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Age of Man-Machine Hybrids

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

Paying homage to Mahatma Gandhi

Dr. T. V. Venkateshwaran

In a letter to Esther Menon, one of his associates, dated 8 August 1926, Mahatma Gandhi wrote "[I] detest the typewriter. I have a horror of it... If someone dispossessed me of the typewriter, I should not shed a single tear". To a casual acquaintance with Mahatma Gandhi's views on railways as evil, his call to burn the mill cloths, his lambaste against modern medical profession and his rejection of modern industrialisation evokes a picture of a Gandhi as a Luddite.

In contrast, while others hesitated, Mahatma Gandhi was one of the first to use the loudspeaker to address rallies, install telephone and advocate modern public health measures to get rid of infectious diseases. He did not shy away from using railways extensively to reach out to people and lauded the Singer Sewing Machine. He said "It is one of the few useful things ever invented...Singer saw his wife labouring over the tedious process of sewing and seaming with her own hands, and simply out of his love for her he devised the sewing machine, to save her from unnecessary labour."

Was Mahatma Gandhi against technology or use of tools? When a disciple of the poet Rabindranath Tagore, Ramachandran, asked him whether he opposed all machinery on principle, Gandhi replied "... my body itself is nothing but a meticulous machinery How can I dismiss it? My spinning wheel or even this toothpick, for that matter, is a machine...I am not fighting machinery as such, but the madness of thinking that machinery saves labour. Men 'save labour' until thousands of them are without work and die of hunger on the streets. I want to secure employment and livelihood not only to part of the human race, but for all."

What he saw as evil in railways was not the technology *per se*, but how it was used by the British to have complete grip over India and send troops from one end of the empire to another; or how it aided the spread of infectious diseases like bubonic plague. Further, he said, "railways have also increased the frequency of famines because owing to the facility of means of locomotion, people sell out their grain and it is sent to the dearest markets."

Gandhi was primarily worried about the inequality that mechanisation could create. "I want the concentration of wealth, not in the hands of few, but in the hands of all. Today machinery merely helps a few to ride on the backs of millions," he wrote. He wanted to change the very attitude of man towards his fellowmen and society and vice versa.

His fetishism with *khadi* and boycott of mill cloths did not stem from a desire to return to imagined glorious golden past, but from astute strategy to augment income for small farmers and landless labourers who had no immediate occupation and remained idle for half the year. It also envisioned an economy that was need-based as opposed to want-based. In an era where the threats of climate change and challenges of new techno-science need not only regulatory policies but also lifestyle changes, the experiment of Mahatma with *khadi* provides a rich source of inspiration and an object lesson. Economics based on morals is not only possible but also desirable, if the goal is not just profit accumulation for few, but just, fair and sustainable living standards for all.

Gandhi was no Luddite. He was not content with *charkha* as a traditional tool, but wanted constant improvements. He called upon the technologists to come up with an improved *charkha* and announced a Machine Design Contest in 1929. The criteria that he stipulated were fascinating as well as telling. For example, he specified that the enhanced tool should be operable by women, reducing drudgery and must be affordable. 'The machine should be strong and well-made and with time-to-time servicing it should be capable of running for at least 20 years without any stopping'.

Befittingly, reverberating with the ethos of Mahatma Gandhi, the Department of Science and Technology has announced "National Grand Challenge Awards for Designing User-Friendly Smart Solar Cooking Solutions" to commemorate his 150th birth anniversary. The improved solar cooking solutions must work in all weather conditions and should be able to processes the Indian style of cooking (boiling, steaming, frying, *chapatti* making). What else could be the best homage to a man who called for 'constructive work' all through his life?

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Saving the Nepthes of Meghalaya

Dipanjan Ghosh

'Monkey Cup', a tropical pitcher plant which is a native of Meghalaya. This plant is very unique from the evolutionary point of view, as it traps insects to compensate for nitrogen deficiency in the soil. However, this unique plant of Meghalaya is under tremendous pressure of over-exploitation, illegal trade and habitat loss. Conservation strategy requires more attention towards managing disturbance to the natural habitat of Nepenthes. Also there is a need of trade regulation to ensure sustainable collection of the plant

Introduction

India is ever distinctive in many respects as this vast country offers home to many incredible living beings. In every nook and corner of our country, some amazing plants have been waiting for us to be discovered. Today we are talking about 'Monkey Cup',a tropical pitcher plant which is a native of Meghalaya. This plant is very unique from the evolutionary point of view, as it traps insects to compensate for nitrogen deficiency in the soil. The utilisation of this additional nutrient source enables Monkey Cups to colonise extremely nutrient-poor habitats where other plants struggle to survive.

In Khasi language Monkey Cup is called '*Tiew-rakot*' meaning 'devouring plant'. Another hill tribe Jaintias calls it '*Ksete-phare*' which means 'lidded fly net' whereas in Garo language it is called '*Memangkoksi*' meaning the 'basket of the devil'. Monkey Cup is the only insectivorous pitcher plant species found in India. This particular plant is biologically known as *Nepenthes khasiana* Hook.f. and belongs to the monotypic family Nepenthaceae.

Distribution

Nepenthes is endemic to Meghalaya, where it is confined to certain small habitats (Figure 1) such as open rocky slopes amidst grass, forest edges and dense humid primary forests at altitudes between 1,000 and 1,500 m. In rocky places the plant becomes stunted, whereas in dense forests and forest edges it grows more and climbs over bushes and trees. It has a much localised distribution and is rare in the wild. Fragmented subpopulations are recorded from Belpara, Balpakram and Nokrek in Garo Hills and Sutnga of Jaintia Hills. Isolated populations are known to occur in the Jarain area of the Jaintia Hills and the Baghmara area of the Garo Hills adjacent to the Khasi Hills region of Meghalaya.

Figure 1. Monkey Cup (Nepenthes khasiana) in its natural habitat at Jarain, in Jaintia hills of Meghalaya [Photo: Dipanjan Ghosh].

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Figure 2. Nepenthes is an erect, scandent shrub with sub-cylindrical, colourful pitchers for trapping insects passively [Photo: Dipanjan Ghosh].

Figure 3. The pitcher that grows on tendril extending from the midrib of a leafis a sort of modification of leaf [Photo: Dipanjan Ghosh].

Figure 4. The lid with bright colours covers the pitcher opening and shelters it from heavy rain [Photo: Dipanjan Ghosh].

The plant

*Nepenthes*is an erect climbing shrub, up to 4m high, and dioecious (having male and female reproductive organs in separate plants) in nature (Figure 2). Leaves are alternate, bearing a pitcher at apex (Figure 3). The pitchers are brightly coloured, 15-29 cm in length and 4-7 cm in diameter, with two longitudinal ribs or wings in front, and a lid (Figure 4).

Flowering starts at the advent of monsoon, i.e., in June-July. Flowers are clustered into 15-60-cm long racemes or branched inflorescences. Flowers are actinomorphic (capable of division into symmetrical halves by any longitudinal plane passing through the axis), greenish-red, about 8 mm across.

Trapping process

The pitcher trap (Figure 5) consists of several specialised structures. The inner pitcher wall is divided into a lower glandular and upper waxy zone. The pitcher rim is often conspicuously coloured and characterised by a regular pattern of radial ridges. Its inner edge overhangs the pitcher and is densely studded with glands called extrafloral nectaries(nectar-secreting plant glands that develop outside of flowers). The rim is often elongated upwards to the pitcher lid, forming a distinct 'neck'. The lid covers the pitcher opening and thus shelters it from heavy rain.

Like insect-pollinated flowers, pitchers of the Monkey Cup attract visitors by presenting visual and olfactory signals and offering food as reward. In most of the cases, the upper part of the pitchers exhibit distinctive ultraviolet reflection patterns and exude a strong sweet scent. The attraction is achieved by large number of extra floral nectaries located on the tendril, the outer pitcher wall, the underside of the lid and the inner margin of the rim.

All the parts of a Monkey Cup snare are inactive in nature, i.e., no moving plant parts are involved in the trapping process. Prey is captured by an apparently simple pitfall mechanism. Insects lose their footing on the specialised, anti-adhesive surfaces of the rim. The projected spindle-shaped epicuticular wax (a coating of wax covering the outer surface of the plant cuticle) crystals on the upper part of the inner pitcher wall are so fragile that they break off very easily when an insect tries to stop falling into the pitcher. In addition, the slipperiness of the inner wall surface is further aided by downward-pointing epidermal cells that provide no foothold for insect claws while climbing upwards.The bottom part of each pitcher is filled with a digestive fluid in which the captured prey drowns and subsequently decomposes. The released nutrients are absorbed through multicellular glands on the inner pitcher wall.

