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INDUSTRY 4.0: THE FOURTH WAVE OF THE INDUSTRIAL REVOLUTION

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5-8 NOVEMBER 2019
KOLKATA

SCIENCE EMPOWERING NATION
RESEARCH INNOVATION

INSIDE STORIES

EDITORIAL

Research, Innovation & Science Empowering the Nation

Nakul Parashar

Welcome October. Festivities all-round the month.

It happens every year, but how is it different this year? Besides Dussehra and Diwali falling in October, this year October would witness several curtain-raisers related to the fifth edition of the India International Science Festival (IISF) which is slated for November 5– 8 2019 at Kolkata. The theme for this year's IISF is RISEN – research, innovation & science empowering the nation.

IISF, every year has become bigger than its predecessor and IISF 2019 is no exception. This year, several new programmes have been planned at IISF. Vigyanika, Science Literature Festival is one such programme that IISF shall witness for the first time. Science through drama, poetry, songs and folk art would be one subset of Vigyanika at the fair. This part of Vigyanika has been planned as 'Vigyan Manchan'. Similarly, book reading, a book fair, book releases, and meet-the-author would fall under another part of Vigyanika and that's been named as 'Vigyan Prakashan'. Besides, subject matter experts and experienced science communicators promoting science popularisation through various genre would discuss and deliberate on various related topics through another part of Vigyanika, titled as 'Vigyan Manthan'. Vigyanika has still a lot more than these. 'Vigyan Spandan' would encourage young science lovers through science writing workshops and competitions for students. Thus, science writers, editors, scientists, teachers, researchers, science communicators, journalists, poets, drama writers and performers, and college students are invited to register themselves as participants or speakers in Vigyanika through online site of IISF 2019. A small book fair at Vigyanika would also be organized at IISF 2019.

Where there's literature, how can cinema be left behind. IISF 2019 will witness India International Science Film Festival as well. Organisers are expecting the best of the science films from around the globe to be screened for registered participants and a panel of eminent jury members. Satyajit Ray Film & Television Institute is a well-known film & television institute of the country, where this film festival would be organised during the IISF 2019.

In line with scientific literature, and films, it is relevant that our science & technology-related media industry is also activated to shoulder the responsibility of science communication, popularisation, and extension. IISF 2019, will have a conclave of S&T Media to discuss with subject matter experts about various issues related to science communication. A new event for IISF, this event would be a two-day opportunity to meet and discuss with S&T media personalities and hear about their experiences.

One of the major attractions at previous IISFs have been the Students' Science Village, where a large number of students from all over the country gather and enjoy through a set of daily entertaining activities. Divided into eight different houses, each of them named after our scientific luminaires, these scientists-in-making go through a different experience all together during the science festival.

A huge S&T expo, on the lines of what was there at other IISFs, shall be there as well – again at Science City. By the side of the mega S&T expo, the visitors are expected to witness technology advancements being made for making things simpler for our divyangjan.

Students in huge numbers get a chance to meet scientists of international repute to respond to their queries in a programme called 'face-to-face with scientists'.

A lot, lot more at IISF 2019. So, please come and enjoy meeting scientists and see several exhibits from within and beyond the national boundaries.

Wishing you and near ones a very happy Durga puja, Dussehra and Diwali.

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European Organisation for Nuclear Research (CERN): Accelerating Science


Jyoti Sharma and Sanjeev Kumar Varshney

The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator ever built that pushes protons or ions to near the speed of light. The core mission of CERN is fundamental research in particle physics, but CERN's basic tools – particle accelerators and detectors and electronic particle detection techniques – also support the frontiers of technology, addressing global societal challenges. Indian scientists have significantly contributed towards major discoveries reported from the LHC

A joint venture of the Department of Science and Technology (DST), Department of Atomic Energy and National Council of Science Museums, *Vigyan Samagam* is a unique travelling, multi-venue, mega-science exhibition to showcase India's collaboration in the world's most ambitious science projects, which was launched in Mumbai on 8 May 2019. It features live working models of seven-breakthrough science projects, namely European Organisation for Nuclear Research (CERN), Facility for Antiproton and Ion Research (FAIR), India-based Neutrino Observatory (INO), International Thermonuclear Experimental Reactor (ITER), Laser Interferometer Gravitational-wave Observatory (LIGO), Square Kilometre Array (SKA), and the Thirty Meter Telescope. The main aim of this exhibition is to highlight the value and impact of fundamental research to a broad cross-section of the audience to bring cross-border science and technology cooperation one-step closer to society.

The Indian government is committed to facilitating Indian scientists, provide them an opportunity to lead at the global level and support academic-industry partnership for the development of cutting-edge indigenous technologies through participation in mega projects. The Science, Technology and Innovation (STI) 2013 policy of India, released by DST also advocates India's participation in mega-science projects. Active participation and billion-dollar investment in mega-science projects depict India's vision and understanding that no single country is capable to fund, executes and bear the risk of the uncertain outcome of these mega projects.

'*Vigyan Samagam*' will open a new Science Gateway that will satisfy the curiosity of millions of visitors who will visit this year-long exhibition. This is a kind of travelling roadshow, which will provide a unique science communication platform for the global scientific community and the common man. This exhibition will take common citizens through the fascinating world to probe hitherto unexplored phenomena such as the formation of black holes, exploding universe, neutron stars and galaxies, the birth of our universe and so on. The exhibition also shows how fundamental research often leads to technological advances that we take for granted in our daily life.

Out of seven breakthrough mega-science projects, 'Accelerating Science' – a flagship 300-square-metre exhibition of the European Organisation for Nuclear Research (CERN) – will display its activities through animations, videos and interactive media to inspire the general public, particularly high-school and college students. Its main themes are cosmology, particle physics and CERN's key research activities. This CERN exhibit is expected to attract anyone curious about the origins of the universe, the nature of particles we are made of and fundamental science. Experiments on display include the 'Big Bang', the building blocks of life, mysteries of the universe, and a series of

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fundamental breakthroughs in modern science, including the Large Hadron Collider (LHC), which helped hunt for the 'God particle', another name of the 'Higgs boson'.

Origin of the European Organisation for Nuclear Research (CERN)

A handful of visionary scientists in Europe and North America conceptualised an idea to establish a world-class physics research facility. Their vision was both to stop the brain drain to America that had begun during the Second World War and to provide a force for unity in post-war Europe.

CERN - European Organization for Nuclear Research, Switzerland

The first official proposal for the creation of a European laboratory was proposed by the French physicist Louis de Broglie at the European Cultural Conference on 9 December 1949. This resulted in the adoption of the first resolution concerning the establishment of a European Council for Nuclear Research (in French *Conseil Européen pour la Recherche Nucléaire, or CERN)* at an intergovernmental meeting of UNESCO in Paris in December 1951. Two months later, 12 countries (Belgium, Denmark, France, the Federal Republic of Germany, Greece, Italy, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, and Yugoslavia) signed an agreement establishing the provisional council and the CERN was born.

In June 1953, the final draft of the CERN Convention stated that *'The Organisation shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available'*. It was agreed upon and signed by the 12 Member States. The foundation stone was laid in July 1955 to establish new milestones in fundamental research and stretch the limits of imaginations and innovations.

Member countries

The organisation is based in a northwest suburb of Geneva on the Franco-Swiss border and officially has 23 member states: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Spain, Sweden, Switzerland and the United Kingdom till date. After the discovery of the Higgs boson, India also became one of the Associate Members. Lithuania, Pakistan, Turkey, and Ukraine are other Associate Members while Cyprus and Slovenia are the Associate Member States in the pre-stage to Membership. The European Union, Japan, JINR, the Russian Federation, UNESCO and the United States of America currently have Observer status. Funding agencies from both Member and the Non-Member States are responsible for the financing, construction, and operation of the experiments on which they collaborate.

CERN's key achievements

World Wide Web

In today's world, life without the internet and the web seems unthinkable. CERN had pioneered the introduction of internet technology, beginning in the early 1980s through a software project called ENQUIRE, written in 1980 by the British scientist Tim Berners-Lee, which was the predecessor to the World Wide Web. Based on the concept of hypertext, the project was intended to allow an ever increasing number of scientists to share automated information. After the activation of the first website in 1991, it was announced by CERN on 30 April 1993, that the World Wide Web would be free to anyone. Later, CERN made it available in the public domain with an open licence to maximise its dissemination. Another equally revolutionary concept is the Grid, which harnesses the power of computers around the world. It has been developed at CERN to process the vast amounts of data collected by the LHC experiments.

