



Science Horizon

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Dr. Hawking and his first wife, the former Jane Wilde



Dr. Hawking married Elaine Mason in 1995



Dr. Hawking in his office at the University of Cambridge in December 2011. His only complaint about his speech synthesizer, which was manufactured in California, was that it gave him an American accent.

Dr. Hawking pushed the limits in his professional and personal life. At 65, he took part in a zero-gravity flight aboard a plane that flies a roller-coaster trajectory to produce fleeting periods of weightlessness.





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The Cover Page depicts : **Stephen Hawking - the 'Living Legend of the Century'**

Cover Design : **Sanatan Rout**

EDITORIAL

STEPHEN HAWKING - THE 'LIVING LEGEND OF THE CENTURY'



Stephen William Hawking, the prominent British Physicist, born on 8th January 1942, passed away on 14th March 2018 aged 76. The science community and beyond; people all over the world; mourn his demise. He was a living legend of this century to capture the public imagination as a true symbol of the 'triumph of mind over matter'. This was because he was nothing other than a brilliant brain and a beautiful mind with a totally crippled body couched in a wheelchair and yet his mind roamed the Universe freely to reveal some of its deepest secrets hidden from ordinary mortal view. His physical impairment seemed compensated by, so to say, some mysterious supernatural gifts to make him an emblem of human determination and curiosity to ponder the nature of gravity, properties of black holes and Origin of the Universe. Against all the odds, finding a true sense of purpose, he once said - *"when you are faced with the possibility of an early death, it makes you realize that life is worth living and that there are a lot of things you want to do. I want to show that people need not be limited by physical handicaps as long as they are not disabled in spirit."* And true to his words, with tremendous determination he pushed the limits not only in his intellectual life, but also in his professional and personal lives. He travelled the globe to scientific meetings visiting every continent including Antarctica, wrote best selling books about his works, married twice, fathered three children and made guest appearance on the TV-Programmes like

'Star Trek', and 'The Next Generation (through in cartoon form)'. He was also portrayed in the movie 'The Theory of Everything' in 2014. Martin Rees; a Cambridge University Cosmologist has said - *"What a triumph his life has been ! His name will live in the annals of science, millions have had their cosmic horizons widened by his best selling books, and even more, around the world, have been inspired by a unique example of achievement against all odds - a manifestation of amazing will power and determination."* Michio Kaku, a Professor of theoretical physics at City University of Newyork said - *"Not since Albert Einstein; has a Scientist so captured the public imagination and endeared himself to tens of millions of people around the world."*

Hawking on his 21st year; when he was a graduate student pursuing his research towards Ph.D. degree at University of Cambridge, was diagnosed as suffering from Amyotrophic Lateral Sclerosis (ALS), the fatal degenerative motor neuron disease. Soon after words, rather than succumbing to depression, as others might have done; he began to set his sight on some of the most fundamental questions concerning the physical nature of the Universe. During his second year of research in 1965; Hawking became fascinated by the work of Roger Penrose, then a young mathematician working at Birbeck College on collapsing over-massive star forming ultimately black holes, which did not require the special constraint of exact spherical symmetry as was earlier assumed by

J. Robert Oppenheimer and Hartland Snyder in 1939. Hawking found soon how to use Penrose Theorem in an unexpected way in a time reversed form for the cosmological setting to show that the space-time singularity referred to as the 'big-bang' could also be a feature not just of the standard highly symmetrical cosmological models, but also of any qualitatively similar but asymmetrical model. Thus he could show that a big-bang type origin of the Universe was a necessary implication of Einstein's general relativity in broad circumstances. This work later became his Ph. D. thesis, which not only contained the vivid picture of his brilliant mind but also for the last time his own signature in an already fragile and uneven hand writing. The disease was taking its toll by reducing his bodily controls to the flexing of a finger and voluntary eye movements only but leaving his mental faculties untouched. But Hawking adapted to his new physical reality with determination and steadfast self confidence. Like a Mozart Composing Symphonies in his head; he developed a superior memory for complex mathematical equations. From the vantage points of such a memory, he could observe the Cosmos from inside his own head. As he lost using his hands to write equations, he developed an ability to use geometrical and topological images in his head to solve problems which enabled him to see things that others did not see. This was in fact central to a lot of his discoveries which are very far-reaching ones. He could combine Einstein's general relativity, the theory of the very large with quantum physics, the weird laws that govern subatomic reality. He did so by considering how quantum particles behaved in the vicinity of a black hole. In a long and complicated calculation, he

discovered to his disbelief that black holes can emit a form of thermal radiation later known as Hawking radiation. As a result black holes would eventually fizzle out leaking radiation and particles and finally would explode to disappear over the eons. This idea overturned much of the standard understanding at the time. Many more important discoveries followed afterwards. He showed that galaxies had originated from the early minute thermal irregularities which subsequently expanded during a period of explosive inflationary expansion of the Universe. In the nineties, Hawking grappled with the fundamental problem of information loss in black holes.

These contributions would alone place him as one of the most influential theoretical physicist and his generation's leader in exploring gravity and the properties of black holes. What made him truly great however was the manner in which those contributions have been made against all the odds stacked against him. He had lost some of the mobility that he had in his face and his hands became completely immobile. His hand-clicker was replaced by an infrared sensor attached to his glasses, which would activate by moving cheek muscle to communicate via a text-to-speech computer application. In fact that one muscle was the only communicating bridge between the world's most fascinating mind and the outside world.

One can conclude with a tribute to Dr. Hawking's soul following similar lines as of Einstein on Gandhi that - **'Generations to come will scarce believe that such a one as this ever lived on this earth with a bundle of flesh and blood only but with a brilliant brain and a fascinating mind.'**

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THE HAWKING 'PHENOMENON' IN A NUTSHELL

Dr. Bijay Kumar Parida

The 'phenomenon' called Hawking

The man, 'expected' to die of a life-threatening disease in 1965 dies in 2018, after 53 long years, that too being acclaimed as a worthy successor of the greatest 20th century physicist Einstein. This succinctly sums up the story of the man called Stephen William Hawking (8 January 1942 - 14 March 2018). He did beat all odds, including whole-body paralysis, confinement to wheelchair, loss of voice and other physical impediments; all due to a dangerous degenerative disease called *Amyotrophic Lateral Sclerosis (ALS)*. His superlative willpower and super-active brain enabled him to lead a complete life, with family, friends, fun, and fame; besides doing cutting-edge research in cosmology. This is nothing short of a miracle. But, as science does not subscribe to miracles and Hawking was a hardcore scientist, it may be more appropriate to term the man and his life, a unique and unparalleled 'phenomenon', a term sometimes used in press reviews of his life and work.

Hawking's official website (www.hawking.org.uk) introduces him as a cosmologist, space traveller and hero. He was a truly colourful personality. In this article, therefore, we shall take a glance into the various aspects of the life of this genius besides his scientific contributions.

