circumvented.

Realising there was a protein that could make other proteins visible inside cells revived Betzig's thoughts of how to circumvent Abbe's diffraction limit. The real breakthrough came in 2005, when he stumbled across fluorescent proteins that could be activated at will, similar to those that Moerner had detected in 1997 at the level of a single molecule. But Betzig realised that the fluorescent molecules did not have to be of different colours, they could just as well fluoresce at different times. When the fluorescence dies out after a while, a new subgroup of proteins is activated so that another fraction of them is made to fluoresce this time. This gives rise to another image and this procedure is repeated several times. By superimposing such a series of images, Betzig obtained a super-resolution image of the lysosome membrane with a resolution far better than the diffraction limit. While an individual image only shows the locations of a few molecules, repeating the process many times allows a composite image of all the molecules to be created.

The technique developed by Betzig and Moerner involves illuminating a biological sample tagged with a custom-made fluorescent protein with a weak laser pulse of the correct wavelength. Using a weak light pulse only a fraction of the proteins in the sample is made to glow. Owing to their small number, the positions of all the glowing proteins molecules are such that their distances from one another are greater than 0.2 micrometre. By this, the position of each glowing protein molecule could be registered very precisely.

The methods developed by the three laureates have led to several nanoscopy techniques and are currently used all over the world. The techniques allow biologists to look at the mechanism of biological processes such as how DNA folds and unfolds within living cells using optical microscopy. In fact, over the past 10 to 15 years there has been increasing use of optical methods to look at single molecules at the nano level. ■

When a fish went for walking

Dr T V Venkateswaran
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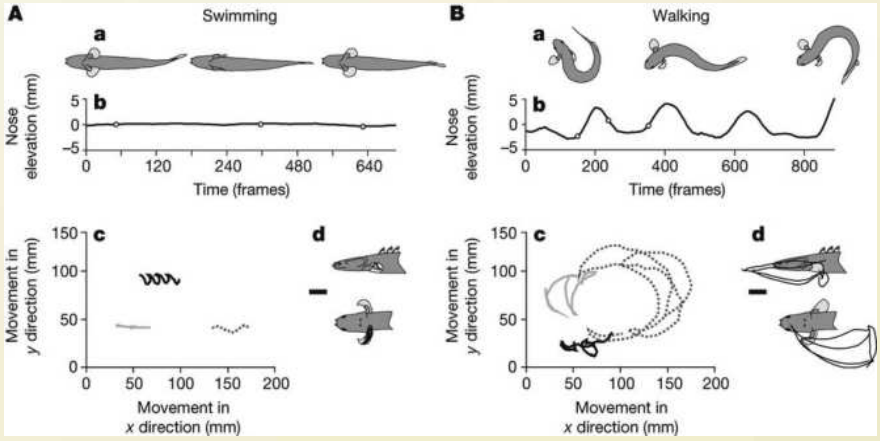
Once upon a time, long long ago – about 400 million years ago – a kind of a fish decided to take a walk; they came to the land and evolved into tetrapods (amphibians, reptiles, birds, and mammals) that roam four corners of the world today. Although copious fossil records suggest this scenario, how they used fishy bodies and fins in a terrestrial environment is one of the unsolved mysteries of evolution. A recent study by team of researchers led by Emily Standen of the University of Ottawa, Ontario, Canada on a type of fish of the genus Polypterus perhaps may shed some light on what might have happened when fish first attempted to walk out of the water (Nature, 4 September 2014 | doi:10.1038/nature13708).

When Polypterus senegalus or Senegal bichir, as it is commonly known, finds itself on the banks of the river, it is not 'fish out of water'. P. Senegalus is a strange African fish, one of the rare species that has both gills and lungs. It has an elongated shape, about 7-8 cm long, and is found abundantly in African rivers. It can use its fins and tail to scurry around the banks of the river and survive on land. It can breathe air, 'walk' on land and closely resembles the extinct ancient marine organism Tiktaalik that later evolved into land creatures. Emily wondered what would happen if juvenile P. Senegalus are raised in terrestrial conditions without permitting them to swim. Would there be any change in the phenotype (observable characteristics or traits)?

A poet rued in dejection, 'With him for a sire and her for a dam. What should I be but just what I am?' But truly speaking, there is nothing to despair; if heredity deals the cards; environment plays the hand. Take for example the freshwater planktonic crustacean, Daphnia. Under laboratory conditions, if the water in the aquarium is laced with chemical traces of the predator then the pregnant Daphnia gives

birth to offspring with a defensive 'helmet' that protects the juveniles against predators. On the other hand, when the aquarium is free of predator scent, then the offspring hardly have the 'helmet', which in predator-free environment is a liability for both survival and reproductive success.

More and more studies show that phenotypes are not necessarily set in stone, though some may be more responsive to change than others, depending on the age of exposure and degree of severity, to different environmental variable. Genetics and environment are inextricably intertwined; there is no organism without a genome; but there is also no such thing as an organism without an environment. Hence it is not always just nature; nurture is as important in the growth and development of an organism.



Taking cue from this 'developmental plasticity' perception, Emily wanted to examine the effect of shallow water on the developmental phenotype of Polypterus and find out if that could shed light on the enigma of marine creatures migrating to terra-firma. She constructed a special tank with an unusual floor. While the bottom of the tank could hold only millimetre-deep water, the aisles on all sides were dry patches covered with sand. Schools of juvenile Polypterus were placed in these tanks and were observed for eight months. Having too little water to swim, these animals used their fins and tails to scoot around, looking for food in the fish tank.

As these Polypterus matured, Emily studied their anatomy, physiology and behaviour. She found that, like soldiers trained to crawl under barbed wire keep their arms in the front and plod forward, the Polypterus raised in terrestrial condition walked more effectively by placing their fins closer to their bodies. Further the Polypterus raised on land could lift their heads higher and keep their fins from slipping. They used the fin almost like a crutch, which gave them a little extra height when their "shoulders" rose upward and forward. As this posture temporarily hoisted more of the fish's body into the air, there was less tissue to rub along the ground and be slowed by friction. On the other hand, those Polypterus which were raised in tanks filled with water were clumsy; when placed on land, they sort of moved around gawkily.

Secondly, young Polypterus forced to walk, not swim, developed a sturdier build and certain specific bones in their heads and shoulder regions began developing differently. The clavicle bone in their chests

Continued on page 27

Does mobile phone radiation affect public health?

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This article is intended to provide awareness on mobile phone radiation, its effects on public health, and precautions to minimise exposure. The efforts of regulating authorities like International Telecommunication Union (ITU) and Department of Telecommunication (DoT) of Government of India, and World Health Organisation (WHO) to provide hazard-free communication for public is explained.

Statistics

As per a United Nations study, which was published in March 2013, out of the world's estimated population of 700 crore, 600 crore people have access to mobile phones whereas only 450 crore people have access to working toilets. As per the estimates available with International Telecommunication Union (ITU), by the end of 2014, there will be almost 300 crore of internet users and 230 crore mobile-broadband subscribers globally.