The Large Hadron Collider

The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator ever built that pushes protons or ions to near the speed of light. It is located between France and Switzerland and is housed in a tunnel of 27 km circumference, 100 m below ground, with a number of accelerating structures to boost the energy of the particles. It is used for colliding protons and lead ions at centre-of-mass energies of 13 TeV and 5.7 TeV respectively, creating controlled physical conditions that would have existed soon after the Big Bang.

The beams inside the LHC are made to collide at four locations around the accelerator ring, corresponding to the positions of four particle detectors – ATLAS, CMS, ALICE and LHCb. The whole process needs a high level of precision as the particles are so tiny.

Higgs boson – the God particle

4 July 2012 was a historic day in particle physics, when a team of scientists of the ATLAS and the Compact Muon Solenoid (CMS) experiments at CERN›s LHC announced they had each observed a new particle in the mass region around 125 GeV. This is about 125 times the mass of a proton, the positively charged particle found in the atomic nucleus. It was the 'Higgs boson', one of the final puzzle pieces required for a complete understanding of the Standard Model of particle physics. This was the first time the elusive particle was detected although its existence had

been predicted in 1964. The lack of an accelerator of sufficient energy came in the way of its detection till the LHC became available. Higgs boson is a unique boson which imparts mass to other particles.

Antimatter

Antimatter is produced in many experiments at CERN. In collisions at the Large Hadron Collider the antiparticles that are produced cannot be trapped because of their very high energy; they annihilate harmlessly in the detectors. The Antiproton Decelerator at CERN produces much slower antiprotons that can be trapped. These antiprotons can then be studied to explore the nature of antiparticles.

High-Luminosity Large Hadron Collider (HL-LHC)

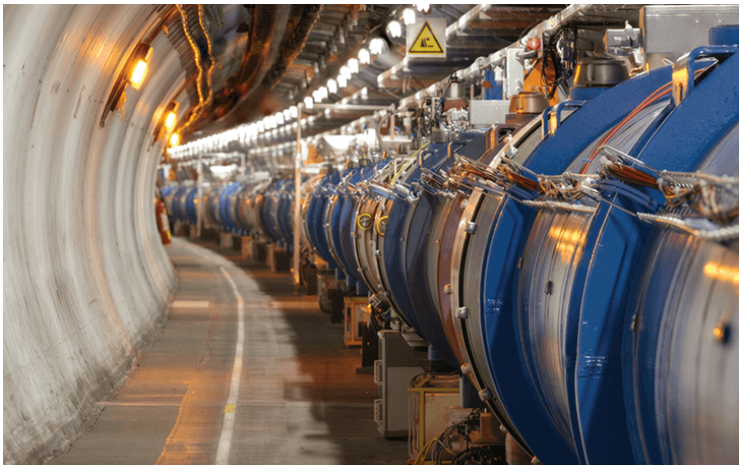
Luminosity is proportional to the number of collisions that occur in a given amount of time and an important indicator of the performance of an accelerator. Luminosity LHC project was stated to produce at least 15 million Higgs bosons per year, compared to around three million from the LHC in 2017. It should be operational around 2026. The accelerator will be built with support of an international collaboration of 29 institutions in 13 countries, including the United States, Japan and Canada.

Societal applications

The core mission of CERN is fundamental research in particle physics, but CERN's basic tools – particle accelerators and detectors and electronic particle detection techniques – also support the frontiers of technology, addressing global societal challenges. The technologies and scientific advances at CERN have contributed to medical science, biotechnology, aerospace applications, cultural heritage through art restoration and emerging technologies and are expected to have a significant impact in the future. Apart from CERN's contribution to early studies on Positron Emission Tomography (PET) devices, CERN's unique expertise and technologies are being used in areas related to medical diagnostics and imaging, therapy as well as computing and simulations for health applications. CERN has a partnership with a variety of players in aerospace sectors and shared technologies, facilities, and expertise in the flight and ground segments of many space missions.

India's position in CERN

The Department of Atomic Energy entered into a co-operation agreement with CERN on 28 March 1991, followed by a protocol for collaboration in LHC on 29 March 1996. CERN invited India to participate in the construction and commissioning of Advanced Accelerators under Novel Accelerator Technology (NAT) Protocol in 2006. India's participation and contribution became stronger when India became an Associate Member of CERN in 2017.



The Large Hadron Collider

Indian scientists have significantly contributed towards major discoveries reported from the LHC, viz., the discovery of the Higgs boson in 2012 and formation of Quark Gluon Plasma (QGP), a confined state of quarks and gluons in strongly interacting matter at extreme temperatures.

Indian scientists and engineers have participated in the construction, commissioning and operation of the two large experiments at LHC, viz., A Large Ion Collider Experiments (ALICE) and Compact Muon Solenoid (CMS). The ALICE experiment, which is a dedicated experiment for the study of Quark Gluon Plasma and to get a glimpse of how matter behaved within a few microseconds after the birth of our universe. The Photon Multiplicity Detector (PMD), the Muon Spectrometer, the MANAS chip, and silicon pad detectors are the main hardware contributions to the ALICE in which the PMD is a fully Indian effort from conception to commissioning. Indian scientists have been involved in the design and have manufactured the Hadron Barrel Outer Calorimeter, silicon strip-based pre-shower detector and RPC detectors, part of the CMS experiment. CMC is one of the two experiments that led to the discovery of the Higgs boson. It involved 40 Indian scientists out of a total 4,000.

Experiments at CERN produce colossal amounts of data (roughly 30 petabytes a year), which are processed using Grid computing, enabling sharing of resources among computer centres located around the world. India has established and is running two tier-2 grid computing centres in the country for the LHC data analysis. Theorists from India are constantly working at the data generated and making it available to advance knowledge in the field.

The Raja Ramanna Centre for Advanced Technology (RRCAT), Indore served as a nodal institute for this collaboration. Later, the finding has been aided by researchers from Delhi University, Bhabha Atomic Research Centre, Panjab University, Tata Institute of Fundamental Research (TIFR) in Mumbai, Saha Institute of Nuclear Physics (SINP) in Kolkata and many other Indian research institutions, universities and industries.

Science diplomacy through CERN

A programme which was started in Europe, now unites scientists from around the world in the pursuit of knowledge, overcoming political barriers. Scientists worked together even during the cold world war and many Eastern European countries joined CERN soon after the fall of the Berlin Wall. As of 2017, more than 17,500 people from around the world were working together to push the limits of knowledge.

CERN provides a large platform and an opportunity for students in applied physics, engineering and computing to learn on the job at CERN and for technicians to train in fields at the cutting-edge of technology. CERN's training and education programs cover all ages from high-school students to particle physics professionals.

Industry 4.0: The Fourth Wave of the Industrial Revolution

Dr. Prashant R. Nair

ICT technologies under the ambit of Industry 4.0 transform the supply chain to a value chain. ICT adoption and deployment across various processes and links in the supply chain has become a determinant of competitive advantage for enterprises. ICT tools are great enablers, enhancers, levellers and facilitators of enterprise operations. Deployment of these tools in supply chain planning and execution processes have resulted in better transparency, visibility, resilience, adaptability, dialogue, adaptability and decision-making for enterprises.

Introduction

Rapid technology advances and dynamic market forces have altered the business landscape as also fundamentally altered existing business models. Information and Communication Technology (ICT) usage and deployment has opened the doors for companies to compete in any marketplace. Even companies, which have been benefiting from protectionist policies by governments, are now exposed to the perils of increased competition due to liberalisation, privatisation, pricing pressures and globalisation. This challenging and dynamic business environment is popularly referred to as VUCA short for Volatility, Uncertainty, Complexity and Ambiguity. Information superhighway has further muddled the competitive waters by providing round-the-clock access and dissemination of information. The following examples illustrate the power of ICT, Internet and world-wide web:

- The largest transportation company in the world is Uber, but interestingly Uber does not own any car.
- The largest media company in the world is Facebook, but interestingly Facebook does not create any content.
- The largest retailer in the world is Alibaba, but interestingly, Alibaba does not own any store or retail establishment.