Hawking as a scientist

Though he was diagnosed with the life-threatening disease quite early in his research career, witnessing at that time during his hospitalization; the tragic death of a boy suffering from leukemia, he strengthened his resolve to live and succeed as a scientist. He made his decision clear: "My goal is simple. It is a complete understanding of the universe, why it is as it is and why it exists at all." This remained his mission till the end. He made extraordinary contributions in the domain of cosmology by putting together gravitation, thermodynamics, and quantum mechanics, once considered as three distinct areas of physics.

A major subject of Hawking's study was black hole, which, by definition, is a region in spacetime whose gravitation is strong enough to pull down everything near it into itself, including light thereby making itself 'black' or invisible. In 1970 Hawking and Penrose applied the concept of black hole to show that the beginning of the universe (the big bang) had a singularity (a spacetime point having an infinite spacetime curvature and infinite density). In 1974 Hawking used quantum mechanics to claim that instead of remaining 'black', black holes should emit radiation (called the Hawking radiation) because of which normal sized black holes might completely evaporate slowly whereas small size ones could explode with the energy of a million hydrogen bombs. When scientists objected to Hawking's contention that in the process of evaporation the entire

store of information collected by the black hole would be lost forever, thereby violating a fundamental law of quantum mechanics, he revised his view and admitted that information loss wouldn't occur.

In 1982 he showed that quantum fluctuations (a vacuum spontaneously producing pairs of particles and antiparticles) could be responsible for the formation of galaxies, stars, planets and life in the universe. Max Tegmark, an MIT physics professor remarked, "It is one of the most beautiful ideas in the history of science."

Other areas of research interest to Hawking included quantum gravity, an attempt to formulate a quantum theory of gravity. He was a firm supporter of the 'the theory of everything' that is a single theory which could explain everything in the universe and about the universe, though nobody knows if and when such a theory might emerge.

Hawking as a science popularizer

Hawking became a star communicator of science in 1988 when his first popular book *A Brief History of Time* was published. It remained on the Sunday Times bestsellers list for as many as 237 weeks and entered into the Guinness Book of Records. It got translated into 40 different languages and sold multimillion copies around the world. Some, however, claim that it is the greatest unread book in history. His other books for common man includes *A Briefer History of Time*, *Black Holes and Baby Universe* and *The Universe*

in a Nutshell. In the book *My Brief History*, Hawking gives a candid account of his own life story. With his daughter Lucy, Hawking wrote popular books such as *George's Secret Key to the Universe* and *George and the Blue Moon* for children.

Despite physical limitations, Hawking loved to tour the world and give public lectures on invitation. His lectures were always overflowing with audience. Though initially his students used to help him make his presentations on stage, later on he used computerized speech synthesizer specially designed for him. He enjoyed visiting places and doing things not available to all physically able persons, such as going down a mine shaft, visiting the south pole and experiencing the zero-gravity free fall.

Hawking had also made forays into popular TV programmes such as *Star Trek: The Next Generation*, *Masters of Science Fiction*, *Red Dwarf*, *The 11th Hour*, *Genius of Britain*, etc., cartoons such as *Dilbert*, *Futurama*, *The Simpsons*, and sci-fi films like *The Theory of Everything*.

Awards and Honours

In 1974 Hawking was elected Fellow of the Royal Society. In 1979 he became the Lucasian Professor of Mathematics at Cambridge, the distinguished chair earlier held by luminaries like Isaac Newton, Charles Babbage and Paul Dirac. In 1983 he was awarded the CBE (Commander of the Order of the British Empire) award by the British

Queen. The US President Barack Obama honoured him with the Presidential Medal of Freedom in 2009. He won the Albert Einstein Award, the Wolf Prize, the Copley Medal, the Companion of Honour, the Fundamental Physics Prize and many more. He received more than a dozen honorary degrees from various universities and institutions. He was disappointed that none of his predictions such as the Hawking radiation could be detected during his lifetime that could have fetched him a Nobel Prize.

Family life

Despite severe illness, Hawking tried to live his life fully. He married his college sweetheart, Jane Wilde, in 1965. She supported her husband wholeheartedly, perhaps exemplifying the dictum that behind every successful man there is a woman. She gave him three children. The marriage, however, collapsed in 1991, Jane being unable to put up with his unmanageable ego and demands any more. He then married Elaine Mason, one of his medical nurses, and the marriage lasted 11 years. It is perhaps an irony of fate that the first wife sought divorce from Hawking whereas he himself sought divorce from the second wife.

Hawking loved bets

Hawking enjoyed putting up bets on scientific issues and didn't mind losing them. In 1975 he claimed that the cosmic x-ray source Cygnus X-1 was not a black hole and bet with Kip Thorne, a US physicist a subscription to the famous magazine

Penthouse. He lost the bet in 1990. In 1997 Hawking and Thorne bet John Preskill an encyclopedia that information would be lost in black holes. Hawking reversed his view in 2004 and lost the bet. In 2012 he lost \$100 to Gordon Kane for the bet that the Higgs boson would not be discovered.

Hawking on disability

Was Stephen Hawking a disabled person? Most certainly yes and, perhaps, one of the most famous persons with disability. It would therefore be interesting to find how he views disability. Once, in an interview to the BBC TV he admitted that his disability did have a bearing on his celebrity status as a scientist. He said, "I'm the archetype of a disabled genius, or should I say a physically challenged genius, to be politically correct. At least, I'm obviously physically challenged. Whether I'm a genius is more open to doubt. "Though he didn't like patronizing stance of people for the physically challenged, he was well accepted by people whether they knew him or not. He supported the children's charity SOS Children's Villages UK.

He opined that his physical limitations were not a hindrance to his research as an astrophysicist as it needed mind and not physical ability. When asked what his advice would be to a physically challenged person wanting to be a physicist, he said, "I can recommend theoretical physics as a career for a disabled person. Of course, they would have to be interested in physics and fairly good at it."

Hawking on religion

We commonly observe that a person with disability and his or her relatives tend to become religious minded and seek divine intervention for relief. But it was not so, for Hawking. He did not believe in the idea of personal God. He said, "There is a fundamental difference between religion, which is based on authority (imposed dogma, faith) and science which is based on observation and reason. Science will win because it works. "In fact, he believed that his calculations in cosmology led to the conclusion that God had no role to play in the creation of the universe. He opined, "Because there is a law such as gravity, the universe can and will create itself from nothing."

Some amusing anecdotes

Though talented, Hawking did not take his assignments seriously as a student. He was considered a difficult student by his teachers in his undergraduate years at Oxford. When he realized that he was tottering between a first-class degree and a second-class degree, he informed his viva examiners that if he got a first class he would go to Cambridge for Ph.D. or he would stay back at Oxford if awarded a second class. He was then offered a first-class degree!