Mobile phone functioning and radiation

The first hand-held mobile phone was demonstrated by John F. Mitchell and Martin Cooper of Motorola in 1973, using a handset weighing around 1 kg. The mobile phone has undergone so many developments during the last three decades and the smartphones of today are capable of supporting a wide variety of other services like text messaging, internet access, e-mail, short-range wireless communications (Bluetooth and Wi-Fi), business applications, banking applications, gaming, photography, video shooting, etc., in addition to voice calls.

A mobile phone, also known as a cellular or cell phone, is a portable device that can be used to make and receive telephone calls over a wireless link while moving. The connection is established between the mobile phone and nearest cell tower (also called as Base Transceiver Station, or BTS) of the service provider. This microwave radio link established between the mobile phone and the BTS of Global System for Mobile Communication (GSM) Network is the channel for communication.

When a mobile phone is switched ON, its receive circuit is ON and a radio link (down link) is established between the mobile phone and nearest cell tower (BTS). The mobile phone transmits signals to the BTS through uplink for brief periods during (i) establishing contact with BTS after switching ON; (ii) sending acknowledgement to BTS; and (iii) while sending an SMS. But when we are talking over a mobile phone its transmitter will be radiating electromagnetic waves – radio frequency (RF) fields – until the call is disconnected. This radiated signal carries the voice information as modulated waves. So, the radiation exposer is much less while sending text messages compared to while talking

In receive mode, the signal being received by the mobile phone from the nearest BTS is of very low level, of the order of nanowatts (unless very close to BTS) and the receiver is very sensitive. The received signal is processed, decoded and demodulated to convert it back to text message or audio signal.

First Mobile Phone and Latest Smartphone

Table 1: Distance versus power density

Distance R	Power density
10 cm	0.00126watt/cm^2 (=12.60 watt/m^2)
20 cm	0.000315watt/cm^2 (=3.15 watt/m^2)
40 cm	0.00007875watt/cm^2 (=0.7875 watt/m^2)
50 cm	0.0000504watt/cm^2 (=0.504 watt/m^2)
1 m	0.126 watt/m^2
5 m	0.00504 watt/m^2
10 m	0.00126 watt/m^2
100 m	0.0000126 watt/m^2
1 km	0.000000126 watt/m^2
2 km	0.0000000315 watt/m^2

The transmitter of the BTS of mobile communication network is always ON and radiates electromagnetic waves continuously. The transmitter power of a cell tower is of the order of 20 watts and that of a mobile phone is of the order of 1 to 2W. The transmission power at the antenna of both BTS/mobile phone is high, but as the distance increases, the transmission signal level decreases rapidly. This is because the observed power level at any point is inversely proportional to square of the distance of the observation point from the radiating source.

From the Table 1, it can be understood that if we move away from the radiation source, the electromagnetic field density decreases rapidly. For instance, if we kept a mobile handset at a distance of 30 to 50 cm away from the body when (i) we are sending a text message. or (ii) browsing internet, or (iii) talking over phone using hands-free devices like wired head-set/Bluetooth device, the radiation exposure level will be reduced very much. If we talk for a long time

it is better to connect a wired head-set to mobile phone. In case of cordless phones, the transmission power level of radiated signal is of the order of 0.01 to 0.1watt, which is much less than of a mobile phone. Hence, Radiation exposer level to cordless phone users is far less. The same thing holds good while using Wi-Fi/Bluetooth signals because these operate in license-free frequency bands of very low power level.

A BTS usually carries multiple antennas and therefore the power density would be quite high near the antennas of a BTS. Generally, a BTS is installed on a mast of about 35 metres or on top of the highest floor of an apartment on a separately built elevated mast which is not easily accessible except to maintenance people, who follow the safety guidelines framed by the regional regulating authorities of the government.

Mobile phone frequency band is in the lower side of electromagnetic spectrum

Frequency bands used for GSM 900, CDMA, GSM 1800 and 3G are subsets of ultrahigh frequency (UHF) band, i.e., 300 MHz to 3000 MHz. Even the frequency band used for GPS (L band) and Wi-Fi (normally 2400-2483.5MHz, which is very low power license-free band) are also subsets of UHF band only. All the above bands occupy the lower side of the electromagnetic frequency spectrum whereas X-rays and gamma rays occupy the higher side. Mobile phone radiation is considered as non-ionizing, like infrared, ultraviolet, and visible radiation. At the frequencies used by mobile phones, most of the radiated energy is absorbed by the skin and other superficial tissues, resulting in very small temperature rise in the brain or any other organ of the human body. According to physicist Bernard Leikind, known carcinogens such as X-rays, gamma rays and UV rays have energies greater than 480 kilojoules per mole (kJ/mole), which is enough to break chemical bonds. Green-light photons hold 240 kJ/mole of energy, which is enough to bend (but not break) the rhodopsin molecules in our retinas. A cell phone radiation has energy of less than 0.001 kJ/mole. That is 4,80,000 times weaker than UV rays and 2,40,000 times weaker than green light. Hence, we can say that radiation from mobile phones is less harmful than long exposure to the summer Sun.

Specific Absorption Rate

Radiofrequency exposure limit (human exposure standard) for Mobile phone users is specified in terms of a parameter called "Specific Absorption Rate (SAR)". SAR is the rate of radiofrequency energy absorption per unit mass of the body. All mobile phones are supposed to radiate below this exposure level standard. The recommended value of SAR in India is 2 watts/kilogram maximum. Modern mobile phones have in-built integrated patch antenna located near the rear bottom of the mobile phone. While carrying a mobile phone in belt pocket in switched ON condition, it is better to place the mobile in such a way that its front display faces the body so that antenna is away from the body.

Use of hands-free devices like wired head-set and Bluetooth devices while talking can help reduce the radiation exposure levels because the mobile phone can be kept at a distance of 30-50 cm away from the body.

Mobile phone's transmit power is auto-selectable and depends on the link quality between BTS and the mobile phone. Before making the call it is better to look for clear signal or at least move near to open window/ glass window instead of being in a closed room. If the link between the phone and BTS is strong, then the phone will radiate relatively less transmission power during voice call, which results less radiation exposer to user. The attenuation caused by different materials for electromagnetic radiation fields in increasing order is as follows:

Air < Glass < Wooden door < Concrete wall.

Contribution and efforts of regulating authorities

The International Telecommunication Union (ITU) is the specialized agency of the United Nations for Information and Communication Technologies (ICTs). ITU allocates global radio spectrum for mobiles and other communication systems and develop the technical standards to improve access to ICTs throughout the world in a comfortable and affordable manner. ITU currently has a membership of 193 countries and over 700 private-sector entities and academic institutions. ITU is headquartered in Geneva, Switzerland and has twelve regional and area offices around the world. ITU helps in finding technological solutions and works to improve telecommunication infrastructure in the world. By the end of 2020, ITU plans to implement broadband mobile communication including the worldwide villages in a safe environment with the help of regional support.

In India, the Wireless Planning & Coordination (WPC) Wing of the Ministry of Communications is the National Radio Regulatory Authority responsible for frequency spectrum management, including licensing and caters for the needs of all wireless users.