Uncertain future

This unique plant of Meghalaya is under tremendous pressure of over-exploitation, illegal trade and habitat loss. The other major threats include deforestation for slash-and-burn method of cultivation, forest fires, coal mining, limestone mining, stone quarrying, grazing,

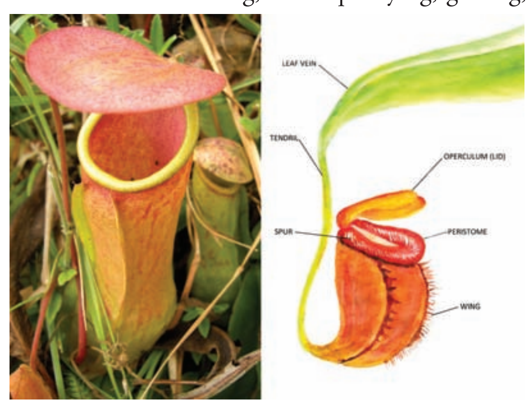

Figure 5.A trap and terminology related to the pitcher morphology [Photo: Dipanjan Ghosh and Drawing: Arnab Banik].

and road building. This species is intensively exploited by the local inhabitants of Khasi and Garo community, for its medicinal use and as a source of income for their daily basic needs. They collect the plants from the nearby area and sell them to the local markets for a cheap price. The dried powdered root and pitcher is applied to cure skin diseases, and the fluid of unopened pitcher is used by aboriginals as eye drops to cure cataract and night blindness, and in treating stomach troubles, diabetes and gynaecological problems. The extract is used as ear drops. The pitcher with its contents is made into

Continued on page 26

The Nobel Prizes in Science 2018

Biman Basu

The Nobel Prize is widely regarded as the most prestigious award available in the fields of literature, Physiology or medicine, physics, chemistry, economics and activism for peace. The Nobel Prize in Physics is awarded "for ground-breaking inventions in the field of laser physics". The Nobel Prize in Chemistry is awarded "for the directed evolution of enzymes" and "for the phage display of peptides and antibodies". The Nobel Prize in Physiology or Medicine is awarded "for the discovery of cancer therapy by inhibition of negative immune regulation".

Physics

The Nobel Prize in Physics 2018 has been jointly awarded to Arthur Ashkin of Bell Laboratories, USA, Gérard Mourou of École Polytechnique, Palaiseau, France and University of Michigan, Ann Arbor, USA, and Donna Strickland of University of Waterloo, Canada "for ground-breaking inventions in the field of laser physics". Ashkin will receive half the prize amount for "the optical tweezers and their application to biological systems". The other half is to be shared by Mourou and Strickland "for their method of generating high-intensity, ultra-short optical pulses". At 96, Ashkin is the oldest scientist ever to be awarded a Nobel.

According to the Royal Swedish Academy of Sciences, "The inventions being honoured this year have revolutionised laser physics. Extremely small objects and incredibly rapid processes are now being seen in a new light. Advanced precision instruments are opening up unexplored areas of research and a multitude of industrial and medical applications".

(l to r) Arthur Ashkin, Gerard Mourou, Donna Strickland

Arthur Ashkin invented optical tweezers that grab particles, atoms, viruses and other living cells "with their laser beam fingers". This new tool allowed Ashkin to use the radiation pressure of light to move physical objects. He succeeded in getting laser light to push small particles, not possible to hold using conventional tweezers, towards the centre of the beam and to hold them there thus acting as optical tweezers. A major breakthrough came in 1987, when Ashkin used the tweezers to capture living bacteria without harming them. He immediately

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began studying biological systems and optical tweezers became a standard tool for investigating the machinery of life.

(l to r) Gregory Winter, Frances Arnold, and George Smith (Credit: AP).

Gérard Mourou and Donna Strickland paved the way towards the shortest and most intense laser pulses ever created by mankind. They used an ingenious approach to generate ultra short high-intensity laser pulses, which was not possible earlier because it destroyed the amplifying material. To prevent this they used a different strategy. First they stretched the laser pulses in time to reduce their peak power, then amplified them, and finally compressed them again, thus avoiding the destruction of the amplifying material. If a pulse is compressed in time and becomes shorter, then more light is packed together in the same tiny space – the intensity of the pulse increases dramatically. Strickland and Mourou's newly invented technique, called 'chirped pulse amplification', or CPA, soon became standard for subsequent high-intensity lasers. Its uses include the millions of corrective eye surgeries that are conducted every year using the sharpest of laser beams.

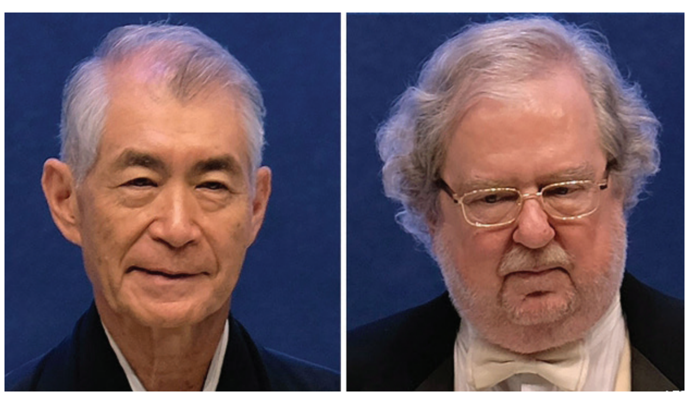
Chemistry

The Nobel Prize in Chemistry 2018 has been jointly awarded to Frances H. Arnold of California Institute of Technology, Pasadena, USA, George P. Smith of University of Missouri, Columbia, USA, and Sir Gregory P. Winter of MRC Laboratory of Molecular Biology, Cambridge, UK. Arnold will receive half of the prize money "for the directed evolution of enzymes" while the other half will be shared between Smith and Winter "for the phage display of peptides and antibodies".

According to the Royal Swedish Academy of Sciences, this year's laureates in chemistry "have taken control of evolution and used it for purposes that bring the greatest benefit to humankind". Enzymes produced through directed evolution are used to manufacture everything from biofuels to pharmaceuticals. Antibodies evolved using a method called phage display can combat autoimmune diseases and in some cases cure metastatic cancer.

Frances Arnold conducted the first directed evolution of enzymes in 1993. Since then, she has refined the methods that are now routinely used to develop new biological catalysts. The uses of Arnold's enzymes include more environmentally friendly manufacturing of chemical substances, such as pharmaceuticals, and the production of renewable fuels for a greener transport sector.

In 1985, George Smith developed an elegant method known as 'phage display', where a bacteriophage – a virus that infects bacteria – can be used to evolve new proteins. Gregory Winter used phage display for the directed evolution of antibodies, with the aim of producing new pharmaceuticals. The first medicine based on this method called adalimumab was approved in 2002 and is used for treating rheumatoid arthritis, psoriasis and inflammatory bowel diseases. Since then, phage display has been used to produce antibodies that can neutralise toxins, counteract autoimmune diseases and cure cancer that has spread to other parts of the body.



TasukuHonjo (l) and James Allison (r) (Credit: AFP Stockholm)

Physiology or Medicine

The Nobel Prize for Physiology or Medicine 2018 has been jointly awarded to James Allison of the University of Texas M.D. Anderson Cancer Centre in Houston, USA and TasukuHonjo of Kyoto University, Japan, "for their discovery of cancer therapy by inhibition of negative immune regulation". The two laureates independently propelled the field of immunotherapy, laying the foundations for the development of a number of drugs now approved to treat cancer. Cancer immunotherapy is extremely effective for a substantial minority of patients, potentially adding years to their lives and even curing some people.

James P. Allison studied a known protein molecule called CTLA-4 that functions as a brake on the immune system preventing it to be effective against cancer cells. Removing the brake, in many cases, unleashes the immune to fight the cancer. Allison realised the potential of releasing the brake and thereby unleashing our immune cells to attack tumours and developed this concept into a brand new approach for treating patients.

In parallel, TasukuHonjo was studying a different immune brake called PD-1. Allison's success with CTLA-4 in cancer persuaded Honjo to consider his molecule in cancer as well and he found PD-1 therapy was even safer and more effective against a number of cancers, including lung cancer. Therapies based on his discovery proved to be strikingly effective in the fight against cancer.