Industry 4.0

One of the recent buzz words being widely spoken about is Industry 4.0, which is also popularly referred to as the fourth industrial revolution. The first three waves of the industrial revolution were led by the steam engine, assembly line and mass production, and automation facilitated through computers, respectively.

Industry 4.0 is the latest disruptive trend of automation led by cyber-physical system (CPS). It includes cutting-edge ICT tools and technologies such as autonomous robotics, business analytics, Industrial Internet of Things (IIoT), simulation, cloud computing, cyber security, additive manufacturing, horizontal and vertical system integration and Augmented Reality (AR). Industry 4.0 has realised the manufacturer's dream of a "smart factory". Within these modular structured smart factories, cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralised decisions. Interestingly, these systems are fuelled not by gasoline or oil or electricity but by 'data' and the capabilities to leverage and mine this data using machine learning and artificial intelligence. Manufacturing and production become adaptive, agile, autonomous, automated, collaborative, coordinated, connected, decentralised, fast, flexible and intelligent, resulting in greater operational efficiencies and lesser costs for enterprises.

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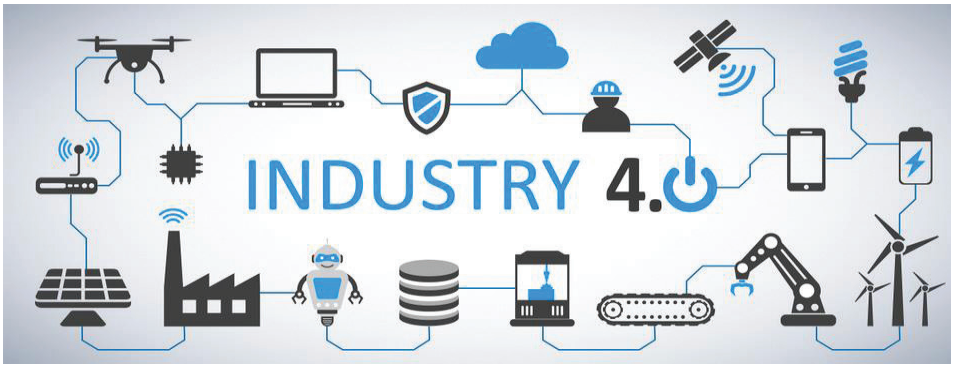


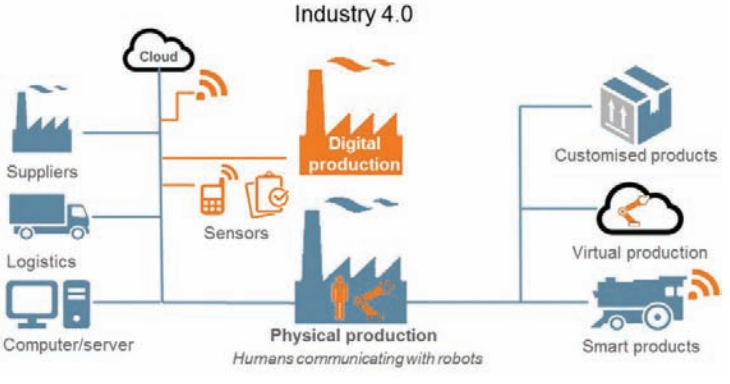
Over the Internet of Things (IoT), i.e., connectivity of physical assets, the CPSs communicate and cooperate with each other and with humans in real-time and both internal and cross-organisational services are offered and utilised by participants of the value chain. CPS consists of collaborating computational elements controlling physical objects, whose processes are seamlessly monitored, coordinated, controlled and integrated. The resultant value chain thereby becomes more agile, collaborative, visible and responsive. An example would be a totally connected and retooled supply chain, which can reconfigure itself on receipt of any new data point. If a weather delay ties up a shipment, a connected system can proactively adjust itself and modify manufacturing priorities bringing about perfect alignment between supply chain planning and execution.

To put it simply, processes and devices become inseparable in Industry 4.0. The origins of these technologies for manufacturing collectively being referred to as Industry 4.0 stems from the famed German engineering. The German Government as also leading industrial powerhouses like Robert Bosch and Siemens unveiled the basic concepts and recommendations in the Hannover Fair to be adopted by industry worldwide.

The German manufacturing powerhouse Siemens is implementing an Industry 4.0 solution in medical engineering. For years, artificial knee and hip joints were standardised products, with engineers needing several days to customise them for patients. Now, new software and steering solutions enable Siemens to produce an implant within 3 to 4 hours. Predix, the Operating System (OS) for the Industrial Internet, is powering digital enterprise businesses that drive the global economy. By connecting manufacturing equipment, analysing data, and delivering real-time insights, Predix-based apps are unleashing new levels of performance for General Electric (GE).

Industry 4.0 Building Blocks

Autonomous Robotics: Advanced and autonomous industrial robots are designed to collaborate with humans in real-time. They have embedded electronic software, integrated sensors, actuators and standardised interfaces that enable them to wirelessly connect with the internet and interact in real-time with other equipment as well as humans. The cost of these robots will progressively decrease, and their capabilities and competencies will improve.



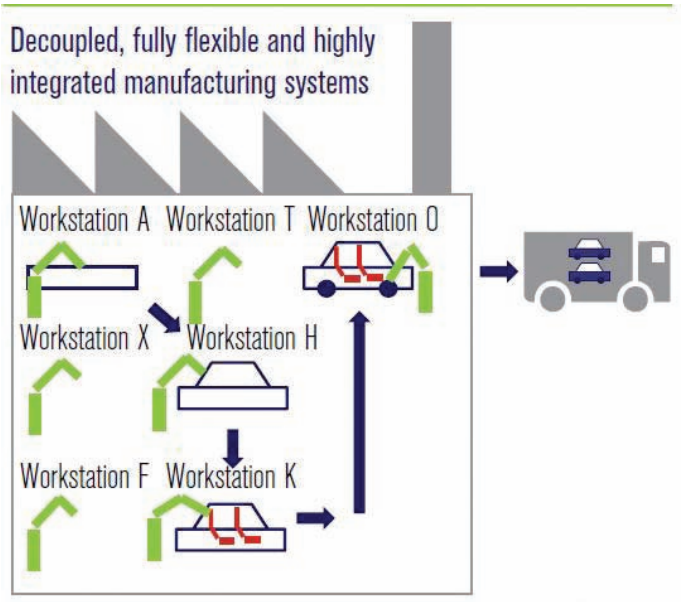
Business Analytics: Business analytics aims at building fresh perspectives and new insights into business performance using data, statistical methods, quantitative analysis and predictive modelling. At a lower level, there is business intelligence that is standard measures for comparing past performance for future improvement based on enterprise data and statistical analysis. Some common usages are retailers using business analytics to predict consumer behaviour and buying patterns; understanding of citizen needs for government to provide better delivery of services; and banks and financial institutions to detect and prevent fraudulent transactions or categorise their customers based on their credit history. Business analytics was estimated to be an industry worth $ 50 billion in 2016. Corporate data generated and managed by enterprises today amounts to billions of gigabytes of data and this data is primarily unstructured and raw. The explosion of information is now dubbed as Big Data and its analytics can point towards actionable intelligence to help enterprises tweak their strategy.

Industrial Internet of Things (IIoT): Industrial IoT establishes inter-connections across all industrial devices, equipment and humans using Internet technologies. Industrial IoT enables networking, collaboration and communication between all internal and external stakeholders in the manufacturing environment, which includes factory machinery, production shop floor, assembly line and their operators such as workers, shop floor supervisors and managers as well as the suppliers and customers. Real-time communication and interaction between all connected stakeholders using results in fast, adaptive and real-time decision-making and responses.

Simulation: Simulation methodologies are modelling tools that are used to predict and evaluate the potential of complex systems and give unique empowerment and autonomy to workers, equipment and processes. Simulations create digital twins of physical processes like manufacturing or inventory. The real-time access to the data as also its interactions with workers, equipment and processes facilitate better decision-making, operational efficiency and speed.

Cloud Computing and Virtualisation: Cloud computing and associated technologies like virtualisation; Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) are touted as the next 'big' thing and game changer for enterprises. The market research company Forrester Research projects that the global cloud computing industry will

grow from $40.7 billion in 2010 to more than $241 billion by 2020. Cloud reduces the total cost of ownership for enterprises. Cloud computing is a form of utility computing, where hardware, software, storage and platform is made available as per need and on a subscription basis. In this service model, clients can access the cloud-based application through an Internet browser. The data can be resident at a remote place also. Complementing the cloud is the usage of server farms and data centres where all applications and data can be stored, shared and accessed on demand using virtualisation. Cloud is a 'green' technology as it eliminates the need for enterprises to procure and maintain large servers and associated space and infrastructure.