Hawking liked to make witty observations for entertaining his audience and for making a subtle point clearer. He thought that the oft-asked question "What came before the big

bang?" was a meaningless one. When requested to clarify, he asked instead, "What lies north of the north pole?"

Tributes

Hawking was extremely popular among people of all walks of life. The galore of tributes flooding the media following his demise is a testimony to this. Let us take a sample cross-sectional view of the tributes offered.

Lord Rees (the astronomer royal): "Stephen was far from being the archetypical unworldly or nerdish scientist. His personality remained amazingly unwarped by his frustrations. Few, if any, of Einstein's successors have done more to deepen our insights into gravity, space and time."

Theresa May (UK Prime Minister): "Hawking's courage, humour and determination to get the most from life was an inspiration."

Concluding observations

Stefan Hawking's life and achievements are a testimony to what he once said, "I'm not afraid of death, but I'm in no hurry to die. I have so much I want to do first." He effectively proved that, even in the shadow of death, it is possible for human intellect to achieve remarkable feats, a true 'triumph of mind over matter'. He also showed that it is possible for a frontline researcher like him to take modern science to the common mass using various media and means despite his physical disabilities.

While acknowledging his own contributions to cosmology, which are extraordinary and have opened up new challenges, Hawking celebrates the spirit of human beings in the statement: "The fact that we human beings who are ourselves mere collections of fundamental particles of nature; have been able to come this close to an understanding of the laws governing us and our universe, is a great triumph."

Though quite a few scientists did have differences with Hawking, the many generations of researchers nurtured and inspired by him are likely to continue his legacy. Above all, his indomitable courage against all adversaries holds lessons for all of us.

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www.theguardian.com/science/2018/mar/14/stephen-hawking-professor-dies-aged-76

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- ❖ *However difficult life may seem, there is always something you can do and succeed at.*
- ❖ *Look up at the stars and not down at your feet. Try to make sense of what you see, and wonder about what makes the universe exist. Be curious.*
- ❖ *Intelligence is the ability to adapt to change.*

- Stephen Hawking

STEPHEN HAWKING: SOME OF HIS PREDICTIONS & BETS



Prof. Ramesh Chandra Parida

A long eventless life smoothly rolling on the rails of time is not worth-living. Only when it is studded with challenges it takes the personality to its full bloom. If we seek an example to realize the truth, the star that first appears in the horizon of our mind is no other than Stephen Hawking (8, January 1942-14, March, 2018). His life was a story of struggle and success. Not only he survived as a medical miracle, but also had a wonderful scientific foresight and therefore could give an account of a brief history of time, beginning from the birth of the Universe and extending the story deep into its future. Through his prophetic vision he could also make many other groundbreaking predictions and even betted with his fellow scientists regarding various aspects of frontiers of science, many of which he lost but never the less, those catalyzed new scientific thinking and enriched science.

Hawking's deep foresight into the future of science has been amply depicted in his epoch-making books like "A Brief History of Time" (1988), "Black Holes and Baby Universes and Other Essays" (1993), "The Universe in a Nutshell" (2001), "The Grand Design" (2010), "My Brief History" (2013) and others. But some of his other predictions have also created many a ripple in the world of science as well as the society. One such that he made in his answer to a question put

to him in the beginning of the 21st century regarding the future of the human race was - "If the World's Population continues to grow at its present rate - doubling every 40 years - there is not going to be enough room for us all on the Earth by 2600. So, will we, I ask, be able to spread to other Planets ?"

Then after a pause, he answered his own questions - "We shall probably manage, should I say, personnel flight to the Mars in the next century. Of course, the Earth is by far the most favoured planet in the solar system and the Mars is small, cold and without much atmosphere. So, that is the best alternative. Unless we learn to in it, the next alternatives are space stations or to travel to the next star, which we won't do in the next century". Again according to him "if the way we are misusing the natural resources and polluting the environment continues, it may take only a few hundred years for the Earth to become unsuitable for life and therefore, we should either refrain from such activities or be prepared to shift to any other planet." Probably that provided the space scientists with the necessary inspiration to think seriously about habitating the Mars, the Moon or the space stations.

Another interesting prediction he had made almost at the same time was on human-genetic engineering, which of course, was not his subject. According to him - "By far the most complex systems we have are our own bodies. There have not been any significant changes in human DNA in the past 10,000 years. But soon we will be able to increase

the complexity of our internal record, our DNA, without having to wait for the slow process of biological evolution. It is likely that we will be able to redesign it completely in the next 1000 years - by increasing our brain size, for example. Of course, many will say genetic engineering on humans will be banned, but I rather doubt that they will be able to prevent it. Genetic engineering on plants and animals will be allowed for economic reasons and someone is bound to try it on humans - unless we have a totalitarian world order, someone will improve humans somewhere." Surely this prediction is marching towards a reality.

Besides, his other major predictions included the improbability of travelling faster than light, the probability of discovering a complete theory of basic laws of the Universe (the so-called theory of everything in which Quantum theory is unified with Einstein's Theory of General Relativity) in 20 to 100 years, development of artificial intelligence with complexity and capability on par with human brain, existence of aliens who may once be able to visit or invade the Earth and many more. All these were based on scientific vision and therefore, were path finders for the future of science.

Similarly, his bets with his fellow-scientists had turned out to be epoch-making. The best known among those was the one he had, which eventually he lost but that enormously added to his fame, was with the cosmologist Kip Thorne of California Institute of Technology (Cal Tech) in 1974. The heavenly body Cygnus X-1 was a mysterious

galactic source of X-rays, which appeared to be a black hole. It was the first time that physical evidence for one seemed to be in the horizon. But, Hawking refused to accept it and said it to be highly unlikely. On the other hand, Thorne was certain that it was a black hole. So the bet ensued. However, after a long period of 15 years, in 1990, Hawking's own work proved him to be wrong and he conceded defeat. As the wager he gifted Thorne a year's worth of Penthouse magazines, but the publicity about the bet raised the profile of black hole as well as that of Hawking.

Similarly, in 1991 he also took another bet with both John Preskill, a Cal Tech physicist and Kip Thorne. It was about the existence of a naked singularity. A singularity is a point of zero volume, where matter becomes infinitely dense. Hawking did not agree that such thing can exist. However, in 1997 he admitted to have lost the bet and handed over the duo \$100 each and T-shirts printed with the slogan "Nature Abhors A Singularity". Actually one of the biggest contributions of Hawking was to show that the Big Bang theory, that is the origin of the Universe from a single point or singularity was physically possible.

Then, Hawking along with Thorne had a bet with John Preskill in which they claimed that information swallowed by a black hole could never be retrieved. At that time, the accepted theory was that black holes suck in everything, even light. So something escaping those would undermine the basic tenets of physics. Again the bet was lost in 2014, when Hawking proposed that a type of radiation

could be emitted by the black holes. Now that is known as Hawking radiation and explains how these heavenly bodies loose mass. It was Hawking's crowning achievement, but he had to present Preskill a baseball encyclopedia as agreed in the Wager.