Contribution of World Health Organization for mobile phone user safety

World Health Organization (WHO) is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, and providing technical support to countries and monitoring and assessing health trends. In response to public and governmental concern, WHO established the International Electromagnetic Fields (EMF) Project in 1996 to assess the scientific evidence of possible adverse health effects from electromagnetic fields. A lot of research has been concentrated on electromagnetic radiation effects of mobile phones on public health like cancer and biological health effects, and also the possible role of mobile phones in traffic accidents.

Studies to date provide no indication that environmental exposure to RF fields from Base stations/mobile phones increases the risk of cancer or any other disease. Scientists have reported other health effects of mobile phones including changes in brain activity, reaction times, and sleep pattern disorders. It was mentioned that these effects are minor and have no apparent health significance. More studies are underway to try to confirm these findings.

Research has shown an increased risk of traffic accidents, some 3-4 times greater chance of an accident, when mobile phones are used while driving. American Society for Reproductive Medicine reported that their studies have found 30% sperm decrease in males who make intensive use of mobile phones.

The international pooled analysis of data gathered from 13 participating countries found no increased risk of glioma or meningioma (two types of brain tumours) with mobile phone use of more than 10 years.

In particular, with the recent popularity of mobile phone use among younger people, WHO has promoted further research on this group. Several studies investigating potential health effects in children and adolescents are underway.

Contribution of government departments and universities in India for mobile phone user safety

In India, Department of Telecommunication (DoT) and its wings, Ministry of Health, Department of Biotechnology and a number of universities and other organisations are initiating research/studies and providing guidelines for safety of mobile users. The strong recommendation mentioned was, "Either keep voice calls short or send a text message (SMS) instead. This advice applies especially to children, adolescents and pregnant women". There was also a suggestion by university studies not to use cell phone for more than 18 to 24 minutes per day for voice calls.

Tips for mobile phone users to reduce the exposure levels of RF fields

The following are tips for mobile phone users to reduce the exposure levels of electromagnetic radiation.

1. While talking, it is better to hold the phone at least about one centimetre away from the head.
2. While making a voice call it is better to look for strong receive signal on the mobile screen by moving nearer to open window/glass window or a balcony rather than being in a closed room.
3. Text messaging or browsing mobile internet is safer than long duration talk.
4. Smartphone can be kept at least 30 cm away from the body while using mobile internet.
5. When long-duration talking or frequent talking is necessary (at home/ safe place), wired head-set or Bluetooth devices can be used so that the mobile phone can be kept 30- 50 cm away from the body. But wired head-sets and Bluetooth devices should be used during usage time only and must be strictly avoided during driving and walking.
6. Talking over mobile phone while walking in public places is not a safe and it should be strictly avoided for self-safety.
7. Conversation can be made short as far as possible in public places.
8. Pregnant ladies better use land line or cordless phone instead of mobile phone at home. While using mobile phone better to use wired head-set or speaker mode (at home) and keeping the talk short.
9. Mobile phones/Smartphone should be kept away from small kids.
10. Mobile phone can be switched off during the night time except when there is an emergency.
11. Talking over mobile phone should be strictly avoided during driving. Drivers should not also use wired head-set/ Bluetooth device while driving. People who are staying in buildings near cell towers should avoid exposure to radiation. They should not spend time on the terrace of the building. Because studies have shown possible risk of biological health effects due to prolonged exposure of radiation.

The above-mentioned tips are based on the safety guidelines recommended by WHO; recommendations of different surveys available on mobile phone radiation; and principles of science regarding radiation and observations in the society. The safety guidelines mentioned in the user manual of mobile phone are to be followed carefully. Fortunately most of the children use mobile phone/smartphone for text/chat/broad-band internet browsing, which gives lesser exposer to RF radiation, but they have to restrict the usage time. If mobile phones or smartphones are used properly, these are very useful devices which make our life comfortable.

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I.V. Tatarao is a scientist with the Wireless Group, R&D division of ITI Limited, Bangalore. He has wide experience in the design and development of wireless communication systems and STM-1/STM-4 interface design for encryptors.

Continued from page 30

(When a fish went for walking)

was more strongly attached to the bone in the shoulder area. While normal Polypterus raised in water used buoyancy to support itself, the conditions faced by theland-living Polypterus enabled it to have a slightly altered skeleton that could bear weight on land.

The gill area in Polypterus raised on land also enlarged a little and at the back of the head, bone connections loosened slightly. This enabled the fish to have a slightly more flexible neck, helping it to feed better on land. In contrast, in water, stiff neck is sufficient as the fish could dart the body above or below or elsewhere to attack the food.

Emily Standen says, "Stressful environmental conditions can often reveal otherwise cryptic anatomical and behavioural variation, a form of developmental plasticity. We wanted to use this mechanism to see what new anatomies and behaviours we could trigger in these fish and see if they match what we know of the fossil record". The changes observed in the land-reared Polypterus suggest how some prehistoric fish-like ancestors of tetrapods might have moved.

In evolutionary terms, the changes observed in eight months are indeed lightning speed. This suggests that quirky conditions early in life similarly might have given ancient fish a little head start in adapting to life out of water. Strictly speaking, however, showing that a modern fish has the flexibility to cope with land does not prove that prehistoric fish also had it. Yet, the experiment sheds some light on the kinds of changes that enabled fins to become limbs, as many of the anatomical changes observed in Polypterus mirror the fossil record.

Ebola virus disease: A natural disaster


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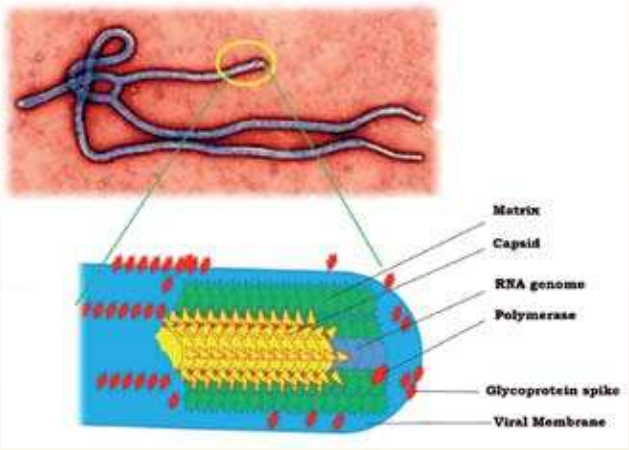
What is Ebola?

Ebola is a rare, acute and severe disease caused by Ebola virus, also known as Ebola haemorrhagic fever or Ebola virus disease. It could be fatal if not treated. It spreads in humans and non-human primates, viz., monkeys, chimpanzee, and gorillas. The Ebola virus belongs to Filoviridae family. Its genome contains single-stranded RNA. When the virus particle attaches to a specific cell surface receptor (a glycoprotein) of cell membrane, it releases its nucleocapsid (protein shell along with the nucleus) into the cytoplasm and replicates its genetic material. The newly formed nucleocapsids and envelope proteins associate at the host cell's plasma membrane. Its budding occurs and destroys the cell.