After the initial studies showing the effects of CTLA-4 and PD-1 blockade, the clinical development has been dramatic. The treatment, often referred to as "immune checkpoint therapy," has fundamentally changed the outcome for certain groups of patients with advanced cancer.

Age of Man-Machine Hybrids

Dr. Govind Bhattacharjee

Can a machine be conscious in the sense that we understand the term? Consciousness is not a property possessed by an entity that can be measured; it is a combination of many elements spread across a continuum of experiences shared by all living entities, as well as and non-living things or machines. Future humans will not be distinct from machines, it will not be a question of 'us' or 'them'. Humans and machines will merge to constitute a unified entity where the distinction between man and machines will be obliterated. The question itself whether machines can have consciousness will then become meaningless.

When Garry Kasparov, the world chess champion lost the chess match to Deep Blue, the IBM supercomputer in 1997, *Time* magazine had commented, "Luddites everywhere were on notice: here was a machine better than humankind's best at a game that depended as much on gut instinct as sheer calculation." A distraught Kasparov sighed and rubbed his face in disbelief before abruptly walking away, forfeiting the match.

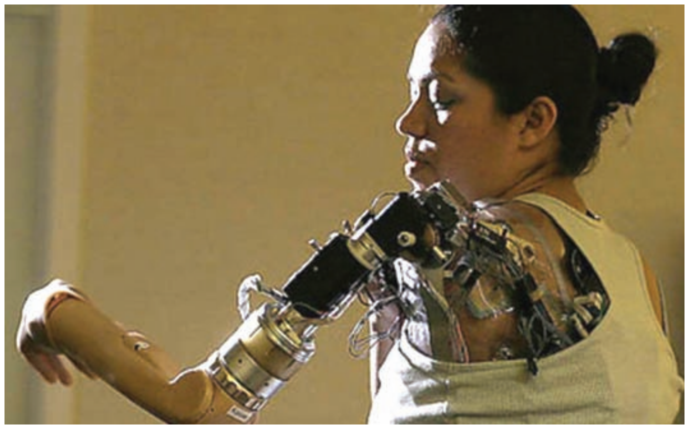
That was the first time that a machine had beaten an expert at an intelligent game. Since then milestones have been breached at regular intervals. We are living in the era of Artificial Intelligence (AI) in which machines have been taught to think like humans and act. They still lack self-awareness, an essential attribute of human consciousness and cognition. Robots do not yet know that they are robots. But given the exponential growth of technology, it is only a matter of time before they will acquire self-awareness that rivals human intelligence.

Of course, the advent of such super-intelligent machines will take some time yet to happen. Human intelligence is essential for reasoning, planning, learning, communication (using the rules of natural language), perception, decision making, and ability to manipulate objects and perform complex tasks. AI today can handle only some of these tasks, such as visual perception, speech recognition, decision-making, and translation between languages, writing reports based on data analytics, etc., though the AI wave-front is being pushed over to include new areas of cognition almost on a daily basis. It is drawing increasingly from interdisciplinary areas spanning multiple aspects of human knowledge and cognition, like mathematics, logic, probabilistic and econometric methods, computer science, psychology, linguistics, philosophy, neuroscience, neural networks, probability theory and statistics, genetic algorithms and complex paradigms based on reverse engineering of the brain as well as other areas.

Today's computers have super memories; they can easily perform millions of calculations every second and perform consistently at peak levels, combining peak skills for an almost indefinite length of

World's first cyborg Neil Harbisson (Credit: Lars Norgaard)

The author is a retired senior bureaucrat and a popular science writer. Two of his books on popular science, "*Story of Universe*" and "*Story of Evolution*" have been published by Vigyan Prasar. E-mail: govind100@hotmail.com



Claudia Mitchell, the first woman to become a cyborg (Credit: youtube.com)

time. They can recall billions of facts most accurately within a fraction of a second. Using these calculations, they can break up an object into its tiniest elements -pixels, lines, circles, triangles, squares - and describe each of these parts as mathematical equations. This is the way a machine tries to recognise patterns and identify objects. It can possibly identify a rose, but will have no idea about the 'rosiness' of roses. It cannot yet attribute any qualia (a quality or property as perceived or experienced by a person)to an object, something the human mind does effortlessly. Machines do not also understand the simplest of things about our physical world, let alone the subtle nuances of the working of human mind with all its complex web of emotions.

But as human knowledge migrates to the Web, their horizon would expand exponentially, though that alone would not endow them with consciousness. There are several problems that remain to be resolved before thinking of creating "conscious machines". For one thing, much of our thoughts are subconscious, the conscious realm actually constitutes only a small part of our total cognition. Emotion is another vital area; without emotions, we would often find ourselves constrained to make judgments and decisions. The problem is, how do you create a robot with emotions and a value system? Emotions like fear, anger, distress, etc., helped human evolution, but which emotions will help robotic evolution?

The Future Man-Machine Hybrid? (Credit: ichef.bbci.co.uk/wwfeatures)

English physicist Paul Davies uses the term "Designed Intelligence" (DI) instead of Artificial Intelligence (AI) in the book *What to Think about Machines that Think*: "Designed intelligence will increasingly rely on synthetic biology and organic fabrication, in which neural circuitry will be grown from genetically modified cells and spontaneously self-assemble into networks of functional modules……Unlike in the case of human brains, which are only loosely coupled via communication channels, DI systems will be directly and comprehensively coupled, abolishing any concept of individual 'selves' and raising the level of cognitive activity ('thinking') to unprecedented heights." That will allow humans someday to modify their brains and bodies, augment their human intelligence in ways not conceivable today and achieve a superhuman intelligence. In course of time, collective super-intelligence and an ecosystem of ideas to control that intelligence for benevolent purposes would evolve.

Whether it would be intelligent design or Darwinian evolution of robotic intelligence is a question which is still open-ended. Just as our intelligence was not designed by an omnipotent creator but had evolved gradually, it is not necessary that we have to design the intelligence of machines we create and teach them how to think; in all probability they may not think like us, but 'think' nevertheless. As Quentin Hardy of the University of California at Berkeley says in his essay "The Beasts of AI Island" in the book *What to Think about Machines that Think*, intelligence is merely a toolbox we use to reach a given goal, which doesn't entail motives and goals by itself. The new "Age of Thinking Machines" may even force us to fundamentally rethink and redesign our institutions of governance, allocation, and production which today are far from perfect.

Never before in the history of humanity have we experienced technology changing the entire landscape of man-machine paradigm so swiftly and so profoundly. Revolutionary breakthroughs have been achieved in image recognition, data analysis, autonomous learning, and the construction of scalable systems. These have spawned applications that were unthinkable only a decade ago, giving birth to systems that display significant language skills, skills for manipulating objects, leaning and problem-solving abilities, factual and procedural knowledge, and even some rudimentary imagination. AI is increasingly replacing human decision making in many areas of cognizance – routine administration, engineering and construction, design, data analytics, and even robotics and AI programming itself. Of course there is still a long way to replicate human intelligence, but it may usher in an era in which there will probably be no such thing as 'pure' human intelligence, because all humans will be a combination of biological and non-biological systems which will constitute integral parts of our physical bodies, vastly expanding and extending their capabilities. Humans and machines will merge together to create a human-machine civilisation.

The initial impact of this changeover will be highly disruptive and there will be ethical, socio-economical and other unsettling issues that will have to be addressed, requiring a level of maturity humanity has not yet perfected. As Quentin says, "We're building new intelligent beings, but we're building them within ourselves. It's only artificial now because it's new. As it becomes dominant, it will simply become intelligence. The machines of AI Island are also what we fear may be ourselves within a few generations. And we hope those machine-driven people feel kinship with us, even down to our loneliness and distance from the world, which is also our wellspring of human creativity."