Another very famous bet he lost was the one he had with Gordon Kane of the University of Michigan. It was about the Higg's Boson, a sub-atomic particle, which Hawking claimed would never be found. Commonly known as "God Particle" scientists believe that it gives all the matters their mass. In 2012 it was observed in the CERN's Large Hadron Collider (LHC). Therefore, Hawking had to pay the \$100 Wager to Kane.

It is said that a brave fighter is never defeated irrespective of whether the battle is won or lost. The same is true for Hawking. He successfully fought death for more than half a century and probably the only one in the history to have survived that long with the deadly motor neuron disease. Again in spite of being confronted with an almost all round failure of his physical systems, with his indomitable will power and versatile brain power he could conquer the disability to establish himself as an all time great scientist, whom the mankind can never forget until its extinction.

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❖ *Work gives you meaning and purpose and life is empty without it.*
❖ *Science is not only a disciple of reason but, also, one of romance and passion.*

- Stephen Hawking

BLACK HOLES AND HAWKING RADIATIONS



Sri Kamala Kanta Jena

Sir Isaac Newton believed that the universe must have been designed by God as it could not have been created out of chaos. Stephen Hawking, Britain's most famous scientist, said that God did not create the universe. He, in his book 'The Grand Design', explained that the universe was started spontaneously in a Big Bang, rather than due to the intervention of a divine being. What so ever may be the cause; the creation itself is overwhelmingly spectacular. Each and every domain of the universe is wonderful. However Hawking's most famous scientific insight was focused on the arcane physics of black holes. He once remarked that "fact is stranger than fiction and no where is this more true than in case of black holes."

Black Hole : Magic of Einstein's Theory

Black Hole is one of the most perplexing objects in our universe. It is a highly dense object possessing very strong gravitation. The gravitational pull is so strong that nothing, not



Fig. 1 : Isaac Newton and Stephen Hawking



Fig. 2 : Albert Einstein and Black Hole

even light, can ever escape it. In fact, a Black Hole is a great amount of matter packed into a very small region of space. Our Earth is a sphere of diameter 12,600 km and mass 6×10^{24} kg (6 followed by 24 zeros). Our Sun is 333,000 times more massive than the Earth. If we wish to convert a star ten times more massive than the Sun, we have to squeeze the huge star into a small sphere of 30 km diameter (distance between Soro and Bhadrak of Odisha). It is approximately the diameter of urban New Delhi (area 706 sq. km.). Many physical Black Holes have already been identified. Black Holes located at the centers of most galaxies are supermassive ones, many billion times the mass of our Sun. Such concentrated spheres could result in strong gravitational field.

Black Holes were predicted by Einstein's *Theory of General Relativity*. A massive star, when dies, leaves behind a small dense remnant core. The core's gravitational force would be strong enough to become a Black Hole. It is called '**black**', because no light can come out from this celestial body, and the falling of nearby bodies into it gives the name '**hole**'. Smaller stars when die become dense white dwarfs or neutron stars, which are not

massive enough to trap light. If the total mass of the star is large enough, say, about more than three times the mass of the Sun, it can be proven theoretically that no force can keep the star from collapsing under the influence of gravity.

Event Horizon : 'Lakshman Rekha' for Black Hole

Event horizon is the boundary surrounding a Black Hole within which the gravitational pull becomes enormous to make any escape impossible. Even the light emitted from inside the event horizon can never reach the outside observer. No nearby matter or radiation can escape from the gravitational field of such celestial object, the site of immense gravitational attraction.

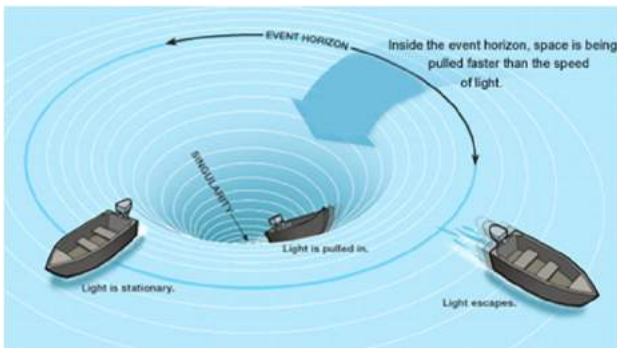


Fig. 2 : Albert Einstein and Black Hole

The *Schwarzschild radius* defines the event horizon of a Schwarzschild black hole, the simplest kind of black hole that doesn't rotate and has no electric charge. This black hole is a theoretical concept that arises as an exact solution to Einstein's equations of General Relativity when solved by Karl Schwarzschild in 1916. The *Schwarzschild*

radius is a characteristic radius which can be associated with every object of any mass. As per example of M is the mass of an object, $G = 6.67 \times 10^{-11} \text{ N.m}^2/\text{kg}^2$ is the gravitational constant and $c=3 \times 10^8 \text{ m/s}$ is the velocity of light; then the Schwarzschild radius $R_s = 2GM/c^2$. Any object whose size is smaller than its Schwarzschild radius is called a black hole. In other words, any object can become a black hole if it shrinks down to its Schwarzschild radius. The surface at the Schwarzschild radius acts as an event horizon. For our huge Sun the event horizon radius is only 3 km. It can become a black hole if it shrinks down to this dimension. This radius is as tiny as 9 mm for the Earth. Therefore, our Earth may behave as a black hole, if all of its matters are squeezed into a tiny sphere of 9 mm radius. However it will be a sphere of such tiny radius with the same mass of $6 \times 10^{24} \text{ kg}$.

Locating Black Hole

Black holes can be big or small. The smallest black holes may be as small as just the size of an atom or a subatomic particle. These black holes are very tiny but may have the mass of a large mountain. Telescopes and other optical devices are used to detect celestial objects by receiving the light and other electromagnetic radiation coming from the objects. But a black hole cannot be seen or detected in the same fashion. It is because strong gravity pulls all of the light and other

radiations into the middle of the black hole. So, light or other detectable radiations cannot come out of the black hole for detection at our end. But scientists can see how the strong gravity of a black hole affects the stars and gas around the black hole. Accordingly, the scientists can study stars to find out if they are flying around a black hole or orbiting the black hole. When a black hole and a star come close to each other, the stellar matter gets sucked in towards the black hole being rapidly accelerated by the strong gravity forming what is called the accretion disc. This mass accretion emits hard X-rays of very high energy. This kind of radiation cannot be seen with human eyes. Scientists use satellites and X-ray telescopes travelling in space to see such high-energy radiation. That is how they are able to locate the black holes.

Hawking Radiation

But one of the remarkable theoretical discovery made by Stephen Hawking in 1974 was to show that Black holes are not really black. They can in fact emit black body like radiations. Such radiation called Hawking Radiation is due to quantum effects near the event horizon. The radiation is sometimes called Hawking-Bekenstein radiation, because Jacob Bekenstein predicted that the black holes should have a non zero and finite entropy implying there by that black holes must have non zero temperature and hence they must emit radiation.