Morphology of Ebola virus

There are three genera of Filoviridae: Cuevavirus, Marburgvirus, and Ebolavirus. Out of the five types of Ebola virus, four have been reported to cause disease in humans and one in non-human primates only. *Zaire ebolavirus* (Ebola virus), *Sudan ebolavirus* (Sudan virus), *Bundibugyo ebolavirus* (Bundibugyo virus), and *Tai forest ebolavirus* (Tai forest virus) cause infection in humans and *Reston ebolavirus* (Reston virus) in non-human primates. The three Ebola viruses, namely Zaire ebolavirus, Bundibugyo ebolavirus, and Sudan ebolavirus have been associated with large outbreaks in Africa.

The disease infects humans through close contact with infected animals including chimpanzees, fruit bats and forest antelope. Later it spreads by direct contact with infected blood, body fluids or with contaminated environments.

Why is Ebola so dangerous?

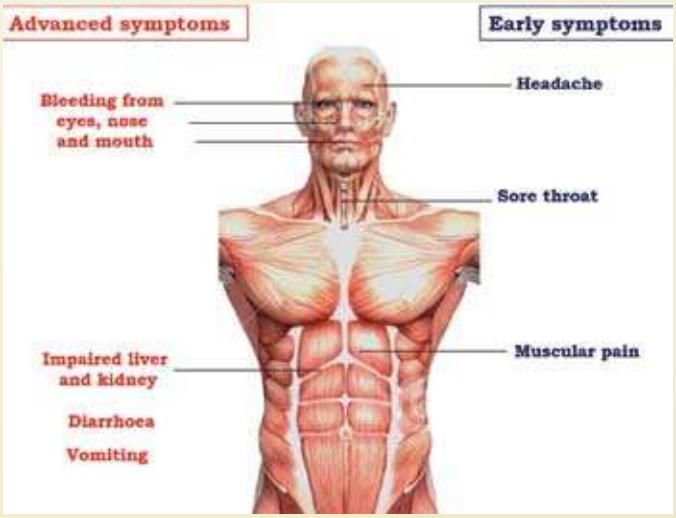
The Ebola virus disease typically occurs in Sub-Saharan Africa, the ongoing outbreaks affecting Guinea, Liberia, and Sierra Leone. It may spread to other countries by persons who have recently visited the affected areas. The deadly outbreak of Ebola virus has spread fear to other continents.

History of Ebola fever

Ebola virus disease (EVD) first appeared in 1976 in two simultaneous outbreaks. The first outbreaks occurred in Nizara, Sudan and the other in Yambuku, Democratic Republic of Congo. The names Ebola comes from the latter outbreak, which occurred in a village near the Ebola River. The current case of Ebola outbreak in March 2014 in West Africa is the largest and most complex outbreak since the 1976. This deadly virus belongs to the Zaire species that caused more deaths in this outbreak than all others combined. The World Health Organization (WHO) declared this outbreak a public health emergency of international concern. There were a total of 1,716 cases reported by WHO till 2013, but the current outbreak has already led to 5,078 deaths and 12,008 suspected cases.

Symptoms of Ebola virus disease

The symptoms of Ebola fever are similar to other diseases common in Africa, including malaria, dengue fever, Marburg virus disease and viral haemorrhagic fevers. The incubation period is 2 to 21 days. Humans become infectious after development of symptoms. The initial symptoms include a sudden fever, muscle pain, intense weakness, headache and sore throat. Later stages include diarrhoea, vomiting, rash, symptoms of impaired liver and kidney function and in some cases internal and external bleeding. There is also decrease in WBC count and platelet count and increased level of liver enzymes.



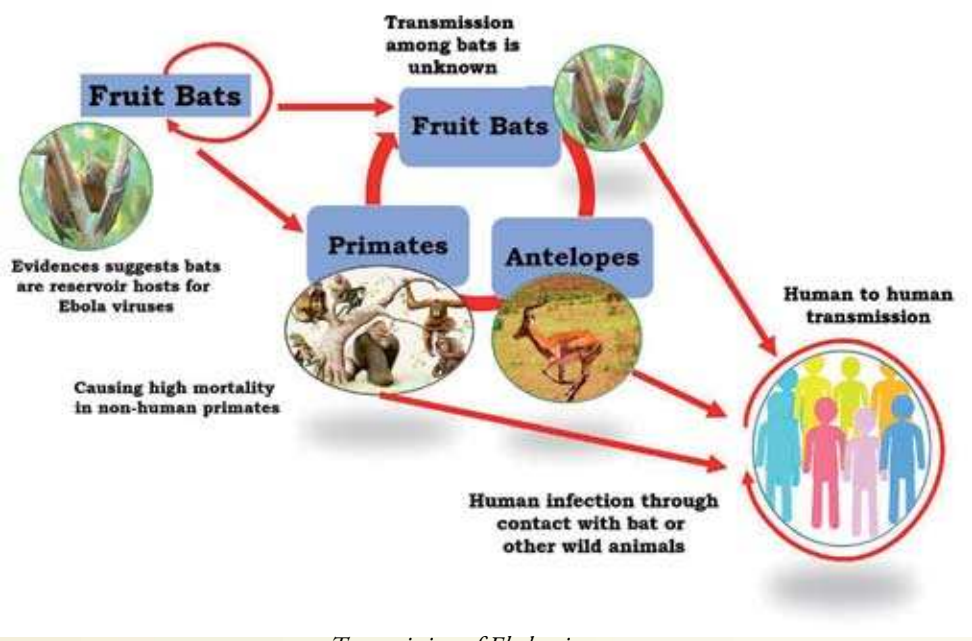
Symptoms of Ebola virus disease

Reservoir of Ebola virus

The natural reservoir of Ebola virus has yet to be confirmed; however, on the basis of evidence and the nature of similar viruses, bats are considered to be the most likely reservoir. Three types of fruit bats were found to possibly carry the virus without any falling sick. These are: *Hypsignathus monstrosus*, *Epomops franqueti*, and *Myonycteris torquata*.

Transmission

It is not entirely clear how Ebola initially spread from animals to humans, but it is believed to be contact with infected wild animals



Transmission of Ebola virus

or bats. It spreads in humans by direct contact with blood or body fluids (mucus, saliva, sweat, tears, vomit, urine, semen, breast milk) of the infected persons. Entry points of the virus include the nose, eyes, mouth, wounds, cuts and abrasions. Men who have recovered from the disease can still transmit the virus through their semen via sexual intercourse for up to seven weeks. Ebola may also occur in the breast milk of women after recovering from the disease and it is not known when it is safe to breast feed again. Evidence indicates the dogs and pigs can be infected with Ebola virus, but dogs don't appear to develop symptoms while carrying the virus and pigs appear to transmit the virus to some primates. Domestic dogs that dwell in the area where outbreaks happened have been found to contain antibodies to Ebola virus, but their role in spreading the disease to people is unclear. So far there is no report of involvement of mosquitoes or other insects in spreading the disease.

