

VIGYAN PRASAR

# DREAM

2047

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# QUANTUM THE INFINITY MACHINE COMPUTING

CEREBRAL PALSY  
IN CHILDREN

IBN SINA:  
MEDICINE MAN OF THE MIDDLE EAST

1940-2020  
DR NARENDER K. SEHGAL

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# MY WORD

NAKUL PARASHAR

## The October Motley

# THE

reputed science journal Nature quotes that 28 October 1920 was the date, about a hundred years ago, when the famous biography titled — The Life and Work of Sir Jagadis C Bose: An Indian Pioneer of Science was published. This wonderful piece of information was authored by famous biologist and town planner, Sir Patrick Geddes (Dream July 2020 cover story). Isn't it interesting that this biography was written about seventeen years before the great scientist, Acharya Jagadish Chandra Bose passed away in 1937? Available online, like any other stuff (a new normal reality), this is a worth read for every science enthusiast.

October also has two other famous scientists from Bengal in its kitty. Famous Indian physicists — Meghnad Saha and Sisir Kumar Mitra were born in October. Their contributions to Indian Science are immense. Prof Saha, besides his notable contributions to the growth of physics in India, is known as the father of the Indian National Calendar. Amazing, isn't it? On the other hand, apart from his notable contributions in astrophysics, Prof Mitra was fortunate to have worked with Marie Curie of the Radium fame. He was the founder of the famous Institute of Radio Physics & Electronics in Kolkata.

The October-November period in India, due to its geographical position is supposed to be a pleasant period, weather-wise. Festivals too, coincide with this period. However, this year, how much the festivities would remain lively is a question, as the race for a vaccine against COVID-19 continues. With the pandemic's second wave being predicted in most parts of the world, it's a 'wait-and-watch' situation all over the world. Scientists and researchers continue to work

relentlessly. As we speak, third phase trials have commenced, indicating that more than half of the research efforts are getting close to the desired goal. This getting-close is, however, still quite relative.

Yet, as we anxiously await the arrival of the vaccine, we are witnessing new formats of the new normal. Awareness about personal hygiene has seen wide acceptance, and as we travel deeper into the countryside one can observe it. People have gained a lot of this awareness through innumerable efforts made by the Government and its agencies. All media formats have been applied to spread the knowledge — print, electronic, social, and digital. With handheld devices getting smarter and accessible, and net connectivity getting better as well, access to timely and precise information is reaching to every household rapidly. It's just to ensure that we stay safe and protected.

While we have all the way been talking about staying positive amidst the gloom caused by the pandemic, we've still witnessed a number of losses this year so far. Indeed, a coincidence that these losses have not occurred due to COVID-19, yet the loss of an eminent personality shall always remain an irreparable one. 7 September this year saw two major scientists passing away almost together. Famous radio astronomer, Prof Govind Swarup, and noted science communicator, Dr Narender K Sehgal left on this day. Dr Narender Sehgal was the founder of the famous National Council of Science & Technology Communications of DST. He was also the founder-director of Vigyan Prasar.

Our heartfelt tribute to the two luminaries of Indian Science & Technology.

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# RECENT DEVELOPMENTS IN SCIENCE AND TECHNOLOGY

## BETELGEUSE'S MYSTERIOUS DIMMING EXPLAINED

**O** Orion (the Hunter) is a prominent and recognisable constellation located on the celestial equator and visible throughout the world. It is named after Orion, a hunter in Greek mythology. Its brightest stars are blue-white Rigel and red Betelgeuse. Classified as a red supergiant of spectral type M1-2, Betelgeuse is one of the largest stars visible to the naked eye, lying at an estimated distance of 725 light-years from the Sun. If it were at the centre of our Solar System, it would engulf the orbits of Mercury, Venus, Earth, Mars, and possibly Jupiter. It has a distinctly reddish colour.

A semi-regular variable star whose apparent magnitude varies between +0.0 and +1.6, with a periodicity of about 425 days, Betelgeuse has the widest range of brightness displayed by any first-magnitude star, though its rise and fall in brightness is not noticeable to casual observers.

In recent times, observations of Betelgeuse have revealed unexpected and significant dimming periods in late 2019 and early 2020. Starting in October 2019, Betelgeuse began to dim noticeably. When the star became very faint by mid-February 2020, this was the faintest that it had ever been since measurements began over 150 years ago; it lost more than two-thirds of its brilliance, from magnitude 0.5 to 1.7.

The dimming of Betelgeuse was even more exciting for astronomers because it is a well-known fact that this star will

someday explode. Speculation raged for weeks, but astronomers subsequently discovered that Betelgeuse's mysterious dimming was due to a traumatic outburst that caused the ejection and cooling of dense hot gases. According to them, as the outflowing expelled gas rapidly expanded outward, it cooled to form an enormous cloud of obscuring dust grains, which could have blocked the light (as

seen from Earth) from a quarter of the star's surface, leading to dimming. (The *Astrophysical Journal*, 13 August 2020 | DOI: 10.3847/1538-4357/aba516).

However, by 22 February 2020, Betelgeuse had stopped dimming and started to brighten again.

Says Andrea Dupree, associate director of the Centre for Astrophysics | Harvard & Smithsonian, and lead

author on the study, "With Hubble, we had previously observed hot convection cells on the surface of Betelgeuse and in the fall of 2019, we discovered a large amount of dense hot gas moving outwards through Betelgeuse's extended atmosphere. We think this gas cooled down millions of miles outside the star to form the dust that blocked the southern part of the star imaged in January and February."



This artist's concept illustrates why the bright red supergiant star Betelgeuse suddenly became fainter for several months during late 2019 and early 2020. (l to r) 1. A bright, hot blob of plasma is ejected from the star. 2. Outflowing expelled gas rapidly expands outward and cools to form an enormous cloud of obscuring dust. 3. The huge dust cloud partially blocks Betelgeuse's light. (Credit: NASA/ ESA/ E. Wheatley (STScI)/ CfA)

## RESEARCHERS USE SUPERCOMPUTER TO UNDERSTAND HEPATITIS B

**H**epatitis B is a serious liver infection caused by the hepatitis B virus that is easily preventable by a vaccine. It is most commonly spread by exposure to infected bodily fluids. The condition often clears up on its own. Chronic cases require medication and

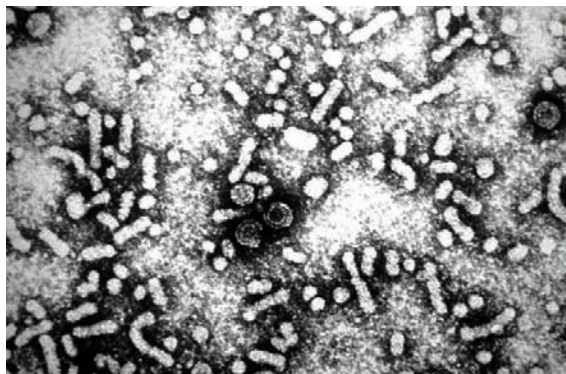
possibly a liver transplant. In India, up to one million cases are recorded every year.

The hepatitis B virus particle consists of an outer lipid envelope and an icosahedral nucleocapsid (the genome+ protein coat of a virus) core. The nucleocapsid encloses the viral DNA and a DNA polymerase that has reverse transcriptase activity similar to retroviruses. The outer envelope contains embedded proteins which are involved in viral binding of, and entry into, susceptible cells.

Recently, researchers at the

University of Delaware (UD) in USA, using supercomputing resources and collaborating with scientists at Indiana University, have gained new understanding of the virus that causes hepatitis B and the “spiky ball” that encloses the virus’s genetic blueprint.

Computer simulations performed by the UD scientists investigated the effects of a mutation that impairs the assembly process. Their work provides insights into how the capsid – a protein shell that protects the blueprint and also drives the delivery of it to infect a host cell – assembles itself. The Indiana University (IU) researchers had been studying the dimers, which are two-part, T-shaped molecular structures, and investigating whether a mutation could activate or deactivate a switch to turn on the capsid’s assembly mechanism. Together the two teams revealed that the region of the protein that contains the



Electron micrograph of hepatitis B virus (Credit: CDC)

mutation, the spike, can communicate with the region of the protein that links with other subunits to assemble the capsid. They found evidence that a change in the shape of the capsid protein switches it into an “on” state for assembly (ACS Chemical Biology, 13 August 2020 | DOI: 10.1021/acscchembio.0c00277).