Cyber Security: 'Data' being the new 'Oil' means that its security becomes paramount. Ensuring secure operations within connected networks and open systems is a challenging requirement of connected enterprises and their supply chain processes. Industrial systems and manufacturing processes have to be protected from cyber security threats. This entails secure and reliable communication as also secure access controls and identity management for both machines and human users.

3D Printing: This is a form of additive manufacturing which can be used for rapid prototyping and produce individual components. The focus is to produce customized modules which are easy to use and minimise transportation and inventory.

Horizontal and Vertical system integration: Horizontal integration is a modular system that connects the information across entire value chain. Vertical integration pulls together information from across all verticals and levels of the organisation and seamlessly exchanges this across all levels of the organisation. As a result, management functions such as production, HR, finance as well as departments, branches and capabilities are interconnected and cohesive as also interrelated with stakeholders such as suppliers, partners and customers.

Augmented Reality (AR)/Virtual Reality (VR): These technologies provide interactive representation of the real-world environment. This is enlarged and improved by computer-generated interpretation of required information to aid decision-making. AR is now possible across sensory perceptions, including auditory, visual, touch, smell, heat/cold and pressure. Potential applications include customer co-creation, remote maintenance, predictive maintenance, virtually guided self-service, and remote monitoring and control.

SMAC: Complementary to Industry 4.0, is the integration of disruptive and game-changing technologies in the form of the SMAC – Social, Mobile, Analytics and Cloud stack, which promises to be the next wave in enterprise computing. By 2020, International Data Corporation (IDC) estimates that ICT spending worldwide could touch US$5 trillion mark with fourth-fifths of this driven by the SMAC stack, which is the seamless intersection of the SMAC technologies. Technologies within SMAC complement each other and combined they deliver a force-multiplier effect to transform supply chains into value chains. The resultant value chain would boast of the advantages of robustness, agility, responsiveness, scalability, transparency and visibility. Mobile technologies and cloud computing can easily integrate diverse hardware and storage devices. Social media can facilitate instant dialogue collaboration. Business Analytics provide dashboards after mining the enterprise Big Data available through several sources. SMAC technologies can be easily accessed by all with the recent trend of enterprises encouraging their employees to Bring Your Own Device (BYOD).

A Research problem for Industry 4.0

ICT technologies under the ambit of Industry 4.0 transform the supply chain to a value chain. ICT adoption and deployment across various processes and links in the supply chain has become a determinant of competitive advantage for enterprises. ICT tools are great enablers, enhancers, levellers and facilitators of enterprise operations. Deployment of these tools in supply chain planning and execution processes have resulted in better transparency, visibility, resilience, adaptability, dialogue, adaptability and decision-making for enterprises. This is not only within the enterprise intranet but also within the extranet consisting of their partners and suppliers.

While most researchers and industry practitioners are unanimous about the fact that ICT positively impacts supply chain management (SCM) performance and improves supply chain capabilities, there an identified gap in terms of assessment and measurement of these ICT benefits and capabilities in SCM. This is despite the fact that there are several SCM performance measurement frameworks. An interesting research is underway to develop an empirical model and assessment framework of the benefits of ICT deployment in SCM and its dovetailing into Supply Chain Operations Reference (SCOR) model of APICS, the association for supply chain management. Validation of this assessment framework has the potential to open new vistas on selection of appropriate ICT tool after measurement of its impact on the supply chain paradigm and understanding success factors and operational challenges for adoption of these tools. This can translate into immense potential and savings for Indian industry, both large and Micro, Small and Medium Enterprises (MSME) standing to gain, considering that global supply chain losses amount to over $100 billion annually. Measuring this impact by providing a benchmark provides them with strategic choices for their investment in ICT as also choice of ICT tool.

Interview with Prof. Robert S. Langer

Dr. Meher Wan

Robert S. Langer is an American chemical engineer, scientist, entrepreneur, inventor and one of the 10 Institute Professors at the Massachusetts Institute of Technology (MIT). Dr. Langer has written over 1,400 articles. He also has nearly 1,300 patents worldwide. Dr. Langer's patents have been licensed or sublicensed to over 350 pharmaceutical, chemical, biotechnology and medical device companies.

Meher Wan: *Thanks a lot, Prof. Langer for accepting my request and investing your precious time for this interview. You have contributed enormously to life sciences and become a scientific celebrity. You are one of the most cited individuals and most cited engineer in human history. You are a scientist who has saved the lives of many.*

Let me start with the question, how do you manage such great scientific output?

Prof. Robert S. Langer: I'm very lucky to have wonderful, brilliant and highly motivated students and postdocs who are responsible for the output.

MW: *What is your process and method or motivation for doing such terrific work?*

RSL: I like to think that that students are motivated by the questions we are asking in the lab; questions that, if answered, can have a big impact on the world.

MW: *How do you remember your childhood, school days, teachers and environment in Albany?*

RSL: I grew up in a small house with two very nice parents who gave me a lot of freedom and told me I should do those things that made me happy. I have fond memories of playing different games with friends in

Prof. Robert S. Langer

my neighbourhood, of several great teachers, and of playing with chemistry, microscope, and erector sets.

MW: *Many people usually complain that basic education is becoming boring and unproductive for students. What was the state of basic education in your times?*

RSL: It really depended on the teacher. Some were very caring or very dynamic. Others were boring or didn't care.

MW: *You have a keen interest in basic education. You started an alternative high school in Cambridge. What was the motivation behind that?*

RSL: In the 1970s, the city of Cambridge (where Harvard and MIT are located) had the highest high school dropout rate of any city its size in the United States. I had done a lot of math and science tutoring to high school students, so when several teachers in Cambridge wanted to create a private high school for poor working-class students, they asked if I would help, particularly in the math and science areas.

MW: *You are an amateur magician and enjoy performing it for students and in parties.*

RSL: I've always been fascinated by magic. I also think a lot of science is magical too.

MW: *What made you curious about chemical engineering? When did you realise that science-tech is the field you would dedicate the life for?*

RSL: I liked chemistry from playing with my chemistry set as a child. I guess that was the start. But I also have come to realise that chemistry and chemical engineering can change the world.

MW: *You mention Judah Folkman as your role model in science! How important is a mentor in the scientific journey of an individual according to you?*

RSL: Very important. It enables you to see what might be possible at a stage in your life when you might feel insecure about what you can accomplish.

MW: *Science is much more interdisciplinary now. You struggled a lot for getting a job during 1970s.*

RSL: I struggled a lot finding a good faculty position. I was a chemical engineer doing some fairly basic biology and medicine, and chemical engineering departments at that time didn't believe in that, so I ended up in a nutrition department.

MW: *How do you feel when you see that working in an interdisciplinary field is a luxury now? You left a faculty job in the nutrition department and wanted to do chemical engineering.*

RSL: I'm glad it worked out the way it did. I learned a lot and I hope the work we've

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done has helped create a portion of what the biomedical aspects of chemical engineering are today.

MW: *In your early days in science, you started working on the structure of polymers for possible drug delivery. You are considered as one of the pioneers of the field; It took around ten years for contemporary scientists to understand the importance of your research. All your nine proposals for funding were rejected at that time. How do you remember your struggle of the time?*

RSL: I was very depressed and sad.

MW: *Please, tell us any interesting story from your scientific life.*

RSL: When I first started my research on controlling the release of large molecules from polymers, many people told me it was impossible. Yet, when we succeeded, we filed a patent, but the patent examiner didn't understand it and rejected the patent five straight times. Everyone told me to quit trying to convince him and give up on the patent. But I don't give up easily. However, I could see scientific explanations were not working. So I wondered if anyone had ever written down the fact that they thought what I was doing was impossible. So I did a literature search and I discovered a scientific journal article written by five famous scientists saying that. They even used the word "surprising" referring to our work. So we showed that to the patent examiner and he said he had no idea people had said that. He said that if I could get written affidavits from each of the five scientists that they really said that, that he would allow the patent. So, I wrote to all of them and each confirmed they wrote it and the patent was allowed. That was my first patent.