Diagnosis

As the symptoms of the disease are not easily distinguishable from malaria, typhoid and meningitis, there are non-specific, specific and differential tests for the Ebola fever. Non-specific tests include low platelet count, increased level of liver enzymes and abnormality in blood clotting. Tests that confirm the Ebola virus includes:

- Antibody-capture enzyme-linked immunosorbent assay (ELISA)
- Antigen-capture detection tests
- Serum neutralisation test
- Reverse transcriptase polymerase chain reaction (RT-PCR) assay
- Electron microscopy
- Virus isolation by cell culture.

Treatment and vaccines

There is no specific treatment approved for the Ebola virus disease so far; however, supportive oral or intravenous fluids and treatment improve survival. Treatments for the Ebola virus disease are being evaluated, but there are no vaccines available yet. Favipiravir (also known as T-705 or Avigan) and Brineidofovir (CMX001) are antiviral drugs currently being used for the treatment of Ebola virus disease. Zmapp is an antibody vaccine comprising three chimeric monoclonal antibodies and is under development. Although some individuals have recovered, the outcome is not considered statistically significant.

Prevention and control

As there is no satisfactory cure for Ebola virus disease and treatments are still being evaluated. So there is a great need to do the following measures to prevent the infection of Ebola virus:

- Surveillance and contact tracing
- Safe burial or cremation of the dead
- Raising awareness among people about the risk factors for Ebola infection
- Use of protective gloves and clothing for safety while handling the animals
- Avoiding direct contact with any kind of bodily fluids such as saliva, vomit, urine, blood, semen, sweat, etc., of Ebola infected people and notifying health officials if there is direct contact
- Washing hands with proper disinfectants after visiting patients in hospital
- Isolating the sick from healthy persons
- Avoid contact with bats or other non-human primates and raw meats from these animals
- Monitoring of health for 21 days after returning from an Ebola affected area
- Seeking medical care immediately after getting symptoms like Ebola fever
- Avoiding contact with virus contaminated objects like needles and syringes, etc.

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Glaucoma— The silent vision thief

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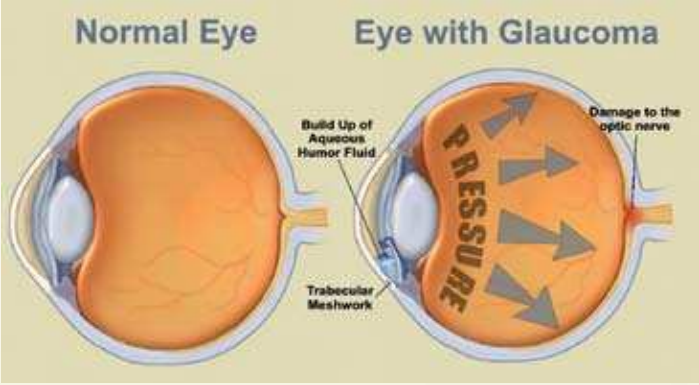
Glaucoma is sometimes called the silent thief, slowly stealing the sight before a person realises anything is wrong. The most common form of glaucoma develops gradually, giving no warning signs. Many people are not even aware they have an eye problem until their vision is extensively damaged.

Actually, glaucoma is not just one disease but a group of them. The common feature of these diseases is that abnormally high pressure inside the eyeball damages the optic nerve.

The optic nerve is a bundle of more than a million nerve fibres at the back of the eye. It is like a big electric cable made up of thousands of individual wires carrying the images you see from the retina to the brain. Blind spots develop in your visual field when the optic nerve deteriorates, starting with your peripheral (side) vision. If left untreated glaucoma may lead to blindness in both eyes.



Fortunately, only a small percentage of people with the disease ever lose their sight. If detected and treated early, glaucoma need not cause even moderate vision loss. Recent medical advances have made it easier to diagnose and treat glaucoma. However, it does require regular monitoring and treatment for the rest of your life.

Understanding eye pressure

Internal pressure in the eye, called intra-ocular pressure, allows the eye to hold its shape and function properly. Intra-ocular pressure is like air in a balloon — too much pressure inside the balloon affects its shape and may even cause it to pop. In the case of your eye, too much pressure can damage the optic nerve.

Fluids inside the eye help maintain the intra-ocular pressure. These fluids are the vitreous humour, which fills the vitreous cavity, at the back of the eye, and the aqueous humour, which fills the anterior chamber, at the front of the eye.

Aqueous humour is continuously produced and circulated through the anterior chamber before draining out of the eye. This continuous flow of fluid nourishes the lens and the cornea and removes unwanted debris. A healthy eye produces aqueous humour at the same rate that it drains fluid, thus maintaining a normal pressure.

Movement of fluid in the eye

Aqueous humour continuously circulates from behind the iris into the anterior chamber. It exits the eye where the iris and the cornea meet. The fluid passes through a sieve-like system of spongy tissue called the trabecular meshwork and drains into a channel called Schlemm's canal. The fluid then merges into the body's bloodstream.

When the drainage system doesn't function properly — for example, if the trabecular meshwork gets clogged — the aqueous humour cannot flow at its normal rate and pressure builds up within the eye. For reasons not completely understood, the increased eye pressure gradually damages the nerve fibres that make up the optic nerve.

Eye pressure: what is normal?

Normal eye pressure ranges from 10 to 22 millimetres of mercury (mm Hg). Anyone with eye pressure over 23 mm Hg is considered at risk of developing glaucoma and needs to be carefully monitored for early signs of glaucoma. People with intra-ocular pressure greater than 30 mm Hg are considered at high risk.

Types of glaucoma

There are several types of glaucoma. The differences have to do with what is causing the fluid blockage that builds pressure in the eye.

Primary open-angle

Primary open-angle glaucoma, also called chronic open-angle glaucoma, accounts for most cases of the disease. Although the drainage angle formed by the cornea and the iris remains open, the aqueous humour drains too slowly. This leads to fluid backup and a gradual build-up of pressure within the eye. Damage to the optic nerve is so slow and painless that a large portion of vision can be lost before you are even aware of a problem.

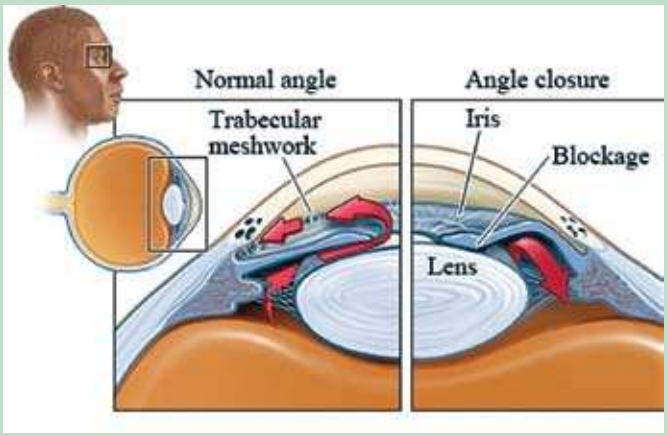
The cause of primary open-angle glaucoma remains unknown. It may be that the aqueous humour drains or is absorbed less efficiently with age, but then not all older adults get this form of glaucoma.