Jodi A. Hadden-Perilla, assistant professor in UD’s Department of Chemistry and Biochemistry and a

co-author of the ACS Chemical Biology paper, and the team used the National Science Foundation-supported Blue Waters supercomputer at the University of Illinois at Urbana-Champaign, the largest supercomputer on any university campus in the world, to perform what are known as ‘all-atom molecular dynamics simulations’. Molecular dynamics simulations allow researchers to study the way molecules move in order to learn how they carry out their functions in nature. Computer simulations are the only method that can reveal the motion of molecular systems down to the atomic level and are sometimes referred to as the “computational microscope”. The researchers believe that the capsid is an important target in developing drugs to treat hepatitis B, a life-threatening and incurable infection that afflicts more than 250 million people worldwide.

## NEW HOPE FOR MILLIONS AT RISK FROM ANTIBIOTIC-RESISTANT INFECTIONS

**A**ntibiotics are medicines used to prevent and treat bacterial infections. But if misused or overused, antibiotics often become ineffective against bacteria that become resistant to them. When antibiotic-resistant bacteria infect humans and animals, the infections they cause are harder to treat than those caused by non-resistant bacteria. Thus, antibiotic resistance leads to higher medical costs, prolonged hospital stays, and increased mortality.

Today, antibiotic resistance has become one of the biggest threats to global health, food security, and development. A growing number of infections – such as pneumonia, tuberculosis, gonorrhoea, and salmonellosis – are becoming harder to treat as the antibiotics used to treat

them become less effective. The good news is, researchers of the University of Queensland in Australia have discovered how bacteria share antibiotic-resistance genes and looking for ways to prevent the sharing, thereby bringing new hope for more than 700,000 people who die each year from antibiotic resistant infections.

Professor Mark Schembri of the University of Queensland says, “The diminishing pool of effective antibiotics makes these infections a major threat to human health, so it’s critical we understand the exact mechanics of how antibiotic resistance spreads between different bacteria.” According to him, antibiotic resistant-bacteria, in particular emerging ‘superbugs’, could lead to around 10 million deaths globally by 2050.

In this study, the researchers examined plasmids – self-replicating DNA molecules – which are one of the major drivers for the rapid spread of antibiotic resistance genes between bacteria. They used a powerful genetic screening system to identify all of the components required for the transfer of an important type of

antibiotic resistance plasmid from one bacterial cell to another. According to Professor Schembri, many plasmids carry 10 to 15 antibiotic resistance-causing genes, and when they transfer from one bacterial cell to another, two important things happen. Firstly, the plasmid is copied so that it is retained by both the donor and recipient cell, and secondly all antibiotic resistance genes are transferred together, meaning that resistance to multiple antibiotics can be transferred and acquired simultaneously.


The researchers claimed to have discovered genes encoding the ‘syringe’ component – the mechanism through which plasmid DNA is mobilised, as well as a novel controlling element essential for regulation of the transfer process. They also investigated the crystal structure of this controlling element and revealed how it binds to DNA and activates transcription of other genes involved in the transfer.

Biman Basu is a former editor of the Science Reporter, published by CSIR.  
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# Augmenting Writing Skills for Articulating Research (AWSAR)

## Call for Entries

“Augmenting Writing Skills for Articulating Research (AWSAR)” is an initiative of Department of Science and Technology (DST), Government of India. It endeavors to disseminate Indian research stories of Science, Technology & Innovation being pursued in the country in a format that is easy to understand and interesting for all the stakeholders. DST invites lucid stories from PhD scholars and Post Doctoral Fellows (PDF) with an aim to strengthen the ecosystem of science communication and inculcate scientific temperament in society.



My  
Research



*Come,  
Join the new breed  
of science storytellers!*



### Who can apply

Indian citizen pursuing PhD or PDF in any stream of Science and Technology (S&T), within the tenancy period of her/his research, can submit the entry. The story must relate to research being pursued by him/her.



### Award categories

#### A. For PhD Scholars

- 1<sup>st</sup> prize : ₹1,00,000 (one)
- 2<sup>nd</sup> prize : ₹50,000 (one)
- 3<sup>rd</sup> prize : ₹25,000 (one)
- 100 selected entries : ₹10,000 each

#### B. For Post Doctoral Fellows

- One Outstanding story : ₹1,00,000
- 20 selected entries : ₹10,000 each



### Selection criteria

A panel consisting of eminent scientists and science communicators, constituted by DST, will evaluate the entries.

Entries can be submitted from **15 August to 30 September 2020**

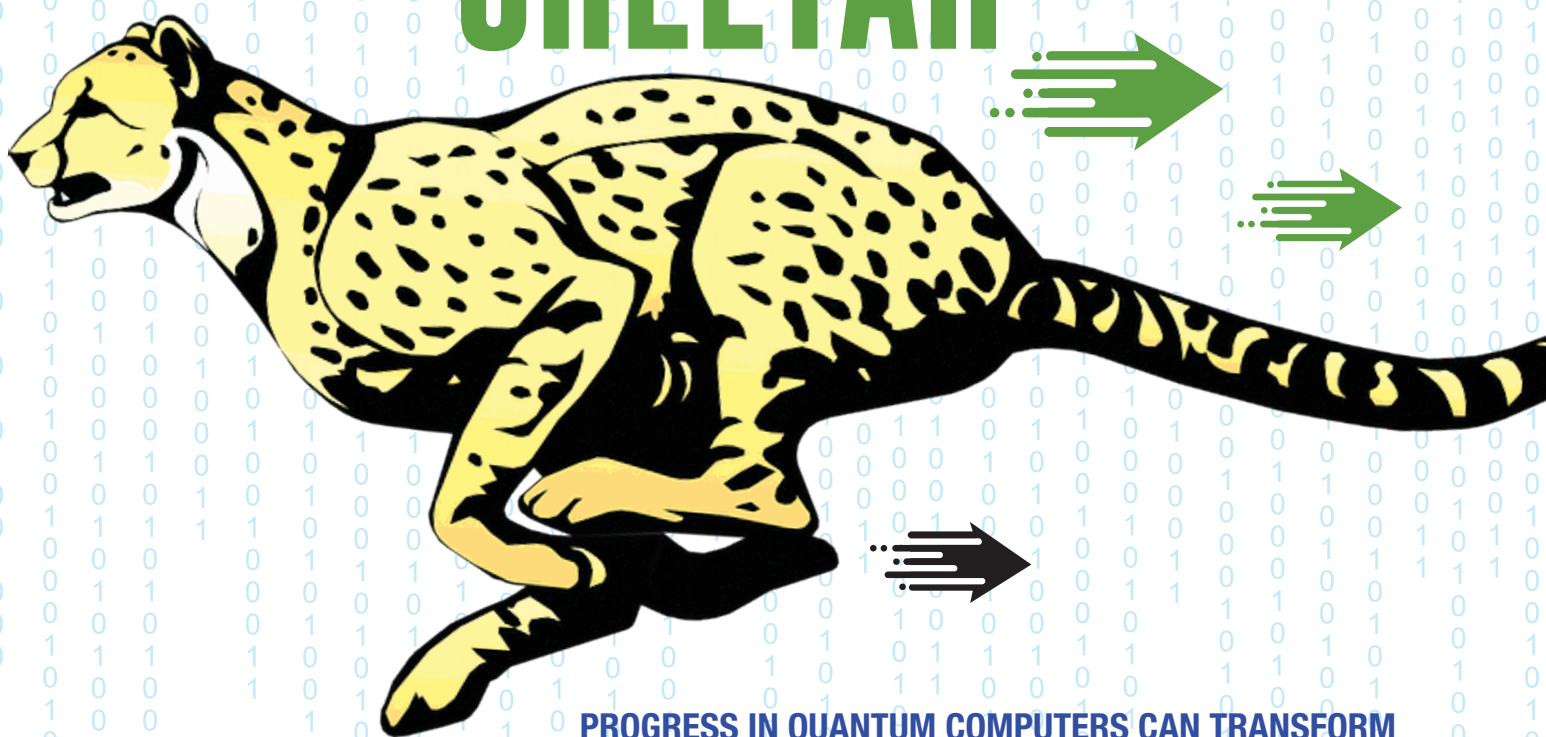
For more information please visit [www.awsar-dst.in](http://www.awsar-dst.in)

**Unleash the Spirit of Science Communication**

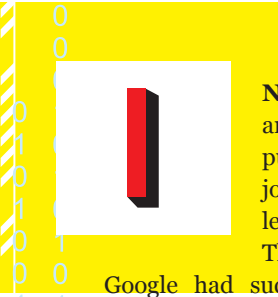
# COVER STORY

GOVIND BHATTACHARJEE

## QUANTUM COMPUTER: SCHRÖDINGER'S CHEETAH



PROGRESS IN QUANTUM COMPUTERS CAN TRANSFORM ENTIRE INDUSTRIES AND RECONFIGURE OUR DIGITAL WORLD. IT CALLS FOR INTERNATIONAL COLLABORATION AND INTERDISCIPLINARY APPROACH INVOLVING PHYSICISTS, CHEMISTS AND COMPUTER SCIENTISTS.