MW: *What was the turning point in your scientific life?*

RSL: Being a postdoc with Judah Folkman at Harvard and Boston's Children's Hospital. I was the only engineer in the hospital. And it gave me a unique perspective on how I could use chemical engineering to solve medical problems.

MW: *How satisfied do you feel now after such a long and fruitful journey in science?*

RSL: I'm very happy. I feel we've trained nearly a thousand students and made some discoveries and inventions that I hope are making the world a better place.

MW: *Do you get 'Eureka' moments for your discoveries?*

RSL: Sure. Research is still very exciting. And I love working with the students in our lab and seeing them get so excited about what they do.

MW: *Which scientific goal you still want to achieve?*

RSL: There is not a single goal. My goal is to have our lab make more discoveries and inventions, to translate these into products that can improve and save lives, and to train the leading biomedical engineers of the future.

MW: *What are the most important unsolved challenges in the field of life sciences for this century?*

RSL: There are many. Understanding how to create new tissues and organs, developing and delivering genetic molecules to the right cells, and better understanding the immune system and how to treat autoimmune diseases and brain diseases like Alzheimer's are just a few.

MW: *Cancer is still a big challenge.*

RSL: It is. We are doing a lot of work applying nanotechnology to new cancer treatments in our lab.

MW: *You have been awarded numerous highly prestigious international awards, honorary doctorates from Harvard and Yale. You are a scientific celebrity whose posters are at the gates of international airports. What type of responsibility or feeling you have now?*

RSL: I want to help young scientists and engineers, and to help people in the developing world.

MW: *Any message to young researchers? Especially, the young minds of developing country like India.*

RSL: I think being a scientist or engineer is a wonderful career. You can discover and invent things, and you can make the world a better place. It's an incredibly fulfilling career and life.

Techniques to Improve Your Memory

Jyotsna Devi

Forgetfulness is a common complaint among people of all ages. Children often complain that although they study hard, they forget their lessons during examination. The problem is more acute in elderly people. However, memory loss is not inevitable. Whatever the age, there are many ways by which we can improve our cognitive skills and keep our brain active.Eating well, having good social connection, managing stress, getting enough sleep, giving up alcohol and smoking and doing regular exercise can go a long way in keeping the brain fit.

It just happens sometimes that we misplace the objects of everyday use. At times, we cannot remember the name of the last book we read or the restaurant we visited or the name of a person we have met before. While shopping, we keep forgetting to buy some items. Sometimes, we walk into a room to get something and then realise that we cannot remember why we went in there in the first place! All these lead us to feel that we are constantly forgetting things, and memory lapses might have occurred. While it seems like we are destined to tolerate these daily annoyances, researchers have found that we can learn to improve our memory. Many scientists are now working on boosting memory power.

No matter which stage of life we are in, memory lapses will be a cause of consternation. For the young, it will affect their studies; for professionals, it will mean poor performance and for the elderly the fear that it may signal Alzheimer's or dementia.

All our physical and mental functions and activities are controlled by a super computer called the brain, housed safely in the skull. Memory starts in the brain with encoding of data. The brain scans inputs much like a computer and files it away for retrieval at a later time. This process requires chemical reactions in the brain involving enzymes, vitamins and essential minerals. It is the neurons or the nerve cells in the brain that help us remember things. When these nerve cells are in short supply, memory lapses occur. As we age, the connections between the brain cells decrease and become less efficient.

Causes of memory loss

Our lifestyle, general health and environment around us can all contribute to memory problems. Many a times, memory loss can be caused by treatable conditions.

Depression: Depression may show the signs of memory loss, making it hard for us to concentrate, stay organised, remember things and get stuff done.

Deficiency of vitamin B12: Vitamin B12 protects neurons and is vital to healthy brain functioning. A lack of B12 can cause permanent damage to the brain. Treatment for vitamin B12 deficiency can reverse the associated memory problems.

Thyroid problems: Our metabolism is controlled by the thyroid gland. Thyroid problem leading to too fast or too slow metabolism can cause memory problems such as forgetfulness and difficulty in concentrating. Medication can reverse these symptoms.

Smoking and alcohol abuse: Alcohol is toxic to brain cells. Therefore, alcohol abuse leads to memory loss which over time increases the risk of dementia. Smoking elevates the risk of vascular disorders and constricts arteries that deliver oxygen to the brain.

Medication side-effects: Many prescribed drugs or a combination of drugs can cause memory loss as side-effect. This is

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especially common in older adults because they break down and absorb medication more slowly. Common medications that affect memory and brain function include sleeping pills, antihistamines, blood pressure and arthritis medication, muscle relaxants, anticholinergic drugs for urinary incontinence and gastrointestinal discomfort, antidepressants, anti-anxiety medicines, and painkillers.

Stress: The stress hormone cortisol damages the brain over time and can lead to memory problems. Thus, we are likely to suffer memory lapse when we are stressed or anxious.

Memory and aging

Forgetfulness is common among older adults. They may find it difficult to remember names of persons, familiar streets, books, movies or other things. As we grow older, we experience physiological changes that can cause minor malfunctioning of brain. That is why, it takes longer to recall information and to learn new things. This slowing of mental process is often mistaken for true memory loss. But in most cases, if we give ourselves time, the information will come to mind. Many mental abilities are largely unaffected by normal aging, such as our wisdom, knowledge, common sense, our ability to form reasonable judgement and our capacity to do the things we have always done.

Causes of age-related memory loss

The hippocampus, a region of the brain involved in the formation and retrieval of memories, often deteriorates with age. Hormones and proteins that protect and repair brain cells and stimulate neural growth also decline with age. Moreover, older people are less efficient at absorbing brain-enhancing nutrients.

Hypertension usually sets in during middle age and if untreated it makes the blood vessels thicker and less pliable. The blood supply to the brain is then affected. Otherwise also, older people often experience decreased blood flow to the brain. This can impair memory and lead to cognitive decline. In older adults, low vitamin D levels are associated with poorer brain function and increasing levels may help keep them mentally fit. This is because activated vitamin D receptors increase nerve growth in the brain. Older adults are particularly susceptible to dehydration. Severe dehydration can cause confusion, drowsiness, memory loss and other symptoms that look like dementia. Therefore, it is important to stay hydrated, especially if one suffers from diabetes, high blood sugar or diarrhoea.

Ways to improve memory

We can increase our memory by regularly engaging in the right activities. Here are some techniques to help us to keep our mind active.

Eating the right food: The diet should be healthy, with less oil, fat processed flour and sugar. It should include antioxidant-rich, colourful fruits and vegetables like curry leaves, celery, broccoli, beans, peas, cauliflower, etc., which can protect the brain from harmful free radicals and prevent cell damage and even stimulate the production of new brain cells. Consumption of fish rich in omega-3 fatty acids helps. Drinking green tea helps since it contains antioxidants. Eating some nuts every day is advisable. In addition, it is better to avoid aluminium as far as possible in the form of aluminium-containing liquid antacids and cooking in aluminium vessels.

Getting sun exposure: Appropriate sun exposure is all it takes to keep our vitamin D level where they need to be for healthy brain function.

Getting proper sleep: It is believed that the brain shifts memories from temporary to longer term storage during a long and deep sleep. Sleep deprivation hampers the growth of new neurons, concentration and decision-making. Sleeping for at least seven hours a night is necessary to improve performance of challenging skills. In fact, a single night of sleeping only four to six hours can impact our ability to think clearly the next day.

Learning a new skill: The unused areas of the brain tend to atrophy. Engagement in purposeful and meaningful activities stimulates the neurological system. So, it is better to try to engage in a new task that is mentally stimulating and gives us great satisfaction. It should be an activity to look forward to doing, such as playing a musical instrument, dancing, gardening, crafting, cooking class, learning a new language, etc.

***Exercising regularly*:** Exercise seems to be good for the human brain, with many recent studies suggesting that regular exercise improves memory and thinking skills. Exercise improves blood flow to the brain. This in turn stimulates the nerve cells of the brain to multiply, strengthen their interconnections and protect them from damage. During exercise, nerve cells release substances known as neurotrophic factors that are responsible for the growth of developing neurons. Thus exercise directly benefits cognitive functions including learning. An easy way to fight memory loss is briskly walking for 20-25 minutes several times a week – a dose of exercise achievable by almost all of us. Walking also prevents brain shrinkage. Exercise also reduces the risk for disorders such as diabetes and cardiovascular disease that lead to memory loss. It also helps in managing stress and alleviating anxiety and depression- all of which leads to a healthier brain.