- (a) **Black Hole Possesses Entropy :** In fact, the topic ranges from quantum physics to thermodynamics. It all started in 1972 when Jacob Beckenstein theorized that Black Holes should have *Entropy*. Entropy is a thermodynamic quantity often interpreted as the degree of disorder or randomness in the system. It basically represents that any system having entropy must release heat, unless it is maintained at a temperature of zero kelvin or (-)ve 273⁰C. If a black hole, according to Beckenstein possesses entropy, it has to radiate. But the case is different for black holes, since on principle nothing can come out of black holes and hence black hole temperature must be zero degree Kelvin.
- (b) **Black Holes Are Not Truly Black :** The thought of Beckenstein encouraged Stephen Hawking to think further. Hawking travelled to Moscow to meet and discuss with Soviet scientists over the radiation by black hole. His trip to Moscow in 1973 was to meet the eminent Soviet physicists Yakov Zel'dovich and Alexei Alexandrovich Starobinsky. Zel'dovich was well known for his prolific contributions in cosmology and the physics of thermonuclear and hydrodynamical phenomena. Alexei Starobinsky was a notable astrophysicist and cosmologist.

The two scientists inspired Stephen Hawking to question the assumption of *whether black holes are truly black*, radiating nothing. Stephen was convinced by the two giants that black holes should be emitting particles according to the quantum Uncertainty Principle. (The principle states that the more precisely the position of some particle is determined, the less precisely its momentum can be known, and vice versa.) The discussion at Moscow led Stephen Hawking in 1974 to publish his paper on *Hawking Radiation*.

(c) **Black Hole in Quantum world :** The Uncertainty Principle comes under Quantum Mechanics the physics of small things, like electrons, atoms, photons etc. On the other hand General Relativity is for everything big, like black holes, stars, planets etc. Stephen Hawking was trying to find a way to understand a Black Hole with the knowledge of Quantum Mechanics. He had to demonstrate a Black Hole in the Quantum world. He wanted to explain the interaction of the tiny little particles with the Black Hole. Since General Relativity couldn't explain why radiation should be coming out of a Black Hole, Stephen expected that Quantum Physics could help him

explain. Of course, his approach was alright. He was eventually able to explain the black hole radiation with the concept of a very specific quantum event called 'Virtual Particles'.

(d) **Virtual Particles : Matter and Anti-Matter :** Virtual Particles arise in transient fluctuations exhibiting some of the characteristics of ordinary particles, but whose existence is limited by the Uncertainty Principle. These particles are basically particles of matter and anti-Matter. Antimatter equivalent of a negatively charged particle electron is a positron, which is positively charged with the same mass. Stephen Hawking figured out a way to explain how particles might escape a black hole. According to this quantum principle; the space near a black hole would be teeming with 'virtual' particles that would pop out into existence in matched particle-antiparticle pairs like electrons and their twin opposite positrons - out of energy borrowed from black hole's

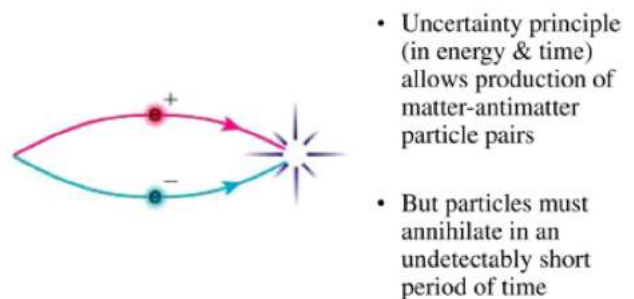


Fig. 4 : Virtual Particle Pair - Particle (+) and Anti-particle (-)

intense gravitational field. They would then meet and annihilate each other into a flash of energy, repaying the debt for their brief existence. But if one of the pair fell into the black hole, the other one would be free to wander away and become real. It would appear to be coming from the black hole and taking energy away from it. The particles so escaped would constitute Hawking Radiation. Thus seems that the particles can be radiated out of the black hole. In fact, they are not actually coming out of the Event Horizon, but they are actually being created right at the side of the Event Horizon. When a black hole absorbs a lot of things, the radiating particles will be very minor when compared to the massive amount of things it is absorbing. A smaller black hole however will actually be radiating more than it is absorbing. Which in turn implies that over time, the black hole will get smaller and smaller until eventually it just disappears. Production of more virtual particle pairs will result in continuous decrease in size of the black hole to fizzle out eventually. That is why it is also called *Black Hole Evaporation*.

Even though matter and anti-matter are opposites, they're both still made out of energy. Energy is released when matter and anti-matter annihilate

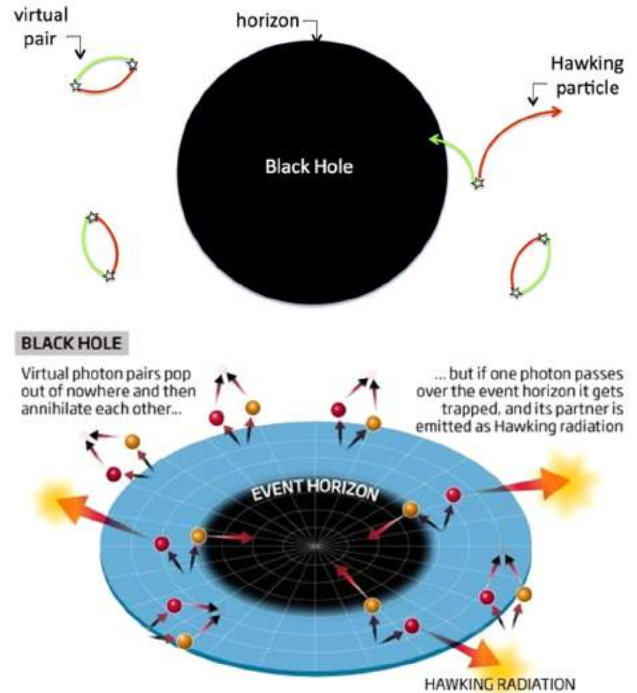


Fig. 5 : Hawking Radiation due to Virtual Particle Pairs

themselves. The energy used to create these particles is actually taken from the black hole's gravitational potential energy. Thus the energy used to create the particles is the energy from the black hole. Radiation may consist of the anti-matter or of the matter. This will result in decrease of energy of black hole. This essentially means that the Black Hole loses energy due to Hawking Radiation. From Einstein's great formula, $E=mc^2$, we know that mass can be converted into energy and vice versa. Therefore, loss of energy from a black hole will result in loss of its mass. Thus the discovery of Hawking radiation, as it is known, transformed black holes from destroyers to creators or at least recyclers.