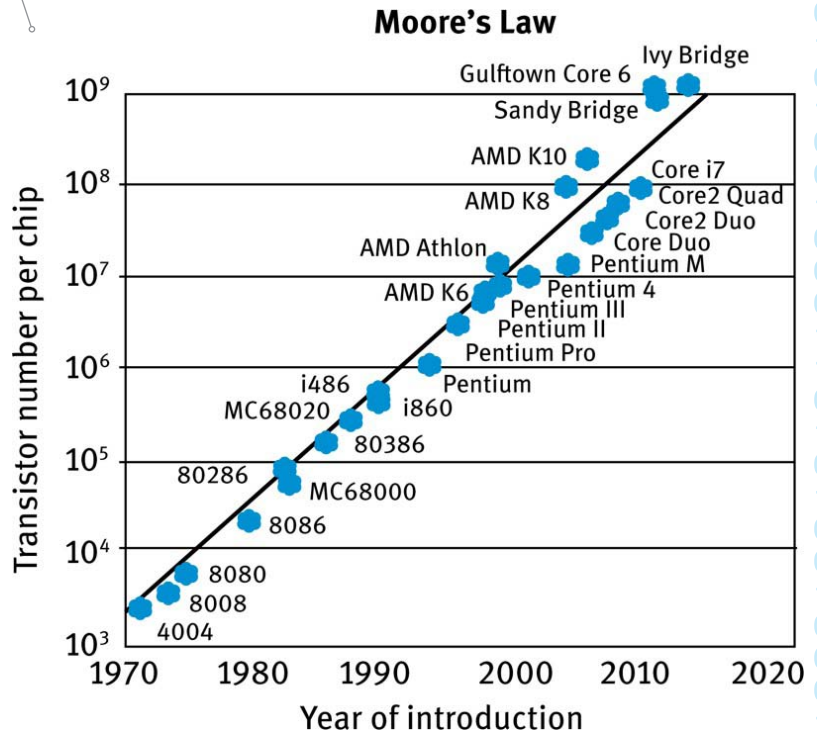


**IN SEPTEMBER 2019**, AN article apparently accepted for publication by the reputed science journal Nature somehow got leaked into the public domain.

The leak revealed that the IT giant Google had succeeded in calculating, in just over three minutes (200 seconds), something that would take Summit, currently the world's fastest supercomputer, some 10,000 years to execute. Google achieved the feat using what is called a Quantum Computer, hitherto the subject of speculation. With this, a new era in computing has arrived. The Economist published an article headlined "Schrödinger's Cheetah", presumably because a cheetah is faster than the famous Schrödinger's Cat that remains eternally trapped in the black box of quantum duality ("Schrödinger's cheetah: Proof emerges that a quantum computer can outperform a classical one", The Economist, 26 September 2019.)

Quantum computing, a topic unknown till the 1980s, is fundamentally different from the way our familiar computers – let us call them "Classical computers" – work. The essential hardware of a classical computer is made of microprocessors - actually integrated circuits (IC) - which are ultra-thin silicon wafers into which are packed transistors. These act as switches allowing the use of bits, either 0 or 1, depending on the 'off' or 'on' position of the switch. Everything from our e-mails to streaming videos is nothing but long strings of bits. A computer works essentially on bits, and therefore the number of transistors that can be packed into the IC determines its speed. Intel's i7 processor launched in 2008 contained 2 billion transistors packed into an IC the size of a fingernail. All modern ICs use Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs) and the number of MOSFETs packed into an IC in modern advanced computers range from 40 billion to more than a trillion. But we cannot go on increasing the number of transistors indefinitely - there is a limit on this scaling of technology expressed by the Moore's Law, propounded in 1965 by Intel's co-founder Gordon Moore, which states that the density of transistors, and hence computer power, doubles every 2 years.

Our ordinary home or office desktops have silicon transistors just 14 nanometres across. Silicon's atomic size is about 0.2 nanometre, and the transistors are just 70 silicon atoms wide. Indeed, we are very close to the limit of how small we can make a transistor, because once it reaches the



Moore's Law  
(Source: [https://www.ncbi.nlm.nih.gov/books/NBK321721/figure/oin\\_tutorial.F3/](https://www.ncbi.nlm.nih.gov/books/NBK321721/figure/oin_tutorial.F3/))

atomic dimension, the age of silicon will necessarily come to an end, and the quantum effects which dominate matter at the microscopic scale, will come into play. Scientists had predicted that the year 2020 would mark the watershed, and right now we are sitting on its cusp. In fact, the classical computers will no longer be able to deal with the size and complexity of problems in a world connected by billions of computer networks, wiring the entire planet together.



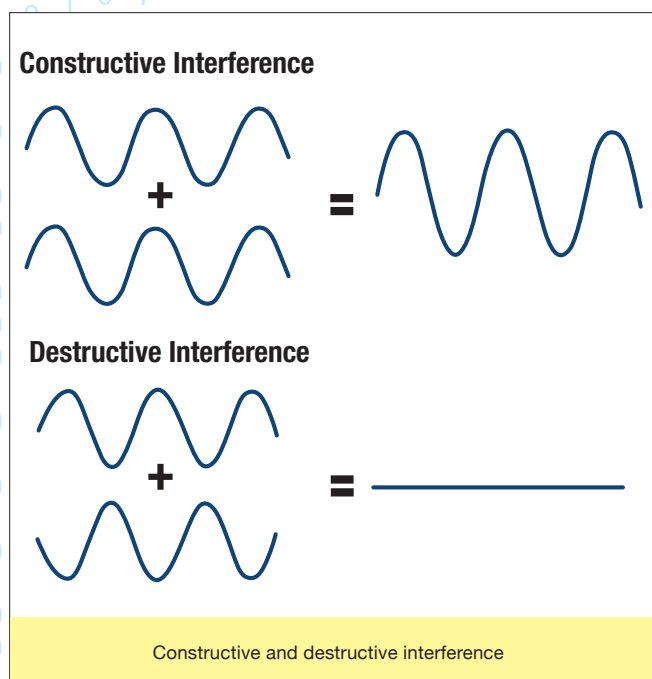
## BIZARRE REALITY AT ATOMIC SCALE

At atomic or molecular dimensions, reality starts to behave in a bizarre fashion, turning our conventional wisdom upon its head. There is no longer the certainty of either 0 or 1. The black-and-white world of either off or on disappears and things become uncertain. The poor Schrödinger's Cat trapped inside the black box is neither alive nor dead, but in an uncertain 'superimposed' state between life and death, of which only the respective probabilities can be calculated, till measurements are made and probabilities are actualised. Even the best classical supercomputers are not efficient at dealing with this kind of uncertainty. That's where quantum



computers become not only necessary but inevitable.

Quantum reality can be expressed by the two essential characteristics: superposition and entanglement. Superposition is a combination of otherwise independent states, like when two separate musical notes are played at the same time, producing a superposed note. Superposition is what causes interference – like when two waves of the same kind, or as we say in the same phase, are superimposed on each other. It produces a larger wave with greater amplitude and hence greater energy, in a positive, or constructive, interference. If they are anti-phase, the resulted wave will have zero amplitude, producing negative, or destructive, interference. Destructive interference may be used to filter out wrong results, while constructive interference can help identify a correct solution of a large, complex computational problem.