Avoiding multitasking: Multitasking is the human attempt to do simultaneously as many things as quickly as possible. Research shows that a person needs about eight seconds to commit a piece of information to his or her memory. So, if one is talking on the phone and carrying in groceries and at the same time also putting down one's ATM card, money, car keys, etc., then one is unlikely to remember where these were kept. Ultimately, multitasking may actually slow us down, make us prone to errors as well as make us forgetful. Therefore, it is better to try to complete the tasks one by one which would be mindful and achieve undistracted focus.

Managing stress: We all experience stress to some degree in our daily life. But while a limited amount of stress is normal, continuous or severe stress can be very harmful to our physical and mental health. Cortisol, a steroid hormone is released in response to stress. High level of the hormone for extended periods of time can lead to memory loss. When we are stressed out or anxious, we are likely to suffer memory lapses and have trouble learning or concentrating. The harmful effects of stress can be reduced by exercising daily, but the exercise should be appealing and shouldn't be considered a tiresome chore. Beside exercise, deep breathing, yoga and meditation are good stress busters. Better to try them.

***Keeping good general health*:**

Certain health conditions that can hasten brain degeneration include diabetes, high blood pressure, sleep apnoea, depression, hypothyroidism and high LDL (bad) cholesterol. If there is any of these health issues, it is better to follow the doctor's advice and keep them under control.

***Staying social*:** People who have strong social ties with family and friends are at lower risk for memory lapse than people who don't have social contact. Social interaction helps brain function better as it often involves activities that challenge the mind and it also helps ward off stress and depression. So, better to reconnect with old friends, joining some club or visiting the local senior centre.

Playing brain games: Just as physical exercise can make and keep the body strong, mental exercise can make the brain work better and lower the risk of mental decline. As we grow older (especially after retirement), we tend to use less of our brain. The areas responsible for swift decision making and mathematical calculation begin to degenerate as they are not actively used. Brain degeneration can be countered by challenging the brain. One way to challenge the brain is via 'brain games'. Crosswords and jig-jaw puzzles or number puzzles such as Sudoku stimulate the brain, thus improving memory and delaying brain decline. Most newspapers regularly feature puzzles. Mind games like chess, scrabble and cards also help. Video games and computer games are good for older people (not good for children though) as they help to develop strategy and speed up reaction time. Memorising poetry and parts from religious or other books, learning new words and engaging in spelling exercises are excellent ways to stimulate the brain. Researchers are of opinion that playing brain games activates the memory areas and help boost brain power.

Prof. Robertson, a neuropsychologist who was a professor of psychology at Trinity College, Dublin, had said that it is possible to boost and improve our mental functions at any age. He had developed puzzles from memory jogs to Sudoku, to crosswords, to number games that have been especially formulated to improve each and every part of the brain, from visual-spatial ability to perception, attention, memory, numerical agility, problem-solving and language. However, it is necessary to play the games every day, forever, to keep up the benefits.

Compensating for memory loss

As we age, the brain cells begin to shrink in size, especially in the hippocampus and the prefrontal cortex. The connections between the cells become weak. These changes make us 'slow down', with decline in cognitive skills. Even if we are experiencing some level of memory lapse, there are several ways by which we can remember things.

- Writing down important dates, appointments, phone numbers/other contact information and tasks that need to be done in a diary/notebook or phone.
- If names are a problem, repeating a person's name several times in the head when being introduced can help.
- Reading a book helps develop concentration.
- Putting things of daily use (keys, glasses, purse, watch, important documents, ATM card, etc.) in the same spot when not using them is important.
- To learn new information, it is important to listen closely when someone talks to us. Then repeat back the information.
- It is important to focus on one thing at a time.
- Mnemonic devices are basically memory tools to help us remember words, names, information or concepts. They help us organise information into an easy-to-remember format. For example, there could be an acronym (BEM for 'buy eggs and milk'); a visualisation (such as imagining a lab coat/stethoscope to remember a doctor's appointment); or a rhyme (if we have to remember name of an acquaintance, for instance, think "Rani Jain dances in the rain"). Chunking, which is breaking up a large amount of information into smaller "chunks", is another option. Suppose we have to memorise this number 6617738919. It's much easier to remember as a phone number: 661-773-8919.

Conclusion

Forgetfulness is a common complaint among people of all ages. Children often complain that although they study hard, they forget their lessons during examination and score less marks. The problem is more acute in elderly people. It is a fact that our health deteriorates as we age and along with it our cognitive skills. Memory lapse in older adults are not always a cause for concern; just that it takes longer to learn and recall information. Our lifestyle, health habits and daily activities have a huge impact on the health of our brain.

However, memory loss is not inevitable. Whatever the age, there are many ways by which we can improve our cognitive skills and keep our brain active. Eating well, having good social connection, managing stress, getting enough sleep, giving up alcohol and smoking and doing regular exercise can go a long way in keeping the brain fit. Regular exercise seems to halt the mental and physical decline that comes with aging, thus improving memory and thinking skills.

Even younger people could benefit from these tips. Strengthening memory is an important component in lessening the odds of developing Alzheimer disease and dementia. Memory lapses can be frustrating but if you are serious about improving your memory and your cognitive function, you can do it easily by observing the tips stated above.

Recent Developments in Science and Technology

Biman Basu

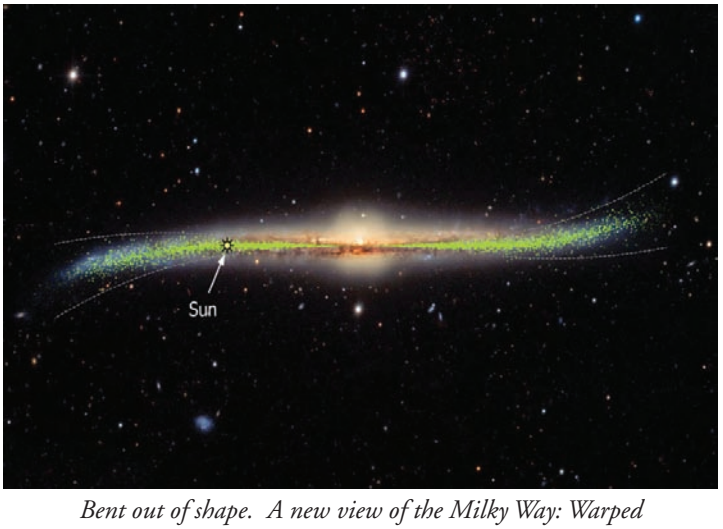
Pomegranate is a fairly common fruit which is known to be nutritious – rich in vitamin C, potassium, and fibre. The fruit has also been claimed to have anti-aging properties, but up to now, scientific proof has been fairly weak. Now, scientists have discovered that urolithin A (UA), a metabolite of biomolecules found in pomegranates formed by microbes in the gut, enables muscle cells to protect themselves against one of the major causes of aging.

New studies show the Milky Way is warped

The Milky Way is not shaped like a flat disc with a bulge in the middle, as was believed till now. New studies have shown that its shape is warped or twisted at the edges like a "misshapen potato chip". The results of the first study to find this out was reported by a team of astronomers led by Dr. Chen Xiaodian of National Astronomical Observatories (NAOC) of Chinese Academy of Sciences (*Nature Astronomy*, 4 February 2019 | doi:10.1038/s41550-018-0686-7). The researchers measured the distances of a special class of stars known as Cepheid variables to develop the first accurate three-dimensional picture of the Milky Way out to its far outer regions. According to them, the pull of gravity becomes weaker far away from the Milky Way's inner regions and in the galaxy's far outer disk, the hydrogen atoms making up most of the Milky Way's gas disk are no longer confined to a thin plane, but they give the disk an S-like warped appearance.

Cepheid variables are young stars that are some four to 20 times as massive as the Sun and up to 100,000 times as bright. Because of their large masses these stars live fast and die young, burning through their nuclear fuel very quickly and live for only a few million years. They show day- to month-long pulsations, which are observed as changes in their brightness. Astronomers can derive the distance of Cepheids reliably from a Cepheid's observed brightness and its pulsation period. The researchers found that "in the Milky Way's outer regions, the S-like stellar disk is warped in a progressively twisted spiral pattern".