5. Conclusion

Stephen Hawking would run complex equations through his mind, night after night. Same was the case of Hawking radiation. Eventually the thought led him to the conclusion that black holes emit particles and, in the process, loose mass, shrink and ultimately disappear. It was an insight that made his name immortal. Interestingly, when his equations claimed that, black holes can radiate mass via the formation of virtual particles, he didn't quite believe it himself. He remained silent about his discovery. It was his former PhD supervisor, Dennis Sciama, who apparently had far more faith in Hawking's equations than Hawking himself did. He spread the news about the breakthrough research of Hawking. Some physicists were actively hostile to the idea. It took a few years for everyone to be convinced about the reality of 'Hawking radiation'. The insight of that day has become a part of the future of black hole physics. It has transformed Stephen Hawking into a true celebrity of science as well.

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"They're named black holes because they are related to human fears of being destroyed or gobbled up, I don't have fears of being thrown into them. I understand them. I feel in a sense that I am their master."

- Stephen Hawking

STEPHEN HAWKING - A REMEMBRANCE



Dr. Dwijesh Kumar Panda

*Almighty's blessing's makes deaf hear,
Dumb speak, and Cripple climb mountain.*

- Shrimad Bhagabat (Veda Vyasa)

All these happened to cosmologist Stephen Hawking, the Lucasian Professor of Mathematics at the University of Cambridge, a position once adorned by Isaac Newton and later by P.A.M. Dirac. He was a scientist undeterred by his disability. During childhood, he had developed a reaction to a vaccine. The effects were felt by Stephen at a young age. The brain's control over the nerves started to reduce gradually. He caught pneumonia in 1985 for which he had tracheostomy operation. After the operation he became unable to speak and almost incapable to communicate. One of his students got him to use a communication program called LIVING CENTER with which he could write books and papers and speak to people using a speech synthesizer which along with a small personal computer were mounted to the wheelchair. He would stumble while walking. During 1966-67, Stephen was successful in solving a difficult question regarding Einstein's general theory of relativity. During that time he couldn't write. So he started doing calculations in his mind. Some of his colleagues would listen to his

unclear speech and write down the equations. Between 1969 and 1973, Stephen presented an important theory on black holes. In 1974, he discovered that black holes could emit radiation, which was surprising. This was then called the 'Hawking effect'.

Stephen Hawking's success was powered by his determination. He got married twice and had three children from his first marriage. He lost his speech and used a voice processor to express his thoughts. He wrote the book "A Brief History of Time", which became immensely popular, where he wanted to convey the basic ideas about the origin and fate of the universe without any mathematics in a form that people without scientific education can understand. In this book Hawking tells (1) how the universe began, (2) what made its start possible; (3) does time always flow forward? (4) is the universe unending- or are there boundaries? (5) are there other dimensions in space? (6) what will happen when it all ends?. He proved the

doctors wrong who had said that he had only two years to survive the deadly motor neuron disease. He suffered from Amyotrophic lateral sclerosis (ALS). He lost his ability to speak and to perform his day to day activities. He developed strained vocal quality with slow speech. Swallowing became difficult for him. It was a multiple degenerative motor neuron disease. Undeterred by this disability, Stephen made path-breaking contributions in fundamental science. His disability never came in the way. He continued to contribute to science till last. He is considered on par with legendary figures the likes Isaac Newton and Albert Einstein. He was regarded as his generation's leader in exploring gravity and the properties of black holes.

Stephen Hawking, the legendary physicist in wheelchair could talk about cosmology and collapsing stars. He confronted the challenges in life to overcome all the odds. He provided deep insights into the connections between quantum physics and

Black holes are a natural prediction of the theory developed by Stephen Hawking with Roger Penrose and Brandon Carter using Einstein's theory of gravity, which explains how mass and energy "curve" space, the way a sleeping person causes a mattress to sag. Light rays will bend as they traverse a gravitational field, just as a marble rolling on the sagging mattress will follow an arc around the sleeper. Too much mass or energy in one spot could cause space to sag without end; an object that was dense enough, like a massive collapsing star, could wrap space around itself like a magician's cloak and disappear, shrinking inside to a point of infinite density called a singularity, a cosmic dead end, where the known laws of physics would break down: a black hole. Einstein himself thought this was absurd when the possibility was pointed out to him. Using the Hubble Space Telescope and other sophisticated tools of observation and analysis, however, astronomers have identified hundreds of objects that are too massive and dark to be anything but black holes, including a supermassive one at the center of the Milky Way. According to current theory, the universe should contain billions more.

- Stephen Hawking

relativity. He gained respect throughout the world as a science communicator. He utilized a device capable of translating his eye movements (since he could no longer utilize a keypad) to speak in a digitized voice. Hawking once said: "when you are faced with the possibility of an early death, it makes you realize that life is worth living and that there are a lot of things you want to do." Millions around the world have been inspired by his unique example of achievement against all odds. His amazing willpower and determination made him the world's most eminent cosmologist. He believed that people need not be limited by handicaps as long as they are not disabled in spirit. He discovered that black hole would eventually fizzle out, leaking radiation, which is now known as Hawking radiation. Hawking helped in laying the foundation for unifying the two forces of nature- gravity and quantum mechanics. He put an end to the 'disabled theory'. He proved that one who has a physically challenging disability can overcome it in spirit and can do every kind of work which 'able' people can do. He could transfer a dream into reality.

Hawking has given all of us the message that we can make a big contribution to humanity and also live in the world with great hope-even in the face of severe obstacles.

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MYSTERIOUS OBJECT QUASAR

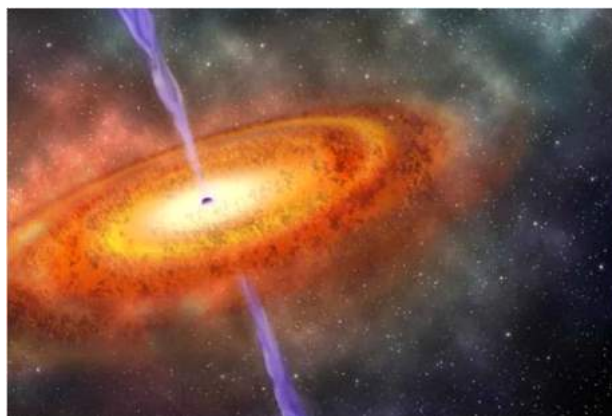


Er. Mayadhar Swain

What is a Quasar ?

A quasar is a huge astronomical object of very high luminosity placed in outer space at very large distance from us. It produces large amounts of energy in the form of electromagnetic radiation. It is powered by super massive black hole and surrounded by an orbiting accretion disk of gas.