Closed-angle glaucoma

Angle-closure glaucoma, also called closed-angle glaucoma, is a less common form of the disease. It occurs when the drainage angle formed by the cornea and the iris closes or becomes blocked. The aqueous humour cannot exit through the trabecular meshwork, resulting in an increase in eye pressure.

Angle-closure glaucoma can progress gradually or coming on suddenly as an acute attack.

Most people with this type of glaucoma have a very narrow drainage angle, which may be an abnormality from birth. Angle closure glaucoma is more common among far-sighted people, who



Closed-angle glaucoma
The angle formed by the cornea and the iris narrows, preventing the aqueous humour from draining out of the eye. This can lead to a rapid increase in intra-ocular pressure.

tend to have smaller eyes that can narrow the angle. Normal aging also may cause angle blockage. As you get older, your lens becomes larger, pushing your iris forward and narrowing the space between the iris and the cornea.

If you have a narrow drainage angle and your pupils become widely dilated, the angle may close and cause a sudden increase in eye pressure. This attack of acute angle-closure glaucoma requires immediate treatment. Although an acute attack often affects only one eye, the other eye is at risk of an attack as well.

Several factors can cause your pupils to dilate:

- Darkness or dim light
- Stress or excitement
- Certain medications, including antihistamines, tricyclic antidepressants and eye drops used to dilate your pupils, which may not cause the angle to close until several hours after the drops are put in.

Acute angle-closure glaucoma is a medical emergency that can cause vision loss within hours of its onset. Without treatment the eye can become blind in as little as one or two days.

Secondary glaucoma

Both open-angle and angle-closure glaucoma can be primary or secondary conditions. They are called primary when the cause of the condition is unknown. They are called secondary when the condition can be traced to a known cause, such as an injury or an eye disease.

Secondary glaucoma may be caused by a variety of medical conditions, medications, physical injuries, and eye abnormalities or deformities. Infrequently eye surgery can cause secondary glaucoma.

Low-tension glaucoma

Low-tension glaucoma is an unusual and poorly understood form of the disease. In this form, eye pressure remains within a normal range but the optic nerve is damaged nevertheless. Why this happens is unknown, although some experts believe that people with low-tension glaucoma may have an abnormally fragile optic nerve or a reduced blood supply to the optic nerve, caused by a condition such as closed arteries (atherosclerosis). Under these circumstances even normal pressure on the optic nerve is enough to cause damage.

Signs and symptoms

Primary open-angle glaucoma

Primary open-angle glaucoma progresses with few or no symptoms until the condition reaches an advanced stage. As increased eye pressure continues to damage the optic nerve, you lose more and more of your peripheral vision.

Open-angle glaucoma usually affects both eyes, although at first you may have symptoms in just one eye. Other symptoms include:

The visual field at left shows a typical pattern found in someone with glaucoma. Over time, if the eye pressure remains high, a person may lose more and more of his peripheral vision (right).

- Sensitivity to light and glare
- Trouble differentiating between varying shades of light and dark
- Trouble with night vision

Acute angle-closure glaucoma

Acute angle-closure glaucoma develops suddenly in response to a rapid rise in eye pressure. An attack often happens in the evening when the light is dim and your pupils are dilated. The symptoms may be severe. Signs and symptoms include:

- Blurred vision
- Halos around lights
- Reddening of the eye
- Headache
- Severe eye pain
- Nausea and vomiting
- Hardness of the affected eye

If you have any of these signs or symptoms, get immediate medical attention. Permanent vision loss can occur within hours of the attack.

Signs and symptoms of secondary glaucoma vary and depend on what's causing the glaucoma and whether the drainage angle is open or closed. ■

{Next month: Glaucoma: Risk factors, diagnosis and self-help}

Recent developments in science and technology

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Spacecraft lands on a comet

European Space Agency's Rosetta spacecraft that had been in orbit around the comet 67P/Churyumov-Gerasimenko since August, achieved a historical feat by landing a probe named Philae on the comet's surface on 12 November 2014. The landing was not quite as planned because in the extremely weak gravity of the comet the lander bounced twice before finally settling down on the comet's surface. According to mission scientists, the probe officially landed three times on the comet: an initial touchdown, a first rebound of almost two hours, which likely caused Philae to reach up to 1 kilometre above 67P's surface, and a second jump that lasted about seven minutes. Finally, Philae settled under a cliff, possibly positioned almost vertically, with one foot in open space and the other two on the ground. Philae's awkward position in shade prevented the probe's solar panels from recharging the battery. As a result Philae went into standby mode within a couple of days.

Rosetta's lander Philae (Credit: ESA/Rosetta/ Philae/CIVA)

But before going into hibernation on 15 November, Philae was able to work for some 60 hours and send the resulting data back to Earth. The probe's multiple instruments were able to collect valuable data about comet using power supplied by its primary battery. Philae's payload included three instruments that are quite common in chemistry labs, but when deployed on a comet could answer questions about the origins of the solar system and life itself. With its 10 instruments, the mini laboratory sniffed the atmosphere, drilled, hammered and studied Comet 67P while more than 500 million kilometres from Earth.

The probe reported discovery of organic molecules in the comet's atmosphere. According to mission scientists, the find is extraordinary considering the organic compound contains carbon atom, which is the basis of life on planet Earth. Further research is being conducted to see if there are complex compounds like amino acids, considered "building blocks" for proteins, or simple ones like methane and methanol. Life on Earth is based entirely on left-handed amino acid molecules that make up proteins. According to Stephan Ulamec, Philae's landing manager, the research "will help us to understand whether organic molecules were brought by comets to the early Earth".

According to Philae scientists, the probe has sent back a great deal of valuable data, which could only have been acquired through direct contact with the comet. Together with the measurements performed by the Rosetta orbiter, it may now be possible to have a much better understanding of comets. For example, Philae data show that its surface properties are quite different than was previously thought. It is not nearly as soft and fluffy as it was believed to be. Philae's instruments found that the surface of Comet 67P is hard as ice and it was not possible to go deep into the surface by hammering a probe into the comet. Philae's Subsurface Science instrument was unable to hammer more than a few millimetres into the comet's surface to take temperature measurements as planned.

Although Philae is currently "sleeping" after exhausting its on-board battery, there is a chance it will wake up again if its solar panels get enough sunlight as the comet moves closer to the Sun. Comet 67P is due to make its closest approach to the Sun, called perihelion, in August 2015.