In August, another study by a team led by astronomer Dorota Skowron of the Astronomical Observatory of the University of Warsaw in Poland corroborated the study published in February and produced



Bent out of shape. A new view of the Milky Way: Warped and twisted. (Credit: OGLE/Warsaw University)

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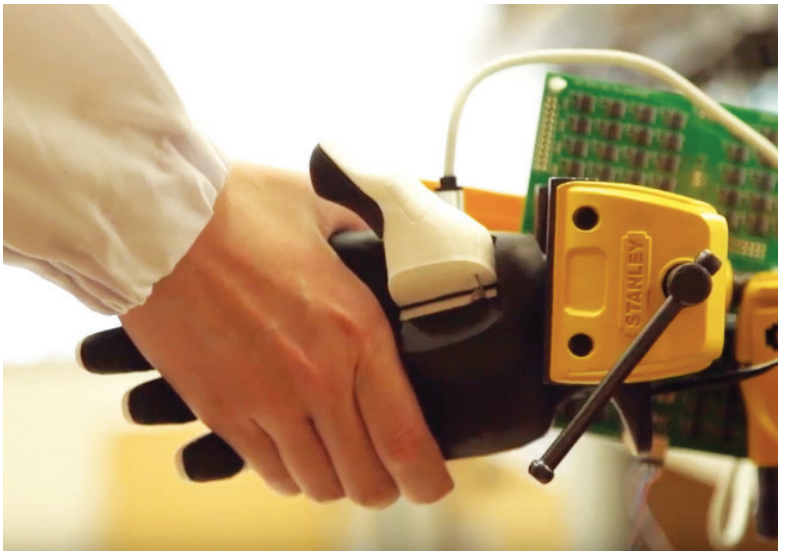
the most complete map of our galaxy to date (*Science*, 1 August 2019 | doi:10.1126/science.aay9675). These researchers didn't try to plot all its hundreds of billions of stars. Rather, they set their sights on "something a bit more subtle – the Milky Way's bends, bulges, and bunches", using distances between Cepheid variable stars as markers. Skowron and colleagues made new observations of Cepheids as part of the Optical Gravitational Lensing Experiment, or OGLE, a telescope and astronomical project that, so far, has more than doubled the number of known Cepheids in the galaxy – akin to improving the resolution on a digital image.

The Polish astronomers scoured the southern skies using a 1.3-metre telescope at Las Campanas Observatory in Chile, snapping hundreds of thousands of photos and monitoring the regular dimming and brightening that would betray a Cepheid's position. In the end, combining their haul with Cepheids known from previous surveys, the team was able to plot the exact locations of 2,431 stars on a 3D galactic map.

The team also used the Cepheids' regular brightness variations to estimate the stars' ages. From the collected data, using computer simulations, the researchers found that younger Cepheids aligned with the Milky Way's four main spiral arms, while the older stars were more scattered, a result of their dispersal over time as the galaxy rotates. They were able to roughly reproduce the stars' actual distributions by simulating stars forming in the galaxy's arms and spreading out over time, helping scientists understand how the galaxy came to have its current structure.

According to the astronomers, as more observations are made, and more data gets collected, it'll be possible to get a better idea of the shape of the galaxy we're living in. In turn, that will help us to investigate the universe at large – the location of dark matter, our neighbouring galaxies, and more.



The National University of Singapore has developed the Asynchronous Coded Electronic Skin, an artificial nervous system that could give robots an exceptional sense of touch. (Credit: National University of Singapore)

New electronic skin can sense touch like human skin

Humans use their sense of touch to accomplish almost every daily task, such as picking up a cup of coffee or making a handshake. Without it, we will even lose our sense of balance when walking. Similarly, robots need to have a sense of touch in order to interact better with humans. But at present, prosthetic devices used in humans and robots lack this ability.

Artificial skin with the ability to feel has been a major research goal for engineers working on improving prosthetic technology. Researchers in the past have created materials with sensors spread over a few square centimetres, but these had several limitations. Now, a team of researchers at the National University of Singapore (NUS) led by Assistant Professor Benjamin Tee has developed the Asynchronous Coded Electronic Skin (ACES), an artificial nervous system that may endow robots and prosthetic devices with a sense of touch equivalent to, or better than, the human skin. Tee has been working on electronic skin technologies for over a decade in hope of giving robots and prosthetic devices a better sense of touch.

The unique sensor system of the new e-skin developed by Tee and his team responds 1,000 times faster than the human sense of touch, the fastest ever achieved for an e-skin. Apart from ultra-high responsiveness, the new electronic skin system is robust to damage and can be paired with any kind of sensor skin layers to function effectively as an electronic skin (*Science Robotics*, 18 July 2019 | DOI: 10.1126/scirobotics.aax2198).

Taking a cue from the human sensory nervous system, Tee and his team at NUS spent a year and a half developing a sensor system that could potentially perform better that the existing systems. To do this they used a different approach. While the ACES electronic nervous system detects signals like the human sensor nervous system, it is made up of a network of sensors

Electronic skin lets any prosthesis feel touch and pain. The skin is made of a combination of fabric and rubber, into which the electronic sensors are embedded. (Credit: img.newatlas.com)

connected via a single electrical conductor, unlike the existing electronic skins which have interlinked wiring systems that can make them prone to damage and difficult to scale up. The use of a single electrical conductor allows ACES-enabled electronic skins to continue functioning as long as there is one connection between the sensor and the conductor, making them less vulnerable to damage. For example, if a corner of the ACES electronic nervous system tears, the rest of the skin continues to have sensation, just like human skin, the researchers said.

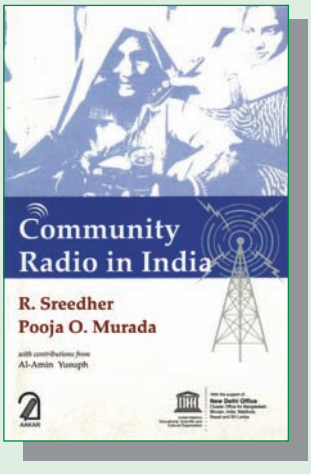
According to the researchers, the ACES electronic nervous system can detect touches more than 1,000 times faster than the human sensory nervous system. For example, it is capable of differentiating physical contacts between different sensors in less than 60 nanoseconds – the fastest ever achieved for an electronic skin technology – even with large numbers of sensors. Moreover, ACES-enabled e-skin can also accurately identify the shape, texture and hardness of objects within 10 milliseconds, ten times faster than the blinking of an eye. This is enabled by the high fidelity and capture speed of the ACES system. The newly developed e-skin could soon enable users of prosthetic limbs to feel sensation on them.

Speaking of the inspiration that led him to this work, Tee said, "The human sensory nervous system is extremely efficient, and it works all the time to the extent that we often take it for granted. It is also very robust to damage. Our sense of touch, for example, does not get affected when we suffer a cut. If we can mimic how our biological system works and make it even better, we can bring about tremendous advancements in the field of robotics where electronic skins are predominantly applied".

According to Tee, the ACES-enabled e-skin can be commercialised for robots within a year or two, but it will take five to 10 years for prosthetics that sense touch to reach patients, to allow for clinical trials. The team will work with prosthetics researchers abroad to conduct a clinical trial of the e-skin with a patient using an artificial hand.

BOOK REVIEW

Community Radio: More relevant in contemporary times and society



India is witnessing a community radio revolution, not only in the nation's progress but also in meeting international development goals. Several attempts have been made at various levels, resulting in community radio getting its due recognition. In the eight chapters of the book *Community Radio in India*, the authors explain the history, evolution, different formats and the reach of the community radio in India. A separate chapter is dedicated to the information about setting up a community radio station in India. The same chapter deals with its financial aspects. The practical challenges related to the content and human resource management, financial structure and operations are discussed in another chapter. The book published by Aakar Books ends with five annexures with relevant information for readers.

Dr. R. Sridhar, one of the authors, has a long experience with the electronic media (TV and radio) and community radio. Pooja Murada also specialises in the subject of community radio. The price offers value for money. It is hoped that the book will prove useful for the practitioners, enthusiasts as well as researchers in the field of the community radio.