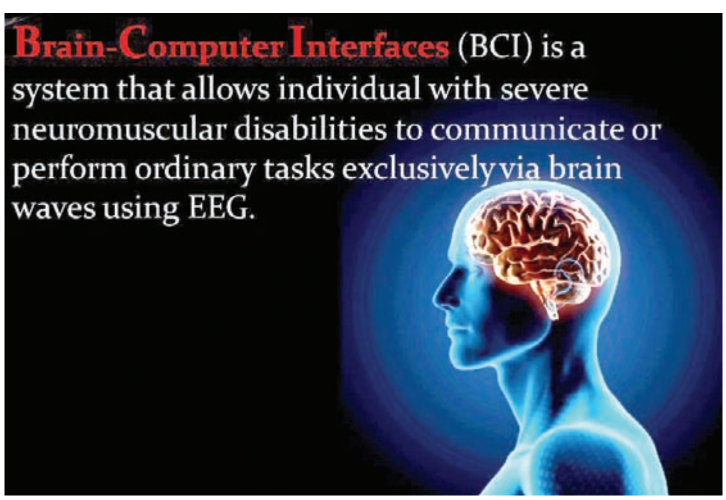
Man and machine will then become one unified, hybrid entity. These entities will perhaps continue to evolve following Darwin's law of selection: through competition, combat, cooperation, survival, and reproduction. They will learn to think, emote and empathise in their own ways which might be different from our human thought processes, emotions and expressions of empathy. As the author Clifford Pickover says in *What to Think about Machines that Think*, "We'll share our thoughts and memories with them. We will become one. Our organs may fail and turn to dust, but our Elysian(relating to the Elysian Fields - a conception of the afterlife)essences will survive. Computers, or computer/human hybrids, will surpass humans in every area, from art to mathematics to music to sheer intellect. In the future, when our minds merge with artificial agents and also integrate various electronic prostheses, for each of our own real lives we will create multiple simulated lives."

In fact, the process of merger has already begun and is progressing as rapidly as the progress of AI. Silicon-based intelligence has already made inroads into our carbon-based intelligence. Through neuroprosthetics (a discipline related to neuroscience and biomedical engineering concerned with developing neural prostheses), we can even today incorporate AI in our own bodies. Tools is what made us human, and we all use technology to augment our cognitive processes in some way or the other; in that sense, a calculator or computer becomes an extension of our computational abilities, a telescope or a microscope becomes an extension of our eyes, and an automobile becomes an extension of our legs. Now we have started integrating these tools into our bodies to create a more complex entity. There is a term for it: 'cyborg', (short for "*cyb*ernetic *org*anism"), someone with both organic and biomechatronic (developed by integrating biology, mechanics, and electronics)body parts.

Brain-Computer Interface (Credit: slideplayer.com)

The idea was certainly not new and has been used in literature, science fiction and movies since ages, and it does not even strike as unnatural or unusual when we see somebody with an intraocular lens, or an artificial cardiac pacemaker or Implantable Cardioverter-Defibrillator (ICD) which can deliver electrical stimuli to the heart to prompt it to beat at a normal rate. Thousands of people who have lost their hearing today can hear, thanks to their cochlear (inner-ear) implants; the auditory nerve reorganises itself to correctly interpret the multichannel signal from the implant. A deep-brain stimulation implant is often used to help Parkinson's patients. People who are completely blind are able to 'see' a rough image of objects when a tiny video camera is fixed in their eyeglasses which converts an image into digital signals which are then transmitted wirelessly to a chip placed in the person's retina, which actives retinal nerves and send messages via the optic nerve to occipital lobe, where visual signals are processed.

These people are partly cyborgs, and there are other real-life cyborgs, individuals who have become part-human, part-machine out of their own free will, signalling an inspiring and yet uncertain future. Musician Neil Harbisson is the first officially recognised cyborg and co-founder of the Cyborg Foundation. Born with achromatopsia, or extreme colour-blindness that meant his world was only of black-and-white, he is now capable of experiencing colours beyond the scope of normal human perception. Harbisson is equipped with a specialised electronic eye, a cybernetic enhancement to his biological self, which renders perceived colours as sounds on a musical scale through vibrations in his skull. In other words, the device enables him to "hear" colour. Through continued use, his brain has formed new neural pathways, allowing him to develop an advanced kind of perception.



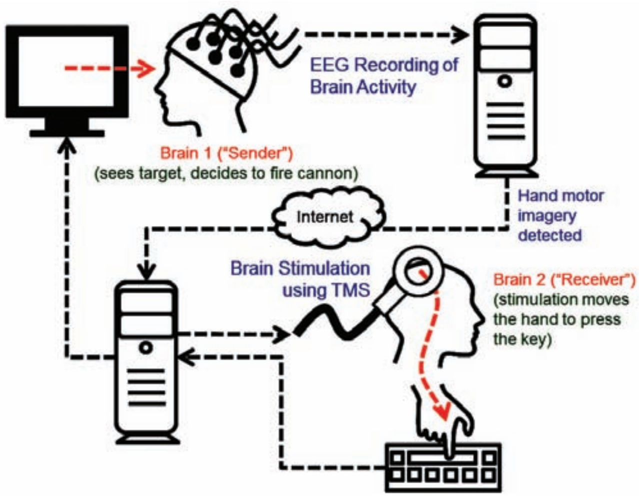
Bill Kochevar was almost completely paralysed from an accident eight years ago, but was able to regain some control of movement of his hand after scientists fitted electrodes to his brain in March 2017, demonstrating the use of brain-computer interface. (Credit: networkedindia.com)

Harbisson stated in a recent TED talk,"At the start, I had to memorise the names you give to each colour and I had to memorise the notes, but after some time, all this information became a perception." "When I started to dream in colour, I felt the software and my brain had united." His antenna was included in his 2004 passport photograph confirming his cyborg status. In 2010, he, along with artist Moon Ribas, created the Cyborg Foundation to help humans become cyborgs.

Jesse Sullivan is a double-amputee, having lost both his hands in an accident, but equipped with two bionic arms connected through a nerve-muscle graft, he can now control his new limb with his mind, feel hot, cold, and the amount of pressure his grip is applying. He can climb a ladder at his house to paint the wall and can even do something much more important - hug his grandchildren. He is the first to have a thought-controlled artificial arm.

After a pair of horrific accidents, Jens Naumann became blind in both eyes. In 2002, he became the first person in the world to receive an artificial vision system, thanks to an electronic eye connected directly to his visual cortex through brain implants. Unlike in Harbisson's case or with other cyborg implants which translate visual information into another sense such as sound or touch, Naumann actually "sees" the world, though roughly – he can only vaguely see lines and shapes. But technically his vision, bad though it is, has been restored.

Claudia Mitchell is the first woman to become a cyborg - she has a bionic limb similar to that of Jesse Sullivan, which is connected to her nervous system, allowing her to control it with her mind. Her robotic arm allows her an extraordinary range of motions for practically all mundane daily tasks from cooking to folding clothes. At 66, Fran Fulton was fully blind for about 10 years, having lost her sight from a degenerative eye disease. Last year she regained her sight, courtesy a system called the Argus II in which a pair of camera-equipped glasses were hooked up to electrodes implanted in her eyeball, which fed her brain visual information.



The brain-to-brain communication system. Brain signals from the "Sender" are recorded. When the computer detects imagined hand movements, a "fire" command is transmitted over the Internet to the TMS (Transcranial Magnetic Stimulation) machine, which causes an upward movement of the right hand of the "Receiver." This usually results in the "fire" key being hit (Credit: Rao et al. (2014) PLoS ONE)

These are only a few of the numerous instances of living cyborgs, the so-called augmented humans. Augmentation is nothing new in human history - from his cave dwelling days when he had learnt to use tools to survive against huge odds, man has been an augmented being. The tools have only become smarter, and smaller – they have been constantly transforming the human condition and expanding the human potential. Given the diversity inherent in human nature, it is also imperative that there will be an explosion in the ways different people will like to augment themselves for diverse purposes, helped by emerging technologies which would 'create a future where a thousand augmented flowers will bloom'. Yet it is a myth that such augmentation will produce superhuman beings – augmentation isn't a "magic bullet" that will instantly endow every human being with incredible faculties to fulfil all his or her wishes; augmentation can only be a tool to help a human develop in new directions. It is also nothing unnatural.

Augmentation is not the only way to expend the capabilities of the mind, there is also the brain-computer interface which can transcend the physical barriers through thought alone. Fifty-six-year-old Bill Kochevar was almost completely paralysed from an accident eight years ago - he had no control over his entire body. In March 2017, scientists fitted electrodes to the part of his brain associated with motor movements which, in turn, were connected to a brain-computer interface and could interpret his thoughts and send messages to other electrodes designed to stimulate the muscles in his right arm and hand. As the science correspondent Ian Johnston reports, Kochevar is now able to "eat mashed potato with a fork or drink coffee simply by thinking about wanting to do it." His arm is still in a sling and its movement slow and awkward, but he can move it. It was the first time someone with complete paralysis had been able to grasp something and feed himself using a brain controlled implant in this manner.