The word quasar has originated as a contraction of 'quasi-stellar radio source'. It was named quasar because it looks like a star but was not one, as no star could be that bright. So astronomers called it quasi-star (looks like a star). Further, the first quasars were discovered as radio sources. So it was named quasi-stellar radio source or in short as quasar. The term 'quasar' was coined by Chinese-born American astrophysicist Hong-Yee Chui in may 1964 in *Physic Today* to describe these puzzling objects. Of course, now it is



confirmed that only ten per cent of the total quasars discovered so far, emit strong radio waves. So quasars are now being called as quasi-stellar object (QSO).

Formation

Most galaxies have super massive (billion times the mass of Sun) black holes at their centers. Black holes are massive objects having high density and low volume. When hydrogen fuel of big stars (more than three time mass of Sun) are exhausted nuclear fusion process to generate energy is stopped. As a result, the gravitational force exceeds its outward radiation pressure and the star collapses forming the black hole. Due to its high gravitational force, it attracts all the nearby objects into it and nothing, even light cannot escape from it.

The super massive black hole has accretion discs which consist of materials spiraling into the black hole. When material falls into the accretion disc, it gets heated by friction and gravitational force. The energy produced by this causes the huge output of a quasar.

Now it is certain that super massive black holes reside at the centers of most of the galaxies. When sufficient materials are available close to the event horizon of the black hole so that these materials fall into the accretion disc and thereby producing huge amount of energy, then quasar is formed. Generally, young galaxies and colliding

galaxies have enough material to create a quasar. Known quasars are found in very distant galaxies from which light takes billions of years to reach us. From this light, we are actually seeing young galaxies as they were when the Universe was young.

It has been calculated that to sustain a quasar around a black hole, the mass of the black hole needs to be about ten times the mass of Sun. A black hole of this size has radius of about 10 Astronomical Units (or about the distance between the Sun and Saturn).

Quasar emission can only last as long as material is available to form an accretion disk. A quasar can consume up to 1000 - 2000 solar masses of material per year and has typical lifetime of around 100 - 1000 million years. Once the materials are exhausted, quasar activity ceases completely, leaving behind the dormant massive black hole in the center of the galaxy.

Super massive black holes have been found at the centers of many large galaxies. But in about 5 to 10 percent of these galaxies quasars are found in their centers which is called active galactic nucleus.

Properties

Quasars are the most luminous objects in the sky. As they are situated far away from us, we are not able to see them in naked eye or even with small telescopes. The brightest quasar in the sky is 3C 273 in the constellation

of Virgo. It has an average apparent magnitude of 12.8 and absolute magnitude -26.7. It is seen through a medium size telescope. Its luminosity is about four trillion times that of the Sun or about 100 times that of the total light of our galaxy Milky Way which contains 200 to 400 billion stars.

The spectrum of quasar has red shift. By measuring the spectrum of their light, astronomers determine their distances from us and also their speed of travelling. The red shift of their spectrum informs that they are farthest away from us and are travelling away from us. By applying Hubble's law to these red shifts, it is found that they are more than billion light years away. From this, it can be inferred that we are seeing a quasar that was alive ten billion years ago. When we see it, the actual quasar (not its light) might already be gone. Today, these are identified by their red shift. If any object is discovered to have a very high red shift and appears to be producing large amount of energy, it becomes a prime candidate for quasar.

The brightness of quasar varies irregularly and they emit X-ray. Indeed, a high level X-ray emission is considered by astronomers as a sure indicator of quasar.

From observations, it has been found that quasars are bright in the X-rays and ultraviolet frequency range, where as the optical light output is only a small fraction of their total energy output.

Discovery

The first quasar was discovered by the Dutch - American astronomer Marten Schmidt in 1963. It is designated as 3C 273. In fact, in 1950s while surveying the sky for radio sources, astronomers had indentified some strange objects that appeared to be unusually blue stars. When their spectra were studied, it was found that their wave lengths are somehow different from those of familiar celestial sources. Then Schmidt solved the problem by finding that the spectrum from 3C 273 had a red shift of 0.158. This wave length was 1.158 times longer than the wave length measured in laboratory. It was because of stretching of light waves towards red end as they travelled to Earth due to the expanding Universe. This is called as cosmological red shift. The higher the red shift, the more distant is the quasar from us.

By applying Hubble's law, this quasar was calculated to be at a distance of about two billion light years from us. This is the brightest quasar discovered so far. If it was located 30 light years away from Earth, it would appear as bright as the Sun in the sky.

After the discovery of the first quasar, the astronomers faced a puzzle. This quasar is about 100 times more luminous than the brightest galaxy. Since the quasars are very compact and very luminous, the radiation pressure inside it must be huge. To balance the huge outward radiation pressure, its

gravitational force must also be very high. It means that its mass must be very large. It was calculated that its mass must be equal to at least a million solar mass if it is not to exceed the Eddington limit. Eddington limit is the minimum mass of a star at which the outward radiation pressure is balanced by the inward pull of gravity. The English astronomer Arthur Eddington (1882 - 1944) had calculated this and so it is named after him.

How could an object about the size of solar system have a mass of about a million stars and outshine by 100 times a galaxy of a hundred billion stars? Astronomers were puzzled over this. Russian astronomers Yakov Zeldovich and Igor Novikov and American astronomer Edwin Salpeter independently solved the puzzle that this was due to accretion by gravity onto super massive black hole.

Till date more than 2000 quasars have been identified. The most distant quasar has been detected at more than 13 billion light years from earth and it is designated as J1342 + 0928. It means that it had been formed only 680 million years after the Big Bang.

Implications

The discovery of quasars had large implications in astronomy. It provided a strong evidence against the steady state cosmology of British astronomer Fred Hoyle (1915 - 2001) and in favour of the Big Bang cosmology. Quasars also show the locations of massive black holes in the Universe.

In 1979, the gravitational lens effect predicted by Einstein's General Theory of Relativity was confirmed observationally for the first time with the images of the double quasars 0957 + 561.

Astronomers use quasars as background light sources to study the intervening galaxies and diffuse gas. Astronomers cannot see the distant galaxies due to their dim light, but they become visible after absorbing some of the light of the quasars when it travels to Earth. In this way quasars help astronomers to study details of distant galaxies far too faint to be seen directly. This is called 'absorption spectroscopy'.

Conclusion

Quasars are very mysterious objects. Astronomers have still not understood properly about their nature and formation. The Hubble Space Telescope is searching them and giving us more information. As technology progresses, we can know more about them.

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- ❖ *We are just an advanced breed of monkeys on a minor planet of a very average star. But we can understand the Universe. That makes us something very special.*
- ❖ *There is no unique picture of reality.*
- ❖ *My advice to other disabled people would be, concentrate on things your disability doesn't prevent you doing well, and don't regret the things it interferes with. Don't be disabled in spirit as well as physically.*

- Stephen Hawking

CAN UNIFICATION OF RELATIVITY AND QUANTUM THEORY EXPLAIN THE WHY AND WHEN OF THE CREATION



Prof. Ramasankar Rath

Scientists are still in search of an answer to exactly when and how our universe was created. The answers to who created, it and why, might be the concern of the Philosophers but never of the scientists. Laplace was the first scientist in the search of an answer and advanced a technique called the 'Principle of determinism'. It postulated that if at any given moment we somehow know the configuration of the universe, then we can frame rules (i.e. formulae) to know its configuration at any subsequent moment. The principle however neither clarified the configuration at the initial moment nor the basis on which the formulae referred to were to be framed. Hence it was not possible to progress any further in this direction.