The idea of entanglement runs counter to the classical logic of physics. If one tosses two coins, the outcome of one toss has no bearing on the outcome of the other in classical logic, but in quantum logic they do influence each other; in other words, they are entangled. At the microscopic level, Nature is entangled or interconnected. Entanglement binds quantum particles together across time and space in a way classical physics cannot explain. In the entangled state, particles that have interacted at some point in time become permanently entangled even when they are separated by distances so enormous that it is impossible for information or light to travel between them instantaneously, yet changing the state of one particle automatically and instantaneously changes the state of the other. A baffled Einstein called it a “spooky action at a distance”, but what it implies is that measuring the state of one allows us to simultaneously derive

the state of the other, regardless of their separation. If the bits of a quantum computer are entangled, then they can all be measured simultaneously and hence provide more processing power to the computer.



## OVER TO QUBITS

Unlike the bits 0 and 1 in a classical computer, quantum computers work on ‘qubits’, or quantum bits, which are superposition states of the bits. Qubits use physical systems like the spin of an electron or the orientation of a photon which can exist in many superposed states at once. Being linked together through entanglement, a set of limited number of qubits can represent many different things simultaneously. In an ordinary computer, 2 bits can store just one of the four possible combinations of states (00, 01, 10 or 11) at any given time, but 2 qubits can store all four at the same time. While a classical computer with  $n$  bits can exist in only one of the  $2^n$  different states at any given time, a quantum computer of  $n$  qubits can be in  $2^n$  different states at the same time. In a classical computer, doubling the number of bits doubles its processing power. But due to entanglement, adding extra

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qubits to a quantum machine produces an exponential increase in its power. Thus, while in a classical computer 8 bits are enough to represent any of the  $2^8 = 256$  numbers between 0 and 255 at a time, 8 qubits can represent every number between 0 and 255 simultaneously. A few hundred entangled qubits would thus suffice to represent more numbers than even the total number of atoms in the universe. Google’s quantum processor ‘Sycamore’ had only 54 qubits, which between them can represent about ten quadrillion

(1016) possible superposed states. This is where quantum computers outperform the classical computers – they can handle vast numbers of possible combinations simultaneously.

Qubits are put into superposition by manipulating them with precision lasers or microwave beams. Because of entanglement, a quantum computer with sufficient number of superposed qubits can crunch huge numbers of potential outcomes simultaneously. In quantum mechanics, a microscopic entity exists only in the quantum state as a “wave function” with different probabilities of existing at different points, until it is actually measured by setting up an experiment in which the observer actually becomes a participator, because he influences the outcome of the experiment through the process of observation. The uncertainty dominates till measurements are made, when the wave function collapses and probabilities transform into actuality. Similarly, in a quantum computer, the final result of calculation manifests only when the qubits are measured, causing their quantum state to “collapse” to either 1 or 0. Uncertainty forms the core of quantum mechanics; in fact, Heisenberg’s famous Uncertainty Principle, discovered in 1927, forms one of the pillars of quantum mechanics. Unlike in the classical computers, qubits can handle uncertainty pretty well.

The “wave function” of a system is described by the Schrödinger equation, which governs the evolution of any quantum system and relates how it changes with changes in the ambient energy environment. The environment is defined by the so-called Hamiltonian of the system, which is a mathematical representation of the energies resulting from all the forces experienced by all elements of the system. To control a quantum system, the energy environment of the system needs to be controlled carefully, both by isolating it from the rest of the universe and also by regulating the energy content within the isolation region. Complete isolation is impossible and interactions with the environment can only be minimised, but over time, the quantum system will ultimately lose energy and information to the environment, which is known as “decoherence”.

Because of the fragile nature of their quantum states, generating and managing qubits is not easy; almost anything, the slightest vibration or change in temperature known as ‘noise’, can knock them out of their delicate superposition state. They are sensitive to heat, electromagnetic radiation or collisions with air molecules and need protection from such external interferences by physical isolation or other mechanisms like cooling. Qubits are also extremely error prone because of decoherence which decays their quantum behaviour and can make them disappear altogether. Then the system crashes, and it crashes faster when more particles are involved. To isolate the qubits from environment, companies like IBM, Google and Rigetti are using superconducting circuits supercooled to a temperature close to absolute



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zero, while companies like IonQ trap individual atoms in electromagnetic fields on silicon chips in ultra-high-vacuum chambers. To correct for errors that creep into the system, additional qubits are needed. Google’s Sycamore has only 54 standard qubits, while the actual requirement may run into thousands of standard qubits. There is still a long way to go before we shall be able to actually use the quantum computers to our advantage.

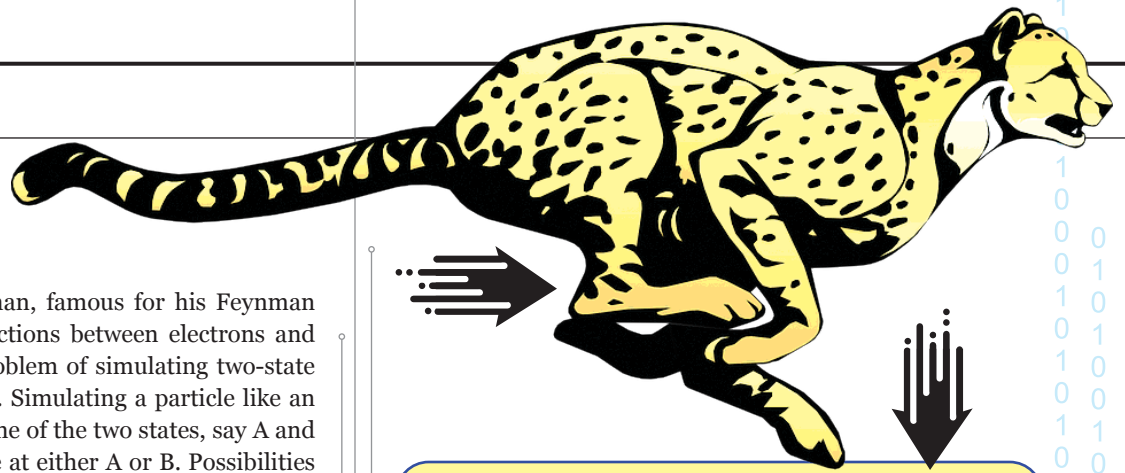
The point at which a quantum computer can outperform the most powerful supercomputer is the point of “quantum supremacy”. One does not know how many qubits will be needed to achieve this, for the classical supercomputing hardware and algorithms are also improving with astonishing speed. For now, Google looks to have achieved this quantum supremacy, but it is not the sole player in the field – other companies like IBM, Amazon, Microsoft, Honeywell, Alibaba and others are also in the race. Amazon has in fact partnered with three companies - D-Wave Systems, IonQ and Rigetti Computing - to create a cloud quantum computing platform called Amazon Bracket.



## **HISTORY OF QUANTUM COMPUTERS**

The history of quantum computers is as fascinating as its challenges. It was in 1980 that Paul Benioff showed the theoretical possibility of quantum computers. At that

## COVER STORY



time, physicist Richard Feynman, famous for his Feynman Diagrams depicting the interactions between electrons and photons, was exploring the problem of simulating two-state physical systems in computers. Simulating a particle like an electron that is observable in one of the two states, say A and B, is rather simple - it could be at either A or B. Possibilities increase with the number of electrons. Thus, with two electrons, there would be 4 possibilities, with 10 electrons, there would be 210 or 1,024 possibilities. But real physical systems have many more particles, and the number of possibilities would be unmanageably large. In his 1982 paper "Simulating Physics with Computers", Feynman argued that regardless of the power or extent of parallelism of conventional computers, quantum mechanical phenomena could themselves be used to simulate quantum systems. In 1985, David Deutsch from Oxford University described a universal quantum computer, like a Universal Turing Machine that provided the basis for digital computers, "capable of perfectly simulating every finite, realisable physical system." In 1992, Deutsch and Richard Jozsa proposed a generalised algorithm that demonstrated the potential speed increases quantum computers could achieve.