Seven Scientific Adventures of Shaurya & Maya

It is said that children are scientist by birth and it is so because they have great curiosity. If you listen the conversation and planning of children, you will feel innovation and uniqueness in them. If these traits od every child could be nourished, they may attain heights in all walks of life including scientific exploration. Eminent scientists like CV Raman, Einstein, APJ Abdul Kalam and Yash Pal had been emphasized to nurture these virtues among children. Raman always said to observe nature and then go to laboratory for research. Nature is the biggest lab to experiment with.

In the book titled "*Seven Scientific Adventures of Shaurya & Maya*", author Shri Dinesh Srivastava has told the whole plot of seven chapters through two imaginary characters namely Shaurya and Maya. Both are telling all the stories in a dialogue format. The stories are based on mathematics, space science, geology, life sciences and anthropology.

The price of this book is Rs. 100 which is very cost effective. Gutenberg Publishing house, Lucknow, Uttar Pradesh has published this wonderful book which is equally worth reading to children and parents.

— Book reviewed by **Dr. Manish Mohan Gore**

125th Birthday of eminent naturalist and science writer Gopal Chandra Bhattacharya Celebrated

Bangiya Bijnan Parishad, Vigyan Prasar and Gopal Chandra Bhattacharya Bijnan Prasar Samiti jointly organised a one-day seminar to celebrate the 125th Birthday of Gopal Chandra Bhattacharya on 1 August 2019 at Bangiya Bijnan Parishad, Kolkata. The seminar was organised in collaboration with Bose Institute. One hundred sixty distinguished guests were present at the seminar.

The programme started with a song by Mrs. Karabi Chowdhury followed by felicitation of the dignitaries by mementos and saplings. Dr. Tapan Saha, Secretary Bangiya Bijnan Parishad delivered the welcome address. Prof. Goutam Basu, Senior Professor of Bose Institute, in his inaugural address explained the importance of life and works of Gopal Chandra Bhattacharya. Chief Guest Dr. Nakul Parashar, Director, Vigyan Prasar delivered the keynote address. Dr. Parashar emphasised that students should be encouraged to know more about Gopal Chandra Bhattacharya and his popular writings. Prof. Satyabrata Dasgupta, President, Bangiya Bijnan Parishad delivered a speech on Gopal Chandra Bhattacharya. Mrs. Mala Chakraborty, Secretary, Gopal Chandra Bhattacharya Bijnan Prasar Samiti delivered the vote of thanks. The programme was presided over by Prof. Sumitra Chaudhuri, President, Gopal Chandra Bhattacharya Bijnan Prasar Samiti. A Bengali book on Gopal Chandra Bhattacharya written by Dr. Ranotosh Chakrabarty was released in the seminar.

A book on Gopal Chandra Bhattacharya is being released. (From left): Dr. Tapan Saha,Dr. Nakul Parashar, Prof. Satyabrata Dasgupta, Prof. Gautam Basu, Mrs Mala Chakraborty, Prof. Sumitra Chaudhuri

(1 August 1895 - 8 April 1981)

Technical Session I was on life and works of Gopal Chandra Bhattacharya. Prof. Bhupati Chakraborty, Ex-Professor, Dept. of Physics, City College and Ex-Secretary, Indian Physics Teachers' Association chaired the session. Prof. Aparajita Basu, Editor, *Jnan O Bijnan* and eminent science write Prof. Ranatosh Chakraborty were the speakers.

Technical Session II was on Biodiversity – Observation, and Conservation. The Session was chaired by Prof. Bhabani Shankar Joardar, Ex-Professor, Dept. of Zoology, Ashutosh College and Ex-Member, West Bengal Biodiversity Board. Prof. Dinedranath Roychaudhury, Ex-Professor, Dept. of Zoology, Calcutta University, and Prof. Shilanjan Bhattacharya, Dept. of Zoology, West Bengal State University were the speakers.

Technical Session III was on Science Literature, Magazines and Gopal Chandra Bhattacharyya. The session was chaired by Dr. Pradip Parekh, former professor of Bose Institute. Prof. Shyamal Chakraborty, Dept. of Chemistry, Calcutta University, and Dr. Manaspratim Das, Programme Officer, Akashvani, Prasar Bharati were the speakers.

Technical Session IV was on Science Communication in Bengali: Road Ahead. Shri Rintu Nath, Scientist F, Vigyan Prasar chaired the session. Speakers were Sri Joydev Dey from Kanchrapara Bijnan Darabar; Prof. Siddhartha Naryan Joardar from Peoples' Association for Science and Environment; and Sri Milan Gayen, Paschimbanga Vigyan Mancha.

A section of the participants at the seminar

Symposium Report:

Science communication and writing: Challenges and concerns

The Vigyan Prasar collaborated with the Prayagraj-based Vigyan Parishad to organise a symposium on the topic 'Science communication and writing: challenges and concerns'. The 2-day seminar was held on 31 May-01 June 2019 at Prayagraj's National Science Academy.

Dr. Nakul Parashar sharing his thoughts at the symposium

Dr. Shiv Gopal Mishra, General Secretary of Vigyan Parishad welcomed the guests and introduced them in the opening session. The convener of the seminar Dr. B.K. Tyagi (Scientist, Vigyan Prasar) presented the outline of the programme.

Addressing the seminar, the chief guest Dr. Manoj Kumar Patairiya, Director, CSIR-NISCAIR highlighted the objectives and importance of science communication and factual writing on science subjects. He emphasised the need for science communication based on public need. Dr. Patairiya exhorted the science communicators to fulfil their responsibility of providing accurate and balanced information to the masses on issues like pollution and climate change.

The opening session was presided over by Dr. Deena Nath Tiwari, Convener of Vigyan Parishad. Dr. Tiwari expounded on the challenges involved in popularising science in his speech. Discussing contemporary issues, he stressed on the need to adopt new technologies in energy and water conservation sectors in the country. The opening session concluded with a vote of thanks by Dr. Manish Mohan Gore.

The first technical session on 31 May was marked by Dr. B.K. Tyagi's lecture on the state of science communication in India. Shri Pankaj Chaturvedi, Editor of the National Book Trust (NBT), spokeon the topic 'science in the print and electronic media' while Dr. Manoj Kumar Patairiya spoke about the role of science communicators and writers in science communication. Dr. Shiv Gopal Mishra chaired this session.

The second technical session was convened underthe chairmanship of the noted science communicator Dr. Chandra Mohan Nautiyal. Among the speakers were Dr. Deena Nath Singh, (scientist at BARC), Dr. Pradeep Kumar Srivastava (former scientist, CDRI), Shri Dilip Kumar Jha (In-charge of Science Section of Akashvani), Shri Deepak Kumar (Assistant Director, The Commission for Scientific and Technical Terminology), Dr. Dinesh Mani (Principal, Allahabad University), Dr. Nagendra Singh Mehta (Editor, *Harit Vasundhra*) and Dr. Arvind Dubey (science fiction writer). Among thetopics covered were: 'The role of scientific institutions in science communication'; 'Scientific cartoons – SciToons'; 'The role of the science communication in achieving the Sustainable Development Goals (SDG)'; 'Importance of scientific terminology'; 'Scientific research and human rights'; and 'Science fiction and fantasy'.


A glance of the participants persent in the symposium

In the third technical session on 1 June 2019. Shri Shashank Dwivedi, Shri Nimish Kapoor, Dr. Manish Mohan Gore, Dr. Zakir Ali 'Rajneesh', Dr. Dhananjay Chopra and Dr. Neeraj Kumar were the main speakers. The topics covered included 'The criteria for science communication'; 'Science communication: What, why and how'; 'Science communication on social media'; 'Effective science communication and scientific thinking'. The Director, Vigyan Prasar, Dr. Nakul Parashar presided over this session.

The ICMR advisor Dr. K.N. Pandey was the chairman of the fourth technical session. Dr Raag Tailang, Shri M.L. Mudgal, Dr. Kumar Bharat Bhushan, Dr. Rajendra Prasad Mishra and Dr. S.K. Singh were the speakers in this session.

Dr. Nakul Parashar was the chief guest at the concluding session. He delved in great detail over the possibilities of science communication and writing. He also discussed recommendations and the future roadmap that came out of the seminar. Dr. Shiv Gopal Mishra was the chairman of this session. Dr. B.K. Tyagi thanked all the guests, specialists and participants in the end. The programme was conducted by the Executive Secretary of Vigyan Parishad, Shri Devvrat Dwivedi.

(Report: Dr. Vikas Mishra)

(Translation: Shri Deepak Sharma)