In another experiment that seemed straight out from science fiction rather than based on reality. As reported by Tanya Lewis, researchers made brain recordings of a person in India, thinking the words "hola" and "ciao," and then decoded and emailed the messages to France. There a machine converted the words into brain stimulation in another person, who perceived the signals as flashes of light. From the sequence of flashes, the French recipient was able to successfully interpret the greetings. It was a brain-to-brain communication via the interface of the computer. It was the equivalent of digital telepathy.

The technology is in its early stages, but it has very exciting potentials. It has the potential of decoding the thoughts of those who can't even blink. Scientists have developed a brain-computer interface that can read the brain's blood oxygen levels and enable communication by deciphering the thoughts of patients who are paralysed and except for up and down eye movements, can only blink and are unable to talk. Such persons are known as having locked-in syndrome. The condition, also known as pseudocoma, is a condition in which a patient is aware but cannot move or communicate verbally due to complete paralysis of nearly all voluntary muscles in the body except for vertical eye movements and blinking. In a trial of the system in four patients with complete locked-in syndrome -incapable of moving even their eyes to communicate - it helped them use their thought waves to respond "yes or no" to spoken questions. The non-invasive brain-computer interface could transform the lives of such patients, allowing them to express and convey thoughts and feelings. It can help patients suffering from the debilitating motor neuron disease regain some control over their lives.

Benefits of technology powered by AI and augmentation are indeed immense and their potential to transform the human condition is almost infinite. It is only up to us to decide how to leverage that potential to our best advantage, which is both our privilege and responsibility to ensure. In fact, by the late 2030s, as the 'futurologist' Ray Kurzweil predicts, unaugmented, unenhanced humans may become a rarity. Reverse engineering may even make it possible to scan and upload the entire human brain onto a computer someday, not too far into the future. But a reconstructed, reverse-engineered brain would need a body to be put into, it could even be a surrogate robotic body playing host to a human - or a human-machine - mind. As Kurzweil says in his book *The Singularityis Near: When Humans Transcend Biology*, "Uploading a human brain means scanning all of its salient details and then re-instantiating those details into a suitably powerful computational substrate. This process would capture a person's entire personality, memory, skills, and history. If we are truly capturing a particular person's mental processes, then the re-instantiated mind will need a body, since so much of our thinking is directed toward physical needs and desires………. The human body version 2.0 will include virtual bodies in completely realistic virtual environments, nanotechnology-based physical bodies, and more." Of course it is still in the realm of pure conjecture. It will make our minds if not our bodies truly immortal. Or the body could be frozen and preserved at cryogenic temperatures till we conquer ageing, disease and death when the body could be revived and the brain, that is the personality, uploaded into it. It might even be possible to gradually transfer our intelligence – with all our skills, learning, memory, emotion and consciousness – in fact our entire personality – to a non-biological form, leaving the mortal body behind like 'an aging shell'. May be the process has already begun unnoticed. To quote Kurzweil again, "We already have a variety of neural implants. In the 2020s we will use nanobots to begin augmenting our brains with non-biological intelligence, starting with the "routine" functions of sensory processing and memory, moving on to skill formation, pattern recognition, and logical analysis. By the 2030s, the non-biological portion of our intelligence will predominate, and by the 2040s,…the non-biological portion will be billions of times more capable. Although we are likely to retain the biological portion for a period of time, it will become of increasingly little consequence. So we will have effectively uploaded ourselves, albeit gradually, never quite noticing the transfer."

There is a final question – can a machine be conscious in the sense that we understand the term? Actually consciousness is not a property possessed by an entity that can be measured; it is a combination of many elements spread across a continuum of experiences shared by all living entities, as well as and non-living things or machines. Objective measurement tools of science are inadequate to measure the subjective elements that constitute consciousness, at best they can measure the correlates of consciousness like behaviour or emotional expressions. Machines even today exhibit some of these behavioural correlates that point to elements that fits very well into the spectrum that consciousness is. But we must not forget that the future humans will not be distinct from machines, it will not be a question of 'us' or 'them'. Humans and machines will merge to constitute a unified entity where the distinction between man and machines will be obliterated. The question itself whether machines can have consciousness will then become meaningless.

Saving the Nepenthes of Meghalaya (*continued from page 33*)

a paste and is applied on affected parts of leprosy patients. The Monkey Cup is also collected indiscriminately from the wild for its botanical curiosity and uniqueness as well as traded for its ornamental value and also for medicinal properties.

The factors responsible for the habitat loss are human population growth coupled with unsustainable patterns of consumption, increasing production of waste and pollutants, various developmental projects related to urbanisation, forest fires, and landslides.

Measures taken

The pitcher plant sanctuary of Jarain, in Jaintia hills of Meghalaya, established in 1974, focusses on the conservation of *Nepenthes khasiana*. The Meghalaya State Forest Department (Silviculture) has set up *ex-situ* germplasm conservation of the plant at Umian (Barapani), Forest Research Station. The species is under cultivation in gardens of Botanical Survey of India in Shillong and Yercaud. In addition, according to the IUCN Red List, *Nepenthes*is grouped under 'Endangered B2ab' category. It has also been brought under Appendix I of CITES and Negative List of Exports of the Government of India and 'Schedule VI' of the Wild Life (Protection) Act, 1972 of India. However, all these efforts are not enough; Monkey Cup needs some more attention for conservation.

End Notes

It is clear that the Monkey Cup faces little threat from Mother Nature but more from local inhabitants who being ignorant about their true values, are destroying them indiscriminately. Therefore, conservation strategy requires more attention towards managing disturbance to the natural habitat of *Nepenthes*. Also there is a need of trade regulation to ensure sustainable collection of the plant. Finally, nature lovers and biologists need to start fresh campaign to ensure a mass consciousness across the territories where *Nepenthes*is found.

Constructed Wetlands: A Green Technology for Wastewater Treatment


Atul Kumar Upadhyay and Ranjan Singh

Constructed wetland (CW) is a low-energy-consuming technology that uses natural biogeochemical cycles to remove a wide variety of waste waters including industrial effluents, urban and agricultural waste waters, leachates, sludge, pharmaceutical waste and mine drainage. Constructed wetlands provide significant water quality improvements along with a number of ancillary benefits.

Fast industrial growth, urbanisation and overexploitation of natural resources degrade ecosystems severely. Of these, aquatic ecosystems are being degraded continuously over the past years due discharge of untreated sewage and wastewater from industries and cities directly into rivers, ponds and lakes. Rivers, being the major reservoir of water, are affected severely. According to an estimate of Central Pollution Control Board, sewage wastes are the largest contributor (75%) of river pollution,which might develop into a panic situation of water crisis in the coming decades. Problems with water are expected to grow worse in the coming decades, with even in the regions currently considered as water-rich facing water scarcity.

India is the one of the major riverine systems in the world. Rivers directly or indirectly meet the drinking water requirement of and provide livelihood to millions of people in India. The Ganga is the one of the largest and most sacred river systems in India. The Ganges basin is the cradle of Hindu and Buddhist pilgrimage culture. Some of the most important centers of spiritual learning and healing have thrived for centuries along its banks. The Ganga water receives large amount of untreated waste emerging from industries, urban sources, sewage treatment plants and agricultural fields. This waste water contains various organic and inorganic substances, pathogenic micro organisms as well as toxic metals and poses a big public health hazard.

To tackle the pollution level of rivers there is imperative need for affordable, green and cost-effective technology which not only treats waste water effectively but also in a sustainable manner. In this regard, constructed wetland could be a constructive measure.

Constructed wetland (CW) is a low-energy-consuming technology that uses natural biogeochemical cycles to remove a wide variety of waste waters including industrial effluents, urban and agricultural waste waters, leachates, sludge, pharmaceutical waste and mine drainage. In constructed wetland different type of rooted, emergent, surface flow and subsurface flow plant are used for the restoration of water ecosystems. Plants used in wetlands may include *Phragmites, Colocassia, Typha,* sedges, *Wolffia, Potamogeton, Hydrilla, Vallisnaria*, *Eichhornia*, etc. constructed wetland shave been proved to be a "cost-effective" method for wastewater treatment. They also provide other benefits such as wildlife habitat, research laboratory and can be used for recreational purposes.