In 1994, Peter Shor, working with AT&T, proposed his famous Shor's Algorithm showing how, using entanglement of qubits and superposition, prime factors of very large numbers could be computed in a quantum computer if one could be built. Factorisation of large integers into prime numbers forms the basis of cryptography; for deriving the prime factors  $p$  and  $q$  of a given number  $n$ , no efficient classical algorithm exists which is why it can be used in cryptography. For example, RSA (Rivest-Shamir-Adleman) algorithm is one of the first public-key cryptosystems used for secure data transmission in which the encryption key is public and distinct from the decryption key which is private, i.e., secret. It was shown that Shor's algorithm could break RSA, the public key cryptosystem, which is the basis for prime factorisation. Shor's algorithm could also break the so-called discrete log problem, the other problem in public key cryptosystem that could break the authentication behind most cryptocurrencies, including Bitcoin, Ethereum, and others, as well as other blockchain technologies. Even a moderate number of qubits may be sufficient to break the RSA (around 4,000 error-corrected qubits for 2048-bit keys), which otherwise could take even the largest supercomputers millions of years to compute.

However, people then had no idea how to build a quantum computer. Yet Shor's algorithm triggered a surge in research, and experiments in isolating and shielding a quantum system from environmental disturbances by using magnetic fields soon began. In 1996, a team of researchers from the University of California at Berkeley, MIT, Harvard University and IBM tried to use nuclear magnetic resonance (NMR) technology on a fluid, actually carbon-13 labelled chloroform.

**IN A CLASSICAL COMPUTER, DOUBLING THE NUMBER OF BITS DOUBLES ITS PROCESSING POWER. BUT DUE TO ENTANGLEMENT, ADDING EXTRA QUBITS TO A QUANTUM MACHINE PRODUCES AN EXPONENTIAL INCREASE IN ITS POWER. THUS, WHILE IN A CLASSICAL COMPUTER 8 BITS ARE ENOUGH TO REPRESENT ANY OF THE  $2^8 = 256$  NUMBERS BETWEEN 0 AND 255 AT A TIME, 8 QUBITS CAN REPRESENT EVERY NUMBER BETWEEN 0 AND 255 SIMULTANEOUSLY.**

Subatomic particles have a quantum property called spin, which is a measure of their intrinsic angular momentum and is as fundamental as their charge. Like charge, spin is also quantised, meaning it can possess only discrete values, expressed as half integer spins or integer spins. Spin is a vector quantity, and direction of the spin (+ or -) is measured by the particle's behaviour in a magnetic field. All fermions (quarks and leptons like electrons and neutrinos) have half-integral spins ( $\pm 1/2$ ), while bosons (carriers of fundamental forces like photons, gluons or vector bosons or composite particles made of an even number of fermions) have integral spins ( $\pm 1$ ). NMR acts on quantum particles in the atomic nuclei of a fluid through their spins. Varying the applied electromagnetic field allowed certain spins of the nuclei to flip between the two quantised states, allowing them to exist, quantum mechanically, in both the states at once, and qubits could thus be implemented as spin states of these nuclei. Each molecule in the liquid acted as an independent quantum memory register. The constant motion of molecules in fluids created interactions allowing the construction of quantum logic gates, the basic units of quantum computation, like the logic gates of ordinary computers. The team thus developed a 2-qubit quantum computer, using radio frequency pulses into



a liquid as inputs which constituted, in essence, the computer program to be executed.

Progressively efficient algorithms started developing. Efficiency of an algorithm is measured by the time it takes to execute, given the magnitude of the input. For example, for a common search algorithm like binary search in a classical computer, an input of  $N$  values would require  $N/2$  number of searches. In 1996, an IIT-graduate working with Bell Laboratories, Lov Kumar Grover, devised an algorithm using quantum superposition to reduce the number of such queries significantly to  $\sqrt{N}$ . The discovery gave the much-needed search tool for quantum computers which could actually be implemented in a scalable quantum computer system only in 2017. Turn of the century saw a 7-qubit computer developed at the Los Alamos National Laboratory in USA.

The year 2001 was a landmark in the history of quantum computers for demonstrating the use of Shor's algorithm. Using the NMR technology in a 7-qubit computer to send electromagnetic pulses through liquid molecules, each with its own nuclear spin state, a team at IBM could prime-factorise 15 into 5 and 3. By 2006, a 12-qubit quantum system was developed with only minimal decoherence. In 2007, a Canadian company, D-Wave Systems, claimed to have developed a 28-qubit quantum computer machine; this

reduce noise will be one of the biggest challenges to overcome; without efficient error correction algorithms, a complex algorithm like the Shor's would be unlikely to run efficiently. Quantum error correction also imposes significant overheads in terms of the number of qubits and their operations and will be highly resource intensive.

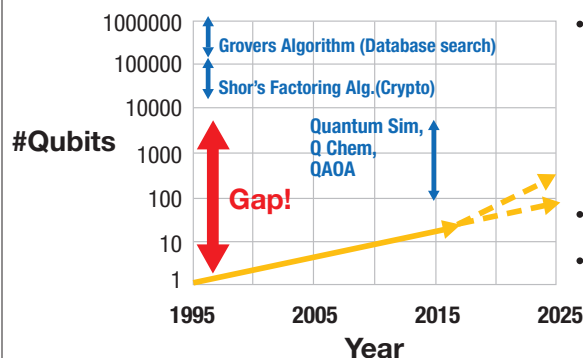
Feynman's original vision of simulating complex quantum mechanical systems still remains important. Much of our understanding of the quantum mechanical systems have emerged as a result of conventional computer simulations, but the complexity and size of these simulations has forced us to employ approximations and limited the amount of useful information that can be extracted. Once quantum computers are able to overcome these limitations, it will open up many disciplines to investigations by them, including quantum chemistry, materials science, nuclear physics, condensed matter physics, etc., by enabling simulation of the material behaviour down to the molecular or atomic levels. Advanced quantum simulation may also greatly expand the range of areas that today lie outside the capacity of our supercomputers, also opening up a billion-dollar market. Some current research is also focussing on a hybrid architecture of quantum-classical computers by attempting to hive off some computations to the classical computers. In such a hybrid

architecture, rudimentary quantum computers can be used as quantum co-processors to speedup critical parts in simulations.

The fabric of quantum technology is as elusive as the Fabric of Reality, a book written by one of the pioneers, David Deutsch. There are indeed many possibilities and approaches, and success will ultimately depend on investments in the technology even without any prospect of immediate returns, openness and sharing of information among different teams calling for close international collaboration, and interdisciplinary approach involving

physicists, chemists and computer scientists. Real progress may be years away, but once that is achieved, quantum computers can transform entire industries and reconfigure our digital world.

## Algorithms to Machines Gap: Algorithm Progress



- New breed of QC algorithm:
  - Lower qubit needs
  - Iterative with classical phases
  - Not exponential speedup, but promising demonstrations
- Hundreds of QC Algorithms in Quantum Zoo
- <https://math.nist.gov/quantum/zoo/>

Algorithms to machines gap (Source: Margaret Martonosi and Martin Roetteler et al, Next Steps in Quantum Computing: Computer Science's Role, Computing Community Consortium (CCC), November 2018, Washington DC.)

they improved upon to 128 qubits the next year. However, their claims have remained controversial because of various reasons. 2011 was the year when a quantum computer was devised with Von Neumann architecture for classical computers, with a CPU and a memory which stored data and processing instructions.

A useful quantum computer would require much larger capacity than the present machines, and bridging the capacity gap will pose many formidable challenges. Error correction to

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# IBN SINA: Medicine Man of the Middle East

Since the outbreak of COVID-19, there has been a renewed interest in Ibn Sina and his seminal works in medicine, particularly on contagions.

Ibn Sina, whose full name is Abu Ali al-Hussain Ibn Abdallah Ibn al-Hassan Ibn al-Ali Ibn Sina, is known in the West by his Latinised name of Avicenna. He was born in 980 CE in Afshana, a village near Bukhara (present-day Uzbekistan) and died in 1037 CE in Hamadan (present-day Iran). He was one of the greatest polymaths and the foremost physician and philosopher of the Islamic golden age of science. In his *Introduction to the History of Science*, the eminent historian of science, George Sarton (1884-1956), characterised Ibn Sina as “one of the most famous exponents of Muslim universalism and an eminent figure in Islamic learning,” noting that “for a thousand years he has retained his original renown as one of the greatest thinkers and medical scholars in history.” In the West, Ibn Sina was so highly regarded that he was compared to Galen, the ancient Greek physician, and was known as the Galen of Islam. Ibn Sina’s contributions in the field of medicine earned him the title of ‘Father of Early Modern Medicine’. His teachings are relevant even today as they were a thousand years back. In particular, since the outbreak of COVID-19, there has been a renewed interest in Ibn Sina, whose seminal works in medicine, particularly on contagions, have shown the world how to deal with the infections caused by viruses by deploying the method of quarantine.