Philae after landing on the surface of Comet 67P/Churyumov-Gerasimenko. But the probe landed in a place where its solar panels could not recharge its battery. One of the lander's three feet can be seen in the foreground. (Credit: ESA/Rosetta/ Philae/CIVA)

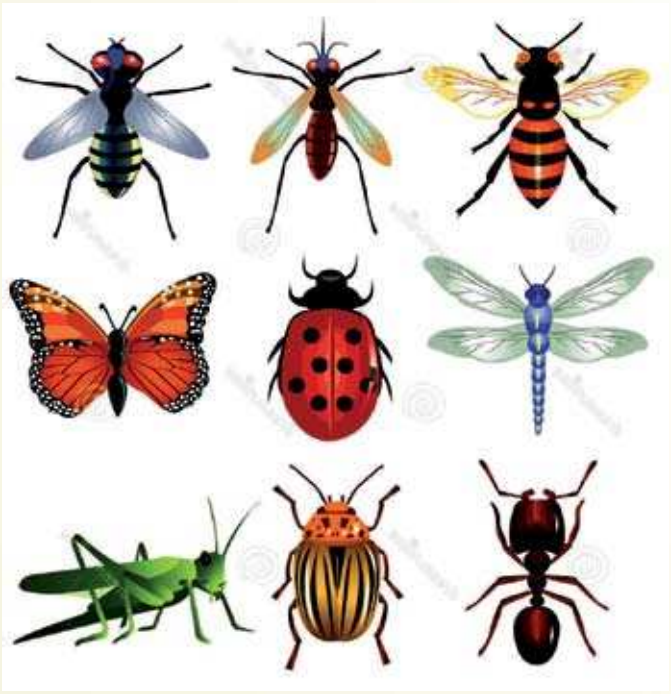
Scientists create family tree of world's insects

The first-ever comprehensive evolutionary tree of insects was recently created by a group of researchers from around the world. The research group created the insect's evolutionary

path using large genetic data sets, integrated with fossil evidence, so they could reconstruct relationships between species across nearly half a billion years of evolution. The project required experts in molecular biology, insect morphology, computing, palaeontology and insect taxonomy, and depended on supercomputers to crunch through the data sets. Led by the '1K Insect Transcriptome Evolution' – or 1KITE – project in China, the researchers used a DNA sequence dataset of unprecedented scale and new analysis techniques. This allowed them to look deep back in time to when insects evolved from crustaceans (crabs, lobsters and prawns) and emerged onto land between 450 million and 500 million years ago. The researchers sequenced all the genes from more than 140 types – such as moths, flies, wasps and beetles. They then compared all the gene sequences from the insects and found all the genes that were common to all species, and were directly comparable and used these to calculate the relationships between all the major groups of insects to resolve longstanding questions about the evolution and diversification of Earth's largest and most diverse animal group (*Science*, 7 November 2014 | doi: 10.1126/science.1257570). The research is the most recent in the emerging field of phylogenomics – the crossover between evolution and genomics.

Insects, which comprise two-thirds of all known animal species, were among the first animals to colonise and exploit terrestrial and freshwater ecosystems. They have shaped Earth's biota, exhibiting co-evolutionary relationships with many groups, from flowering plants to humans. They were the first to master flight and establish social societies.

Insects are essential to human health and the environment, recycling plant and animal material into nutrients and pollinating food crops, worth billions of rupees each year. But insects also spread diseases, and greater insight into their evolution will help researchers explore possible treatments for deadly infections such as malaria. Based on genetic data, the scientists estimate that the first insects appeared about 480 million years ago at about the same time as the first land plants, suggesting that insects and plants shaped the earliest terrestrial ecosystems together.



The first-ever comprehensive evolutionary tree of insects has been created.

The researchers also determined that insects developed wings long before any other animal could do so – around 405 million years ago – at nearly the same time that land plants first grew substantially upwards to form forests. Flying insects evolved after complex ecosystems had already developed on land. According to the researchers, the first winged insects were probably a variety of primitive dragonfly, whose facility for flight evolved about the same time plants started to grow tall. According to a possible scenario, "insects were able to crawl up onto plants and probably began their quest to fly by jumping, then gliding and gradually evolving the flapping wings we see today." The closest modern relatives of the first winged insects are dragonflies and mayflies, and large dragonfly relatives with a wingspan of 60-70 cm existed not long after insects first developed wings.

Interestingly, the new findings show that insects were buzzing around next to the dinosaurs during the Jurassic Period and that these creatures were on Earth long before the evolution of modern humans – *Homo sapiens* – some 200,000 years ago.

Ancestor of rhinos, horses originated in India

An international group of palaeontologists has discovered a horse-like animal that lived in what is now India during Eocene epoch, about 55 million years ago. The discovery fills in a major gap in understanding of the evolution of Perissodactyla, a group of animals that includes horses and rhinos. The discovery also sheds new light on how India shifted over time. The mammal, which was the size of a pig, likely weighed 25 to 30 kg, probably occupied a branch of the evolutionary tree right beside a broad group that has since radiated out into the modern rhinoceros, horse and hippopotamus (*Nature Communications*, 20 November 2014 | doi:10.1038/ncomms6570).

Modern horses, rhinos and tapirs belong to a biological group, or order, called Perissodactyla. Also known as 'odd-toed ungulates', animals in the order have an uneven number of toes on their hind feet and a

An artist's rendition shows Cambaytherium thewissi, which lived in India alongside ancestors to the modern rhinoceros, tapir, hippo and horse. (Credit: Elaine Kasmer)

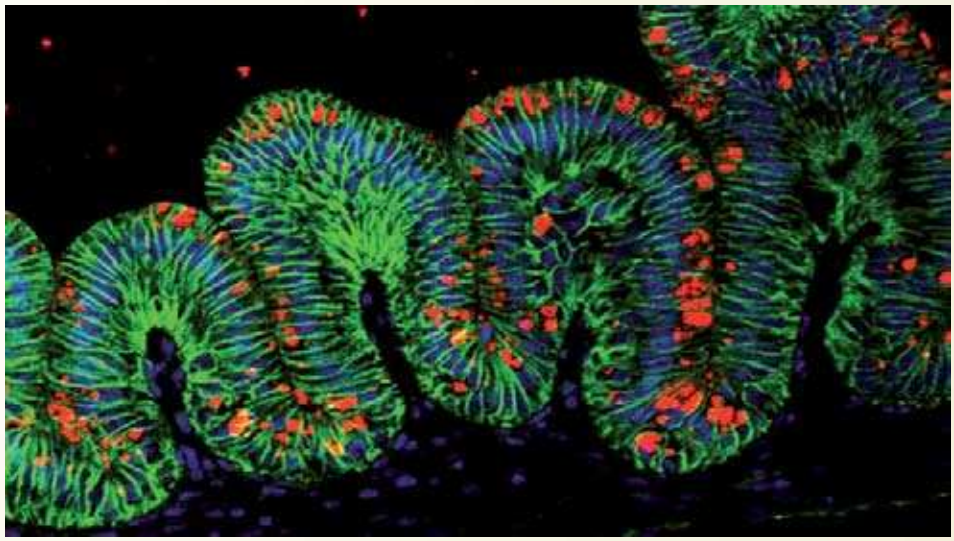
distinctive digestive system. Palaeontologists had found remains of Perissodactyla from as far back as the beginnings of the Eocene epoch, about 56 million years ago, but their earlier evolution has remained a mystery.