Types of constructed wetlands

Constructed wetlands are artificial wetland systems that are designed to exploit the physical, chemical, and biological treatment processes that occur in wetlands

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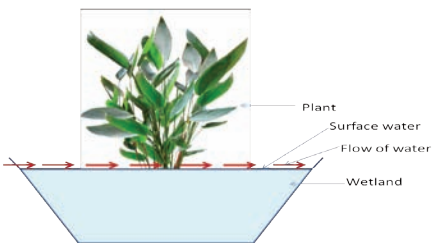
and help in the reduction in organic material, total suspended solids, nutrients and pathogenic organisms. Constructed wetlands are classified into two general types on the basis of flow of water: the Horizontal Flow System (HFS) and the Vertical Flow System (VFS). HFS has two general types: Surface Flow (SF) and Sub-surface Flow (SSF) systems. In HFS, wastewater flows on the surface of the wetland. In VFS, water flows vertically with the help of perforated pipes fitted in the wetland.

Surface flow CW

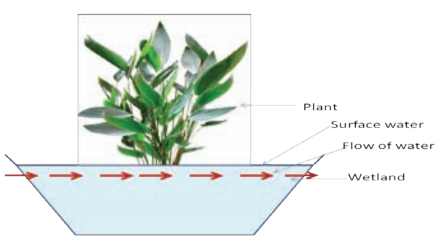
Surface flow wetland is used mainly for municipal wastewater treatment. Majority of the natural wetlands present in world are surface flow type. The water flows



on the surface of the wetland and is exposed to the atmosphere. Examples include bogs, swamps, marshes, etc.

Sub-surface Flow CW

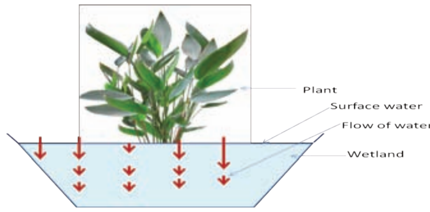
In Sub-surface Flow (SSF) system, water flows from one end to the other end below the surface. In such type of CW, the major advantages are prevention of mosquito breeding,



development of odour, and direct contact of public, which is not possible in surface flow wetland.

Vertical flow wetlands

In this type of CW, water flows vertically in the wetland. Here water is allowed to flow vertically through perforated pipes. The main advantage of vertical flow wetland is the high aerobic condition which



enhances the removal efficiency of the wetland.

Mechanism of removal of contaminants in constructed wetland

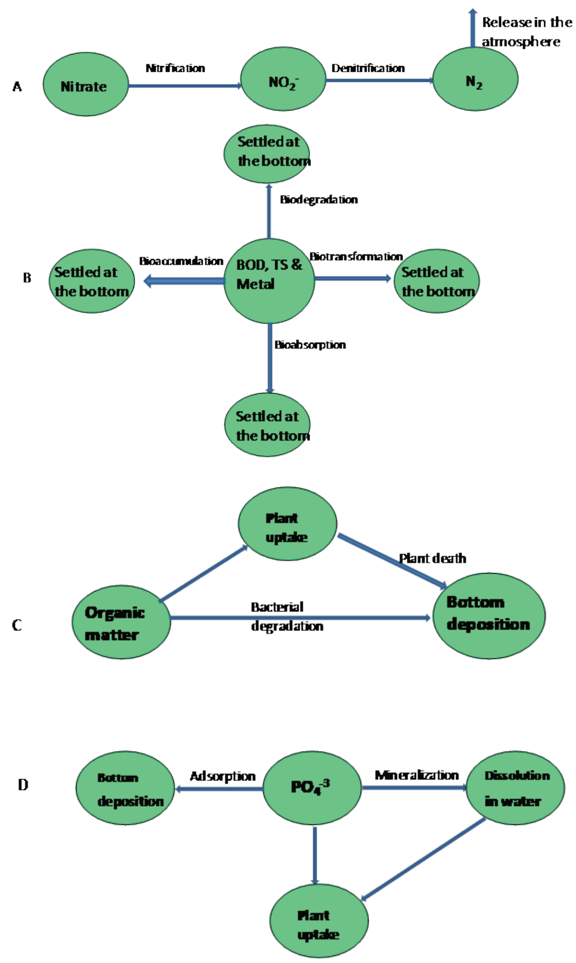
Constructed wetlands can be employed as an off-site or on-site waste water treatment technology. Aquatic plants present in wetlands have hollow stems which trap oxygen and carry it to the roots, which release it in the rhizosphere adding oxygen to the wetland system and forming an unique redox environment. This redox environment facilitates the growth of different community of aerobic anaerobic microbes and freshwater organisms. This community of micro organisms and freshwater organisms is known as the periphyton, which through natural chemical processes helps in degradation of pollutants, contributing approximately 90% of pollution removal. A short summary of removal process of different physicochemical parameters involved in waste remediation are illustrated in Fig.4.

Benefits of constructed wetlands

Constructed wetlands provide significant water quality improvements along with a number of ancillary benefits like creation of wildlife habitat, preservation of green spaces and opportunities for public recreation, monetary improvement and education.

A secondary benefit is the possibility of sustainable harvesting by cropping biomass and utilising the harvested plant for different small cottage industries such as matting, weaving, and medicinal applications,which could be a good aspect in poverty eradication and empowering people. Following are some important benefits of constructed wetlands system.

Pulp obtained from the common reed *Phragmitescommunis* is better and cheaper than derived from straw and bush, and has characteristics suitable for the manufacture of artificial fibres. The use of reeds has saved large amounts of timber which otherwise would have been used for paper. Aquatic grass *Vossia cuspidate*, gives a low yield of short-fibred pulp of poor strength .Fresh leaf stalks (and optionally leaves) of *Eichhorniacrassipes, Cyperus papyrus* and *Cyperusantiquorum* are also used for paper manufacture. Water hyacinth could be used for manufacture of other cellulosic materials such as rayon.



*Azolla*sp. could be useful for mosquito control when encouraged to form a dense mat over ponds. This gave the plant the name "mosquito fern". This attribute has,

Continued on page 19

A Unique Mid-Triassic Age Reptile discovered in India

Shakunt Pandey

A new species of a quadruped reptile with a pair of horns, which roamed the then forests of Central India's Satpura-Gondwana basin, duringthe early Middle Triassic, has been discovered by a joint team of Indian and Argentinean scientists from the Denwa formation of Madhya Pradesh, which has the potential to rewrite the history of evolution.

A new species of a quadruped reptile with a pair of horns, which roamed the then forests of Central India's Satpura-Gondwana basin, during the early Middle Triassic, has been discovered by a joint team of Indian and Argentinean scientists from the Denwa formation of Madhya Pradesh, which has the potential to rewrite the history of evolution. It has been scientifically named *Shringasaurusindicus*. The name has been derived from the Sanskrit term '*Srnga*'(*Shringa*), meaning horn, the Greek term '*sauros*' meaning lizard, and the Latin term '*indicus*' meaningIndian. The discovery was made by Saradee Sengupta and Saswati Bandyopadhyay of the Geological Studies Unit, Indian Statistical Institute, Kolkata and Martin D. Ezcurra of CONICET-Museo Argentino de Ciencias Naturales Buenos Aires, Argentina (*Scientific Reports*, 21 August 2017| doi:10.1038/s41598-017-08658-8).The researchers stumbled upon the new species, while analysing the collection of bones and fossils of pre-historic animals recovered during decade-long excavations carried out in the Satpura-Gondwana basin in central India.

The Triassic was the first period of the Mesozoic Era and lasted from 251 to199 million years ago. The Mesozoic Era is often known as the age of reptiles. Early in the Triassic, a group of reptiles of the order Ichthyosauria returned to the ocean and the land was ruled by the Therapsids, which were mammal-like reptiles, and the more reptilian Archosaurs. By the Mid-Triassic most of the Therapsids had become extinct and the more reptilian Archosaurs ruled the lands and the Ichthyosaurs ruled the oceans. The end of the Triassic period led to the Jurassic age when dinosaurs ruled supreme. The newly discovered species *Shringasaurusindicus* is a genus of allokotosaurian archosaur that appeared in the early or middle Triassic and became completely extinct close to the end of the Triassic (200 million years ago).

The discovery of horns in *S.indicus* is quite significant and opens a new frontier

An artist's impression of Shringasaurusindicus

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in our knowledge about these ancient reptiles. It is widely believed that horned species of reptiles like Triceratops or Styracosaurus appeared in the Ceratopsidae family of the dinosaurs of the Cretaceous period,but before these no species had developed horns. The *S.indicus* fossil discovery now leads us to an eye-opening fact that these reptiles developed or acquired an anatomical diversity in the form of horns more than 100 million years ago before their appearance in dinosaurs.