## Early life

Ibn Sina had his early schooling in Bukhara, where he studied under the guidance of very famous scholars of science and Islamic theology. He got such opportunity because of his father who was a governor in the Samanid Empire, with



Some Postage Stamps issued in honour of Ibn Sina (980 – 1037)



Khorasan as the capital. Ibn Sina was very intelligent and at the age of ten he had memorised the entire Quran. At the age of sixteen, he treated his first patients and his reputation spread so quickly that he treated the Sultan of Bukhara, Nuh Ibn Mansoor, of an ailment, for which all the well-known physicians of the time had given up hope. As a reward, Ibn Sina was granted permission to use the Sultan’s library. This enabled him to expand his knowledge in various areas and he mastered all sciences of his time at the young age of seventeen. His vast experience in medicine led him to enter into the service of the Samanid court as a physician to the Sultan. At the age of twenty-one, Ibn Sina became an established physician and political administrator.

## Contributions

After having got access to the royal library and to the renowned scholars of the Samanid court, Ibn Sina started writing books and treatises. Apart from being a great physician and scientist, Ibn Sina was also a philosopher. He contributed in diverse fields, viz., physics, chemistry, mathematics, astronomy, geology philosophy, music, anatomy, and medicine.

It is believed that Ibn Sina wrote about 450 books and treatises on a wide range of subjects, but only 240 titles of his work are known to have survived. Of those, 150 treatises focus on philosophy, while 40 others are on medicine. Two of his most famous works are *Kitab al-Shifa* (The Book of Healing), a vast philosophical and scientific encyclopedia, and *Kitab al-Qanun fi al-Tibb* (The Canon of Medicine), which is considered as one of the foundations in the history

of medicine. Manuscript copies of all survived works of Ibn Sina are known to be available in the Süleymaniye Manuscript Library in Istanbul, some of which are of 11th century. Among the 600 manuscripts of Ibn Sina's works, 263 manuscripts have different titles. This is the only library in the world that has the largest collection of the surviving works of Ibn Sina. In India, the Ibn Sina Academy of Medieval Medicine and Sciences, Aligarh, also has a good collection of copies of the manuscripts of Ibn Sina as well as the postal stamps released by various countries in honour of the great physician.

Ibn Sina completed his major work on philosophy of science, *Kitab al-Shifa*, around 1020 CE, which is not concerned with medicine, but is intended to heal the ignorance of the soul. The book is divided into four parts: logic, natural sciences, mathematics (a quadrivium of arithmetic, geometry, astronomy and music), and metaphysics. In one of the sections of the book, Ibn Sina described his own method of experimentation as a means of scientific inquiry.

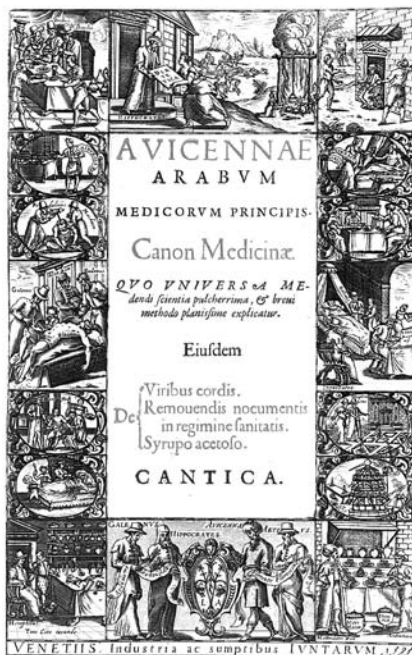
It was almost 150 years after its composition that *Kitab al-Shifa* became available in Europe with its Latin translation under the title *Sufficiencia* in the 12th century. In 1495 and 1500, Ibn Sina's works were published in Venice under the title *Opera* – a compilation of seven books (*Logica*, *Sufficiencia*, *De Coelo et Mundo*, *De Anima*, *De Animalibus*, *Intelligentia*, *Philosophia Prima*).

### The Canon of Medicine

Ibn Sina began writing the book, *Kitab al-Qanun fi al-tibb*, in Jorjan (also written as Gorgan) in 1012 about 30 km away from the Caspian Sea, and continued its composition in Rayy, an important medieval city south of modern Tehran, where two other great medical writers in Arabic, Al-Razi and Ibn Hindu, were born. The *Canon* was completed in 1025 in Hamadan. The *Canon of Medicine* consists of five books, with each book subdivided into various subjects, subsidiary subject summaries, and sections. In the *Canon*, Ibn Sina collected



An illustration of the arterial pattern of the human body and abdominal viscera by Ibn Sina in the Canon of Medicine (Image courtesy Wellcome library)



The cover of the Latin Edition of Ibn Sina's Canon of Medicine, (*Kitab al-Qanun fi al-Tibb*), with the alternate title, "Avicenna Arabum medicorum principis"; Venice, 1508 CE

together the medical knowledge from various civilisations, such as Egypt, Mesopotamia, China and India.

Ibn Sina's Canon of Medicine remained the most popular medical textbook in the world over the next 600 years. Its Latin translations had an important place in the universities in Europe. The University in Poland was the first one to officially

## IBN SINA

completed his major work on philosophy of science, entitled *Kitab al-Shifa*, (*The Book of Healing*) around 1020 CE, which is not concerned with medicine, but it is intended to heal the ignorance of the soul.

accept it in the 13th century for medical education. The first and fourth book of the *Canon of Medicine* were included in the Centre for Medical Studies, Montpellier, France in 1340. The German universities of Leipzig and Tübingen included it in their medical curriculum from 1481. In 1598, the medical curricula of the Vienna University, Austria and the University of Frankfurt, Germany were developed on the basis of the *Canon of Medicine*.

### Ibn Sina's legacy in containing COVID-19

With the spread of the COVID-19, the World Health Organization (WHO) insisted that the affected countries should deploy the method of quarantine in order to minimise the possibility of transmission of the contagious infection from one person to another. In fact, this method was first suggested by Ibn Sina a thousand years back. In his book, *The Canon of Medicine*, Ibn Sina proclaimed that a 40-day period of quarantine was essential to weaken the spread of contagious infections. He explained that the disease can spread through very small invisible particles, a discovery that was proven centuries later after the invention of microscopes. According to historians, Ibn Sina's work laid the foundation for modern quarantine. Some argue that the current nomenclature of "quarantine" originates from the Arabic word "Al-Arba'in" (the fortieth) which Ibn Sina used to designate his isolation method. We may say this is how in the present times the Ibn Sina's legacy is helping the anti-pandemic efforts across the world.

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## Antibodies against coronavirus stay in body for at least 60-80 days, study reveals

**A** sero survey conducted at a leading hospital in New Delhi over five months has found that the prevalence of antibodies, in a person who has recovered from coronavirus infection, persists for 60-80 days, depending on when the participant was infected or came in contact with the infected person.

The participants of the sero survey, jointly done by the Max Hospital and Institute of Genomics and Integrative Biology, under the CSIR, will again be tested to assess how long the antibodies last in the person who contracted COVID-19, said Shantanu Sengupta, the IGIB scientist who conducted the study.

A total of 780 samples were used for the serological testing which include hospital workers and individuals who visited the hospital during the pandemic.

## Drug screening for SARS-CoV-2 at DBT-ILS, Bhubaneswar

**A** research group headed by Dr Anshuman Dixit at the DBT's Institute of Life Sciences (DBT-ILS), Bhubaneswar has used state-of-the-art bioinformatics techniques to screen FDA-approved drugs against thirteen SARS-CoV-2 proteins in order to identify drugs for quick repurposing.

The strategy was to identify potential drugs that can target multiple viral proteins simultaneously and originates from the fact that individual viral proteins play specific roles in multiple aspects of viral life cycle such as attachment, entry, replication, morphogenesis and egress, and targeting them simultaneously will have a better inhibitory effect.