An international team of researchers including three – Rajendra S. Rana, Kishor Kumar, and Ashok Sahni – from India made the discovery while working at the edge of an open-pit coal mine in Gujarat, northeast of Mumbai, which yielded a vast collection of bones. Among those bones were more than 200 fossils from a previously little-documented animal called *Cambaytherium thewissi*. The bones were dated to about 54.5 million years old. According to the researchers, *C. thewissi* likely originated on the Indian subcontinent when it was still an island drifting towards collision with the Asian landmass. The researchers found many of features of *C. thewissi*, like the teeth, the number of vertebrae near pelvis, and the bones of the front and hind feet, are intermediate between Perissodactyla and more primitive animals. Based on analysis of shapes and surfaces of the long bones of its limbs, Cambaytherium probably also had five finger- or toe-like bones. That number was reduced in perissodactyls as they developed modern hooves.

According to the researchers, in addition to opening a wider window onto the ancestry of modern rhinos and horses, the *C. thewissi* fossils also represent the first evidence to support the notion that several groups of mammals from the early Eocene might have evolved on the Indian subcontinent well after that land mass broke off from Madagascar about 80 million to 90 million years ago and drifted toward the continent of Asia, as the Earth's plates shifted.

Miniature stomach grown from stem cells

For the first time, scientists have grown a fully functioning, miniature human stomach using stem cells, guiding them through the stages of development seen in an embryo. The lumps of living tissue, which are no bigger than a sesame seed, have a gland structure that is similar to human stomachs and can even harbour gut bacteria. The researchers – from Cincinnati Children's Hospital Medical Centre in Ohio, USA – say their creation, which they call 'gastric organoids' is an unprecedented tool



Part of a miniature stomach grown in the lab, stained to reveal various cells found in normal human stomachs. (Credit: www.nature.com)

that could also be used to study an array of diseases that threaten public health, such as cancer and metabolic disorders and to test the stomach's response to drugs. According to them, this first-time molecular generation of mini stomachs presents new opportunities for drug discovery, modelling early stages of stomach cancer and studying some of the underpinnings of obesity-related diabetes (*Nature*, 29 October 2014 | doi:org/10.1038/nature13863).

The stem cells used to grow the mini stomachs are pluripotent; given the right environment, they can mature into any type of cell. But to coax them down a specific path in the lab requires recreating the precise sequence and timing of environmental cues in the womb – the signals from proteins and hormones that tell cells what kind of tissue to become. Bits of kidney, liver, brain and intestine have previously been grown in a lab dish using this technique. This is the first time a bit of the stomach has been grown using stem cells.

The researchers used stem cells that were around three days old. They added a cocktail of proteins and timed doses of retinoic acid, a compound in vitamin A. After nine days, the cells were left to grow in a protein bath. After 34 days, the resulting organoids were only a few millimetres in diameter and had no blood cells, immune cells, or the ability to process food or secrete bile. But their gland structures and each marker of their development paralleled development in their control tissues, which the team obtained from mice. According to the researchers, in that sense, they "are remarkably similar to an actual stomach".

That similarity allowed the researchers to use the tiny stomachs as test subjects for human disease by injecting them with *Helicobacter pylori*, a bacterium that can cause ulcers and stomach cancer. Within 24 hours, the team found that *H. pylori* was causing the organoid cells to divide twice as fast as normal, and activating a particular gene that can cause tumours. These effects are also seen in human stomachs infected with *H. pylori*.

Researchers can use human gastric organoids as a new tool to help unlock other secrets of the stomach, such as identifying biochemical processes in the gut that allow gastric-bypass patients to become diabetes-free soon after surgery. Obesity-fuelled diabetes and metabolic syndrome are an exploding public health epidemic. Until now, a major challenge to addressing these and other medical conditions involving the stomach has been a relative lack of reliable laboratory modelling systems to accurately simulate human biology. The new technique overcomes this limitation.

The researchers say that they can grow mini stomachs from both embryonic stem cells and induced pluripotent skin cells (a type of pluripotent stem cell that can be generated directly from adult cells). The research team's long-term goal is to be able to grow personal stomach tissue to patch up ulcers in humans. They are already attempting to use human organoids to plug stomach holes in mice. ■

India joins the Thirty Metre Telescope Project as a full member

India has signed documents establishing the country as a full partner in the Thirty Metre Telescope (TMT) project. An international collaboration of institutions in the USA, Canada, Japan, India and China, the TMT project involves the building of a powerful, next-generation astronomical observatory on Mauna Kea in Hawaii. At a function in New Delhi on 2 December 2014, Union Minister for Science and Technology and Earth Sciences Dr. Harsh Vardhan signed a multilateral agreement admitting India's participation in the development of the TMT. Prof. K Vijay Raghavan, Secretary, Department of Science and Technology, signed documents to change India's formal relationship from Associate to Member of the TMT International Observatory (TIO).

Dr. Harsh Vardhan addressing the gathering at the signing ceremony (Photo: Rakesh Andania)

Indian contribution to the TMT project was cleared by the Union Cabinet in September 2014 and India has agreed to spend Rs.1299.8 crores over the next decade for this project. The TMT's primary mirror will not be a single-piece mirror; it will be made up of 492 hexagonal mirror segments, each 1.44 m in size. Precisely aligned, these segments will work as a single reflecting surface of 30 m diameter, with a total reflecting area of more than 650 square metres. India will provide 74 segments of the main mirror out of the total of 492 segments and the complete segment support assemblies consisting of the edge sensors and actuators for the TMT. A major part of the observatory control software will also be developed and provided by India. Besides learning about the universe, India will gain the technology to manufacture fine aspherical mirror segments from the California Institute of Technology (Caltech).

Speaking on the occasion, Dr Eswar Reddy, Programme Director of TMT-India, a TMT Board Member and an Associate Professor at the Indian Institute of Astrophysics, gave an overview of the project and announced that the ground-breaking ceremony for the TMT has already been held in October and that the telescope is likely to be ready for first light by 2022-23. He said, several Indian companies are gearing up to play a major role in the construction of the TMT and a few firms have been selected following a very stringent process. Other principal Indian scientist involved with the TMT project – Dr. AN Ramapraksh of IUCAA and Dr. GC Anupama of IIA – also spoke about the project.

Prof. K VijayRaghavan, Secretary, DST signing the document (Photo: Rakesh Andania)

Dubbed as the world's most advanced ground-based observatory operating in optical and mid-infrared wavelengths, the giant telescope will be built just below the summit of Mauna Kea volcano in Hawaii. India will contribute 10% of the total cost of TMT. Seventy-five per cent of India's contribution will be in the shape of key components and software for the telescope and the rest in cash. India's contribution to TMT will be jointly funded by the Department of Science and Technology (52%) and Department of Atomic Energy, Government of India (48%). The TMT project is led by the California Institute of Technology (CalTech), University of California, USA and Association of Canadian Universities for Research in Astronomy (ACURA).

With the new membership agreement in place, India has now secured observing time for its scientists at the world-class observatory, slated to see first light in the early 2020s. When completed, TMT will enable astronomers to study objects in our own solar system and stars throughout our Milky Way and its neighbouring galaxies, and forming galaxies at the very edge of the observable universe, near the beginning of time.

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