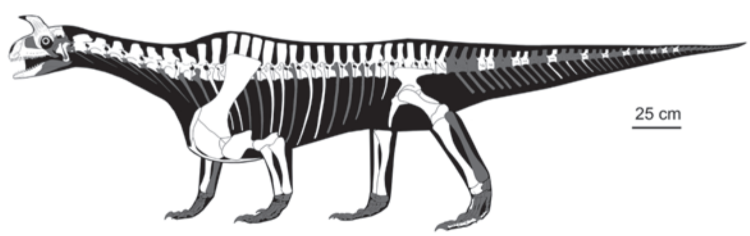
The discovery of *S.indicus* is unique in the sense that it is the only Triassic archosauromorph (a member of bird- and crocodile-line archosaurs) with a pair of horns on its skull and is the oldest fossil of a horned reptile that has been unearthed anywhere in the world.

How did *S.indicus* look like?

The fossil bones of *S. indicus*were recovered from red mud stone in the upper part of the Denwa Formation of Satpura Gondwana basin. The Denwa formation overlies the Lower Triassic Pachmarhi formation and is overlain by the Cretaceous Bagra Formation. At least seven individuals of different ontogenetic stages (usually from the time of fertilisation of the egg to the organism's mature form) were dug up from an area of 25 square metres. Most of them were separated at joints, with exception of a partially articulated skeleton. The scientists reconstructed this lost reptile from the recovered bones, based on which they were able to assess the reptile's length and height. The researchers have identified more than 300 bones. There are nine frontal bones with horns and two without horns. The researchers believe that they can find at least seven individuals from the collection of bones. There are at least six horned individuals and one or two without horns.

Another artistic impression of S.indicus

Though no fossil was recovered with intact pair of horns, the researchers were able to identify the left and right horns from their anatomical features. Also, the discovery of adult reptile bones without horns is indicative of females therefore it could have stood for sexual dimorphism. Juveniles too had horns, though they were smaller in size.



Skeletal anatomy of S.indicus

A different line of evidence suggests that the horns of *S.indicus* originated through sexual selection. These horns would not have been effective against predators. It would have served more to attract females or to fight with other competing males to gain access to receptive females as it happens in present day mammals with behaviour driven by sexual selection. It may also have been used by the males to establish their territory.

Shringasaurusindicusfossil bones

Unlike the other Triassic reptiles, primarily the archosauromorphs which comprises crocodiles, dinosaurs and their descendants, the birds and their ancestors that were about 2.5 metres long, *S.indicus* was 3 to 4 metres in length. It was 1.25 to 1.50 metres tall at the hip and had a relatively long neck and small head. It distinctly exceeds the size range of other Early-Middle Triassic archosauromorphs. Its ribs were also bigger than the reptiles of those times. It had leaf shaped teeth with small cusps which suggested that it was an herbivore.

S.indicus had a comparatively small rectangular skull with a pair of large conical horns, directly above the orbits, a short rounded muzzle and confluent outer nares. Its shoulder girdle or pectoral girdle was massive and its teeth were in the form of leaves.

It is thought that *S.indicus* played an ecological role as a large primary consumer in its ecosystem, a role which was thought to be restricted to synapsids in Palaeozoic and Early Middle Triassic terrestrial communities (e.g. edaphosaurids, dinocephalians, anomodonts), but subsequently successfully exploited by Late Triassic archosauromorphs , such as rhynchosaurs, aetosaurs, and sauropodomorphs.

The relative large size and unusual anatomy of *S.indicus* broadens the morphological diversity of the Early-Middle Triassic tetrapods and complements the understanding of the evolutionary mechanism involved in their diversification after the Permo-Triassic mass extinction.

Shringasaurusindicus is by no means a lesser find than the discovery of India's one and only carnivorous dinosaur Rajasaurus. This discovery must excite the budding palaeontologists of our country and abroad. The Satpura basin may be hiding many more wonders like *S.indicus*,waiting to be unearthed.

Recent Developments in Science and Technology

Biman Basu

> *It is now possible to replace genes for traits we don't like with others we prefer and even add genes that don't occur naturally in an organism. In this study, CRISPR methods have been used to make mosquitoes resistant to malaria infection and the gene modification can be driven through the population with a "chain reaction" to decimate mosquito populations.*

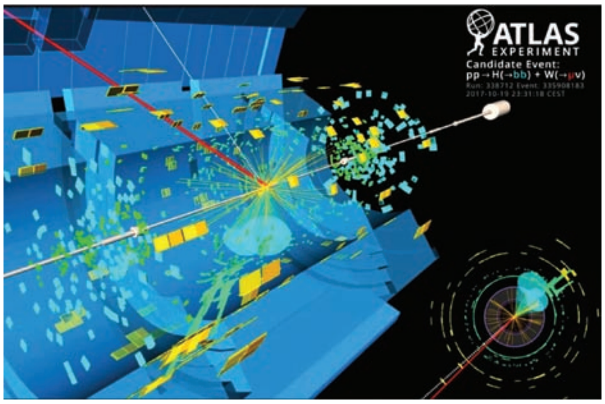
Decay of Higgs boson observed

Six years after discovering the Higgs boson, physicists have observed how the particle decays. This is considered as a monumental contribution to our understanding of the Standard Model of particle physics and the universe at large.

There was lot of excitement when the elusive Higgs boson, predicted in 1964, was discovered by scientists at the Large Hadron Collider (LHC) of the European Organisation for Nuclear Research (CERN) in 2012. Higgs boson is an elementary particle predicted by the Standard Model of particle physics that relates to how objects have mass. The discovery,however, was not the end of the Higgs boson story, because in addition to predicting the existence of Higgs boson particles, the Standard Model also predicted that 60 percent of the time, a Higgs boson will decay into smaller fundamental particles called bottom quarks (b quarks), which has now been observed. The results were presented at CERN on 28 August 2018 by the ATLAS and CMS collaborations at the LHC. According to physicists, the finding provides major support for the Standard Model, which has many implications for how we understand the world and the universe. The finding is consistent with the hypothesis that the all-pervading quantum field behind the Higgs boson also endows the bottom quark with mass.

The Higgs boson is a particle that does not live very long. "You'll never hold a Higgs boson in your hand,"says James Beacham, an experimental high-energy particle physicist working with the ATLAS collaboration at the LHC at CERN."But, although the Standard Model predicts what happens to the Higgs boson when it dies, until now, researchers hadn't observed the particle decay into b quarks", Beacham said.

Although observing the Higgs boson decay may not be as astounding as the discovery of the particle itself, which was awarded the 2013 Nobel Prize in physics, it is a colossal victory, the researchers said. Spotting the Higgs-boson decay channel was anything but easy, as the six-year period since the discovery of the boson has shown. The reason for the difficulty is that there are many other ways of producing bottom quarks in proton–proton collisions, which were used to create the Higgs boson. This makes it



An ATLAS candidate event for the Higgs boson particle decaying into two bottom quarks. Physicists at CERN recently observed this process, which further confirms the Standard Model of particle physics. (Credit: ATLAS/CERN)

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hard to isolate the Higgs-boson decay signal from the background "noise" associated with such processes.

Another problem is that ATLAS and CMS are separate detectors, so the collaborations working on each one must make and confirm these observations separately for it to "count". So the findings may be considered another big step along the journey to better understand the Higgs boson and our universe. And each new discovery or observation, like the discovery of the Higgs boson, has the potential to give way to new questions and experiments. In confirming that this particle does, in fact, decay into b quarks, the physicists have shown that the Higgs field, the field behind Higgs boson particles – the "invisible jelly that permeates all of space"– gives b quarks mass. The Higgs field uses the Higgs boson to interact with other particles, like the b quark, and give them mass.

The first moon around an exoplanet discovered

Astronomers have discovered the first moon orbiting a planet outside the solar system – an extrasolar moon or exomoon. The discovery was made using NASA's Kepler and Hubble space telescopes, which spotted evidence of a Neptune-size satellite orbiting the Jupiter-like planet Kepler-1625b, which lies about 8,000 light-years from Earth (*Science Advances*, 3 October 2018 | DOI: 10.1126/sciadv.aav1784). According to astronomers Alex Teachey, NSF Graduate Fellow in astronomy and David Kipping, an assistant professor of astronomy at Columbia University who made the discovery, the exomoon is unusual because of its large size, comparable to the diameter of Neptune. Such gargantuan moons do not exist in our own solar system, where nearly 200 natural satellites have been catalogued. Incidentally, the mass ratio of Kepler-1625b and its moon is similar to that of our own Earth-moon system, namely 1.5 percent.