Furthermore, Dr Dixit and his team have analyzed that if the identified molecules can also affect the host proteins whose expression is differentially modulated during SARS-CoV-2 infection. A pathway and protein-protein interaction network analysis of the identified differentially expressed genes led to the identification of network

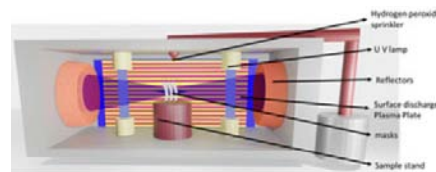
hubs that may play important roles in SARS-CoV-2 infection. The group has successfully identified molecules that can bind to various SARS-CoV-2 and human host proteins.

## Portable sterilization unit using new hybrid technology can decontaminate PPEs rapidly

**S**cientists have developed a portable sterilization unit using a new technology called the hybrid sterilization system that can decontaminate personal protective equipment (PPE) necessary for combating COVID-19, easily and rapidly, allowing them to be used multiple times.

It can be used by health professionals and other COVID warriors for whom PPEs are essential and can prevent generation of hazardous solid waste from PPEs.

IIT Tirupati (IITT) and IISER Tirupati have jointly developed the Portable Optical Cavity Sterilization Unit (POSCU) to provide efficient and



The schematic design of the sterilization unit

rapid decontamination of personal protective equipment (PPE) and other household items. A working point-of-use sterilization unit has been developed with the support of Science and Engineering Research Board (SERB), a statutory body under the Department of Science and Technology (DST).

## AIIMS Jodhpur develops protective gears for health workers in frontline management of COVID-19

**A** team lead by Prof. Sanjeev Misra, Director and CEO, AIIMS Jodhpur, conceptualized and designed a protection box 'Abhedya' which provides enhanced protection to healthcare workers. This box is different from the conventional boxes currently available, as it is sealed from all ends and has self-sealable



hand ports. The rounded smooth edges aid in effective cleaning and disinfection. A negative pressure

environment can be created inside the box, which helps to dispose the aerosols contained within the box. The box is made up of transparent acrylic material with slanting roof assuring appropriate vision for the healthcare worker. The open front end and base are completely sealable with sheets. The box can be kept over the patient's head area for the entire duration of surgery except Head & Neck Surgeries, and intubation and extubation.

## MoHFW releases guidance note on bi-directional TB-COVID screening

**M**inistry of Health and Family Welfare (MoHFW) has issued a guidance note on bi-directional TB-COVID screening. Tuberculosis and COVID-19 are infectious diseases that primarily attack the lungs. They present with similar symptoms of cough, fever, and difficulty in breathing, although TB has a longer incubation period and a slower onset of disease. The prevalence of TB among COVID-19 patients has been found to be 0.37-4.47% in different studies. There has been an overall decline in TB notification by 26% from January to June 2020 as compared to the previous year, due to the COVID-19 pandemic.

Studies have shown that a history of active as well as latent TB is an important risk factor for SARS-CoV-2 infection. This not only results in increased susceptibility but also rapid and severe symptom development and disease progression with poor outcomes. Tuberculosis is associated with a 2.1-fold increased risk of severe COVID-19 disease. In addition, TB patients also tend to have co-morbid or living conditions (malnutrition, diabetes, smoking, HIV, etc.) that increase their vulnerability.

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# Cerebral Palsy in Children

**October 6th is World Cerebral Palsy Day. It gives us an opportunity to celebrate, raise awareness and take action to ensure the rights of people with cerebral palsy.**

If you are observant, you will find many children around you whose physical development is slow since birth as compared to other children. They have stiffness in their limbs (hands and feet) due to which they start walking a bit late. They have difficulty in walking and try to walk on their toes instead of their feet. If not attended to properly, this condition may lead to permanent physical disability. In medical terms, these children are victims of cerebral palsy. As per WHO records, there is at least one child affected with cerebral palsy in every 500 children being born globally.

## What is cerebral palsy?

Cerebral palsy is a neurological disorder. This physical disorder happens due to some damage to the brain of an unborn child during pregnancy or at child birth. Lack of oxygen supply to the child's brain results in damage to some tissues which affects proper development of the brain. The damaged brain in turn fails to supply oxygen to various organs of the body and is not able to transmit signals to the muscles. Shrinking of muscles and loss of muscle tone affects muscle movement and coordination, leading to physical disorder and hampered growth. As a result, the affected child is unable to grow normally.

Due to slowed brain development, some children develop mental retardation. Such children may develop problems of proper listening and

speaking. They start speaking late and are not able to listen properly. Due to weakness in eye muscles, they are not able to focus at one point and often develop squint in their eyes.

## Risks Involved

When a child shows signs of slow development, some parents may be under the impression that their child may just be a slow learner as many other children are and ignore this slow development. But such misconceptions about a child's development result in unwanted delay in proper diagnosis and may lead to the child falling prey to cerebral palsy. Sometimes the muscular disorders become so severe that there is no cure except surgery.

### **CEREBRAL PALSY IS OF TWO TYPES, DEPENDING UPON MUSCULAR MOVEMENTS.**

1. In spastic cerebral palsy the damaged brain is not able to transmit messages to the muscles. As a result, muscles get entangled and become tight and stiff due to which the child is not able to move its limbs. In general, most children are affected by spastic cerebral palsy.
2. In hypotonic cerebral palsy a child's muscles become too relaxed and floppy (flaccid) due to which the child is not able to control his body and his movements become unfocussed and sloppy.

Children suffering from cerebral palsy are different from other children.



They can be easily recognised from their uncontrolled movements and the way they sit or walk. Up to 5-6 months of age, they are not able to control their neck movements and are not able to stand or sit cross-legged. They keep their fists closed because of tightness in hand muscles. Their legs are crossed while standing due to stiffness and they walk on their toes instead of feet. They do not even have orderly posture while lying down, with shoulders becoming slouchy and limbs remaining oblique.

## What causes cerebral palsy?

It has been proven by research that cerebral palsy is caused by infection in the uterus during pregnancy or

**Children suffering from cerebral palsy are different from other children. They can be easily recognised from their uncontrolled movements and the way they sit or walk. Up to 5-6 months of age, they are not able to control their neck movements and are not able to stand or sit cross-legged. They keep their fists closed because of tightness in hand muscles. Their legs are crossed while standing due to stiffness and they walk on their toes instead of feet. They do not even have orderly posture while lying down, with shoulders becoming slouchy and limbs remaining oblique.**

some damage to child's brain due to negligence during or after birth. If the pregnant woman is suffering from TORCH (Toxoplasmosis, Other, Rubella, Cytomegalovirus, and Herpes) infections or measles or experiences excessive bleeding during pregnancy, the child will be prone to cerebral palsy.

Asphyxia (lack of oxygen) is the main cause for cerebral palsy in children. Sometimes, the new-born child is not able to weep for 5 minutes after birth, causing delayed supply of oxygen to the brain leading to brain damage.

Premature children weighing 1-1.5 kg at birth are more prone to cerebral palsy. In India, 3.8% of the population has some form of disability from different causes. Nearly 15-20% of physically disabled children are affected by cerebral palsy; the estimated incidence is around 3 per 1,000 live births. Around 1.7% twins have this disease.

### Treatment

It is very important that the parents keep a record of physical developments and muscular movements in their children. They should not neglect if they find any shortcoming or delay in these as compared to other children.