The new results come from a concerted hunt for exomoons Teachey and Kipping conducted using data from the Kepler space telescope, which has discovered about 70 percent of the 3,800 known exoplanets to date. Kepler uses the "transit method" to discover exoplanets by noting the tiny dips in star brightness caused by orbiting planets crossing in front of their stars. Previous research has suggested that big (and therefore detectable) exomoons are rare around large planets that orbit very close to their parent stars.

To find exomoons, Teachey and Kipping studied Kepler data of 284 planets with relatively wide orbits – worlds that take

An artist's illustration of the exoplanet Kepler-1625b with its large hypothesised moon. The pair has a similar mass and radius ratio to the Earth-moon system, but scaled up by a factor of 11. (Credit: Dan Durda)

at least 30 Earth days to complete one lap. And they noticed weird deviations in the "light curve" generated by the 19-hour-long transit of Kepler-1625b, a planet about three times larger than Jupiter that orbits the star Kepler-1625, about as massive as our own Sun. To study the Kepler-1625b system in more detail, Teachey and Kipping sought time on the Hubble space telescope and were awarded 40 hours of observation time with the HST, which could provide data four times more precise than that of Kepler. They succeeded in observing another transit in late October 2017 – and saw two "substantial anomalies".

The duo monitored the planet before and during its 19-hour-long transit across the face of the star. After it ended, Hubble detected a second and much smaller decrease in the star's brightness 3.5 hours later, consistent with "a moon trailing the planet like a dog following its owner on a leash," Kipping said. In addition to this dip in light, Hubble provided supporting evidence for the moon hypothesis by measuring that the planet began its transit 1.25 hours earlier than predicted. This is consistent with the planet and moon orbiting a common centre of gravity (barycentre) that would cause the planet to wobble from its predicted location.

The researchers note that in principle this anomaly could be caused by the gravitational pull of a hypothetical second planet in the system;but Kepler found no evidence for additional planets around the star during its four-year mission. There is no indication of another planet in the system that could be tugging on Kepler-1625b, and the secondary dimming is consistent with a moon trailing the gas giant during its transit. "A companion moon is the simplest and most natural explanation for the second dip in the light curve and the orbit-timing deviation," said Teachey.

However, the astronomers stressed that the observations don't constitute a definitive detection. They hope to re-observe the star again in the future to verify or reject the exomoon hypothesis.

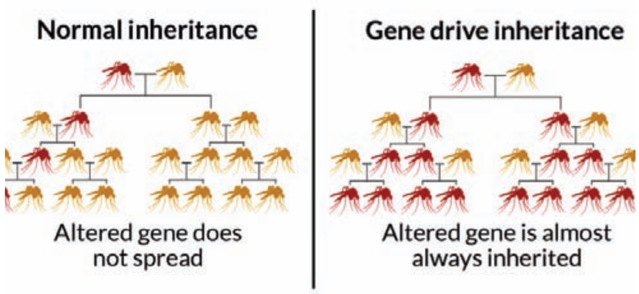
New technique for genetic control of mosquitoes

Ever since the discovery of the double-helix structure of the DNA, techniques for manipulating genes have been growing steadily. It is now possible to replace genes for traits we don't like with others we prefer and even add genes that don't occur naturally in an organism. Over the last few years, scientists have developed several methods for editing genes in this way and excitement over one in particular method, the CRISPR-Cas9 system, has reached fever pitch.

Gene-editing techniques involve cutting genes at specific sites in the DNA of an embryo in order to disrupt those genes' function or insert other genes. The CRISPR-Cas9 makes artificial gene-editing much easier and cheaper, enabling scientist to target specific bits of DNA. As a result, CRISPR gene-editing is widely used, heralding advances in biomedicine such as cancer treatments and protecting individuals from infections. The CRISPR-Cas9 system uses enzymes that can cut specific gene sequences from DNA, guided by a similar molecule known as RNA. Natural gene repair mechanisms then take over and can be used to disrupt the function of the original gene or replace it with a completely different one.

In the latest study, CRISPR methods have been used to make mosquitoes resistant to malaria infections and coupled with a “chain reaction” to drive this gene modification (the resistance to malaria parasite) through the population. This process is referred to as a “gene drive”, which may be used to ensure that a specific genotype (a certain version of a gene) is passed on to the descendants of modified individuals. Gene drive has now been successfully used to decimate a population of malaria-carrying mosquito in the lab. This is the first time the technique has been used make a population of mosquitoes to self-destruct, a result that holds promise for combating malaria(*Nature Biotechnology*, 24 September 2018 | doi: 10.1038/nbt.4245).

The study, led by molecular biologist Tony Nolan and vector biologist Andrea Crisanti, both at Imperial College London, identified three genes in *Anopheles gambiae* that, when mutated, lead to infertility in females. The team targeted a region of a gene called ‘doublesex’ that is responsible for female development. Female *Anopheles gambiae* mosquitoes with two copies of the altered doublesex gene did not lay eggs. After eight generations, the drive had spread through the entire population, such that no eggs were laid, effectively leading to the decimation of the entire population.



Mosquitoes and other organisms normally have a 50 percent chance of passing along a gene to an offspring (left). A gene drive copies and pastes itself into chromosomes from both parents, ensuring it gets passed on more often (right). (Credit; Science News)

“This breakthrough shows that gene drive can work, providing hope in the fight against a disease that has plagued mankind for centuries,” saysco-author Crisanti, a molecular parasitologist at Imperial College London.

A sexually reproducing organism usually has a 50% chance of inheriting a specific genotype (genetic constitution) from one of its parents. Using a gene drive can cause the inheritance pattern to increase that chance to nearly 100%, ensuring almost all descendants possess the genotype. As those descendants mate and produce their own offspring, the proportion of organisms with the genotype increases until it can be found in the entire population.

The idea that a population’s genotype can be “replaced” is particularly appealing when that population is responsible for spreading disease, as mosquitoes are with malaria. Malaria is preventable and curable but still kills over 400,000 people worldwide each year.

The potential for using a gene drive to engineer insects (particularly mosquitoes) was discovered in the 1960s. But the advent of CRISPR’s cheap and easy gene-editing puts this research onto a whole new footing. According to the researchers, the longer term aim of using this method might be to release persistent, modified mosquitoes into the environment to assist in controlling a public health problem.

Constructed Wetlands: A Green Technology ... (continued from page 24)

Table 1 Cost benefit analysis of CW *vs* STP

Factor	Units	STP	Constructed wetland
Hydraulic retention time (through the entire plant)	Day	2	3-5
Average depth	Metre	1.75	2-3
Land requirement	Ha/MLD	0.2-0.3	1-3
Energy requirement	KWh/MLD	180	Nil
Capital cost	Rs.Lakh/ MLD	200.95	15-30
Annual recurring cost		3.0 -5.0	0.5-0.7
		420-470	30-40 (Further no capital cost)
Pollution reduction efficiency (% reduction)			
Suspended Solids	mg/L	90-95	90-95
BOD	mg/L	95-98	85-95
COD	mg/L	92-99	90-99
Faecal Coliform (MPN)	No./100 ml	95-99	95-99
Total Coliform (MPN)	95-99		95-99

however, not been established. *Nymphaea alba and Nuphar* sp. because of their content of gallic or tannic acid, both of which have mordanting properties, have been employed in several European countries in dyeing and tanning. The culms or leaves of *Cyperus sp., Schoenoplectus sp.* and *Typha sp.* are still in use in many parts of the world for weaving and basketry. The culms of *Arundodonax* have provided reeds for wind instruments for centuries. This plant has also been used to provide cellulose for rayon and has been considered for paper manufacture. It is also used for weaving, thatching and making walking sticks and fishing rods. *Cyperus papyrus*, in addition to being used for making papyrus, was made into ropes, canvas, and sails. Dried duckweed (*Lemna sp.*) meal provided an excellent substitute for expensive conventional feed ingredients like soybean and fish meal.

Cost benefit analysis

CW used in the treatment of waste water significantly reduces the capital cost as compared to conventional sewage treatment plants (STP). The details of comparative study along with pollution removal efficiency are presented in Table 1.