Broadly, following are the timelines for checking physical development and other movements in a child:

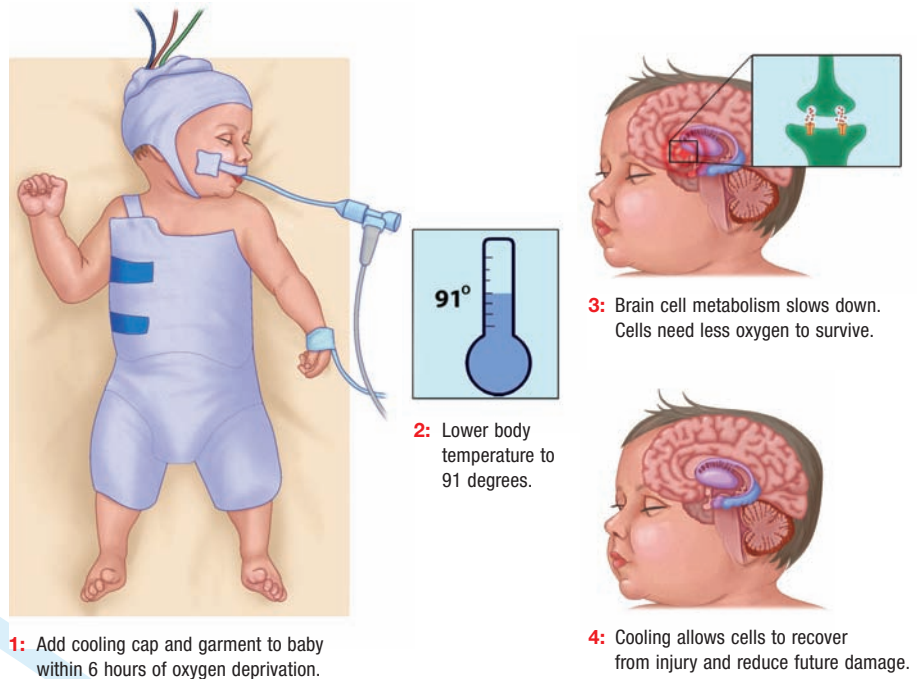
Up to 3 months: Fixation of neck movements

Up to 6 months: Crawling or sitting

Up to 8-9 months: Starts standing

Up to 10-18months: Starts walking

If there is any deviation from this norm or when in doubt, a paediatrician should be consulted before the child completes one year. Though cerebral palsy cannot be cured with treatment, if certain precautions are taken during pregnancy and child-birth, it can largely reduce the chances of cerebral palsy and other related problems. If magnesium sulphate is given to a pregnant woman having a chance of premature delivery, the probable damage to the child's brain can be avoided. Brain damage due to lack of oxygen supply during a second delivery can be reduced by special cooling cap (a cap designed to cool the brains



Cerebral Palsy treatments (Source: <https://www.birthinjuryohio.com/cerebral-palsy/treatments/>)

of babies born with oxygen deprivation during birth to prevent brain damage). Researches prove that gene therapy and stem cell therapy can also cure part of damaged brain to some extent.

The paediatrician may check the medical history, movements and muscles growth thoroughly and may go for MRI and CT scan of the child's brain if required. Medicines are given to bring flexibility in stiff muscles of the affected child. Calcium, multi-vitamins and iron supplements are given for proper development. The child is administered physiotherapy to ease movements of muscles with various exercises. Orthopaedic doctors or physiotherapists may treat the child with massage or exercises by using orthotic braces to strengthen and tone-up the muscles so that the child can walk.

The doctors may also resort to occupational therapy so that the child can do his daily basic routines and can adjust with others. Speech and visual therapy are used to improve the speaking ability of the child. In this the therapist encourages the child to speak by showing cards, pictures or pictorial books and by doing this, the child not only improves his vocabulary but also

develops self-confidence. They are taught to interact with others and become able to express themselves properly.

Surgery is the last option. Orthopaedic surgery or selective dorsal rhizotomy (also known as a rhizotomy, dorsal rhizotomy, or a selective posterior rhizotomy, it is a neurosurgical procedure that selectively destroys problematic nerve roots in the spinal cord) is the last option for the treatment of a cerebral palsy-affected child who is in an emergency situation of having severe pain in muscles and problem of standing.

Children with cerebral palsy need special care. Parents should have a lot of patience and take special care of the child. The child should be looked after properly with a positive attitude for early improvement. Special attention needs to be paid for their diet which should necessarily include adequate proteins, vitamins and minerals.

(Based on conversation with Dr Priyanka Jain, senior paediatrician, Jaypee Hospital, Noida.)

Translation by Surinder Sharma.

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With the demise of Dr Narender K. Sehgal (1940-2020), founder-director of Vigyan Prasar, founder head National Council for Science and Technology Communication (NCSTC) on 7 September 2020, an era comes to an end. From edutainment TV programmes to large-scale science popularisation efforts; busting fake claims to establishing institutions; he was India's architect of science popularisation programmes from the 1980s to 2000. The widespread, albeit still insufficient, science communication and popularisation efforts we see around are built on the foundations laid by him.

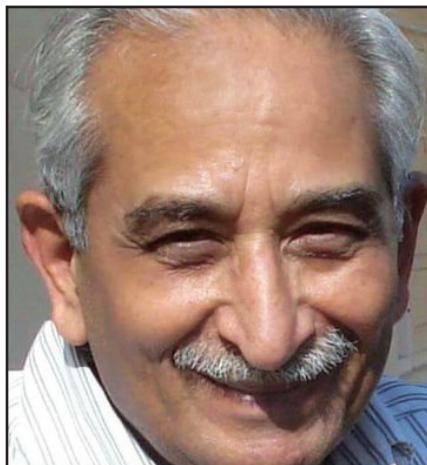
### Man of his times

The late 1980s were fast-changing times. Riding on the winds of change, Doordarshan was also reinventing itself. It was an era of Bharat's; BR Chopra's *Mahabharat* and Shyam Benegal's *Bharat Ek Khoj*. Promptly, Dr Sehgal put together a vibrant team under Chandita Mukherjee and came up with *Bharat Ki Chhap*, a 13-part serial on the history of science and technology on the Indian subcontinent, even today a classic.

During his stint at ISRO's Space Applications Centre (1978-Dec 1981), he had pioneered the use of television as a tool for development. NCSTC, under his leadership, nurtured television science programme in the country. The highly commended 13-part radio serial on the Method of Science was unparalleled. Around 140,000 children in the 10-14 years age-group, were actively associated with the project and were given wall-charts and kits to supplement the radio episodes.

### Unique networking

Forging a unique partnership between government and civil society to implement national programmes in independent India is one of the crowning glories of Dr Sehgal. Dr M.P. Parameswaran, a doyen of science communication in India, recalls how Dr Sehgal was excited about the idea of a 'Vigyan jatha'. A massive nationwide field-level science communication activity reaching out to villages with the participation of more



1940-2020

DR NARENDER K. SEHGAL

than 24 voluntary agencies, catalysed by NCSTC headed by Dr Sehgal was a resounding success. Building upon it, various programmes such as Bharat Jan Vigyan Jatha and Bharat Jan Gyan Vigyan Jatha were organised. Dr Sehgal's name is indelibly linked with the formation of many organisations and institutions including All India Peoples Science Network, NCSTC-Network, VIPNET clubs, and Root and shoot clubs.

### Breaking new grounds

The early 1990s were the times when India was poised to leap into the 21st century. Realising superstitious fake claims are a drag on the project of progress, Dr Sehgal joined hands with experts like Premanand and developed a unique "Science Behind Miracles" programme. He was also instrumental in prodding the Gwalior Science Centre in setting up 'Nidan', a centre for the documentation, research and demystification of these so-called miracles.

Realising the potential of an activity undertaken by a local-level voluntary agency, Dr Sehgal conceptualised the National Children's Science Congress, coordinated by the NCSTC Network. Dr Sehgal said, "The best way to develop scientific temper is to inculcate the spirit of curiosity and questioning, which is what the Congress aims to achieve."

### Bio-sketch

Born in Lahore (now in Pakistan), Dr Sehgal joined the Theoretical Reactor Physics Division of Bhabha Atomic Research Centre as a Scientific Officer. Subsequently, he went on to do a Master's degree in particle physics from the University of Hawaii (1965) and a PhD from the University of Wisconsin, USA, (1969). He taught at the Somali National University's College of Education in Mogadishu (Somalia) for a short period, before joining the Space Applications Centre in Ahmedabad (India) as a visiting scientist.

Dr Sehgal commenced his forays in science communication by establishing a quarterly *Scientific Opinion* during 1972-76. He was also a regular contributor to the international science journal *Nature*. In 1982, Dr Sehgal joined the Department of Science and Technology and went on to establish the National Council for Science and Technology Communication (NCSTC) and oversaw the Government of India's science communication and popularisation programme for about three decades. He also founded the Vigyan Prasar in 1989. Even after his formal retirement from the Government service, he continued to evince keen interest in science communication and guided several youngsters.

He was bestowed with the UNESCO Kalinga Prize for the Popularisation of Science in 1991 and the Honorary Fellowship of the Indian Science Writers' Association in 1993.

### Homage

"In India, we have a very strange situation and also a very challenging one. If you want to spread science over a large area, there is no way that you can do it in English" said Dr. N.K. Sehgal. Vigyan Prasar dedicates the project *Bhasha*, a massive programme to take science in various Indian languages through print, online, television, radio and the emerging social media, as a fitting tribute to his legacy.

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