In quantum mechanics there is a principle called the 'uncertainty principle' which says that in case of a moving particle it is not possible to ascertain correctly both its position and velocity at the same time. This meant that if the velocity is correctly evaluated then the ascertained value of its position is at best an approximate one but never accurate and vice versa. Quantum theory says that particles when in motion are always in the form of waves and hence do not have either a definite position or a velocity. This according

to the principle of determinism means that we can formulate rules for determining the forms of these waves only after a lapse of time, but never at the moment of creation, i.e. at the moment of beginning of time.

The two principles are together working in their own ways as best as possible to predict the configuration of the universe at any desired moment of time, that of determinism in the form of particles and that of uncertainty in the form of waves. But as yet there is no known technique of conversion from the wave form to particles. Knowledge of such technique and the nature and measure of forces at play behind the creation of the universe would certainly help to know the configuration of the universe at a desired moment. We can only hope that scientists can some day find a way out of such difficult issues.

Till now it has been known that four types of forces exist in nature and the weakest but the most important among them is 'gravity' being the one behind the expansion of the universe. General theory of relativity says that at the moment of creation, the universe was virtually a concentrated point, a state which is beyond our power of imagination. The

internal pressure as expected in such a state of existence must have crossed the sustainable limit and made it to explode spontaneously and powerfully creating space, time, matter and forces in rapid sequences. Scientists call this the Big Bang, which they say is the beginning of time. The theory also stipulates one possible future in which the expansion process may stop after a long time from now when the pieces drifting away would start coming nearer each other to merge at the point where they were once concentrated. The process would ultimately end with the formation of the same point of infinite density which had exploded at the beginning due to infinite pressure. This could well be taken as the end moment of time, which scientists call the 'Big Crunch'. The Big Bang and the Big Crunch moments are singularities in the space time curve where no mathematical formula would work i.e. they cannot predict the shape of events either immediately preceding or succeeding these instants, since infinitesimal quantities do not come under the scope of the theory. Quantum theory deals with such magnitudes.

❖ *God may exist, but science can explain the universe without the need for a creator.*

❖ *While physics and mathematics may tell us how the universe began, they are not much use in predicting human behavior because there are far too many equations to solve. I'm no better than anyone else at understanding what makes people tick, particularly women.*

- Stephen Hawking

Since objects of both infinitely large and infinitesimally small sizes also constitute our universe the creation and working of the universe could probably be explained if only it is possible to unify the two theories and apply the appropriate mathematics under such restrictions (boundary conditions) as occasion demands. To start with, an edgeless and expanding four dimensional space-time continuum was taken instead of the earlier three dimensional space concepts such that even if millions of bodies like galaxies, black-holes and stars, planets with moons orbiting them are formed in the continuum, the average density of the universe is not too large. Some people think that an omnipresent and omnipotent God behind the creation with such a wonderful power of imagination may provide the answer to His believers. Einstein once remarked humourously that even if, the creation and the working of this universe was due to God, it could not occur according to God's sweet will but must be under the constraint of some laws.

Any theory of science is essentially a model consisting of a few formulae and equations subject to some boundary conditions. These cannot give the answers to who and why types of questions relating to the creation of the universe as also to whether the creation was an accident or after some careful planning. Scientists are all the while busy explaining in various ways what really

is meant by the word Universe ? They do not search for an answer to the why of it. Those who seek it are the Philosopher class of people.

The difficult formulae and equations of scientific theories are beyond the comprehension of philosophers. In 18th century, scientists and philosophers were able to exchange their views on the creation of the universe. Now such a free discussion is not possible, since scientific language has considerably drifted away from its simpler way of analysis of the past century. Hence even if a unified scientific theory is really found out, it will be intelligible to a countable few scientists only, never to those who are not acquainted with the intricacies of mathematics. Thus the realization of our hope that science would one day be able to share its ideas with us about the mind of God behind this creation would have to wait for a long time to come.



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"If we do discover a complete theory of the universe, it should in time be understandable in broad principle by everyone, not just a few scientists. Then we shall all, philosophers, scientists and just ordinary people, be able to take part in the discussion of why it is that we and the universe exist. If we find the answer to that, it would be the ultimate triumph of human reason - for then we would know the mind of God."

- Stephen Hawking

ARTIFICIAL INTELLIGENCE, CYBERG AND HUMANS

Sri Ansuman Dash

Many many years ago in ancient Greece there was a legendary king named THESUS who had built the city of Athens. The king had a ship known as "ship of thesus" which was preserved in the port of Athens in the honour and the memory of the great king. As time passed the ship started deteriorating. In order to save the ship the damaged part of it was replaced with the new ones one by one. And a day came when all the parts of the boat had to be replaced. Here raised the famous paradox question "will the ship has the same identity as the older one? Can it be called with the same name "Ship of Thesus"? The logic behind this paradox is a bit complex in the way if all the replaced part were used to make a new ship then which ship would be considered to have the original identity. The same theory may be applied on human beings in a similar fashion that if all the organs of a humanbeing is replaced then will it be the same person? It is noteworthy that in the span of seven years all the cells of our body will be replaced with new ones, then how the original identity remains established. Well one can think about the soul which binds the whole human body in a single unit which is intangible hence not replaceable. In true science the duty of the sou! is being carried out by the human brain which restores the consciousness and thought every morning when we wake up. However the role of the

memory is vital for the restoration of the consciousness towards the identity. We look forward to in this article how the future science will deal with human brain, the most complex organ in the universe.

The advancement of science in the past hundred years unfolds many unanswered questions of the universe. With technology being the fuel, Science is going to achieve many more possibilities. Thanks to the evolution of the computers from a single counting machine to the series of super computers on multiple networks that makes human life easy today. Imagine a day in present scenario with no computers or the internet the intensity of the chaos or the hoax that would be produced is beyond measureable. To make human life further easy continuous effort has been made in the development of a computerised machine which will have human like intelligence. Significant progress has been made in this field so far which is known as artificial intelligence (AI).

The first industrial revolution had the base of steam engine while the second was based on the electricity. Similarly the third industrial revolution is caused by the computers and internet. Now the fourth industrial revolution which is ongoing in present era is backed on AI. World's largest smart phone manufacturer Apple's I phone personal assistant "Siri" which is a voice activated computer that helps the user find information is an example of artificial intelligence (AI) in a lower version. IBM's "DEEPBLUE" computer is one similar type of AI device which is programmed for playing a chess

game and the chess match under regular time controls (shown in figure 1) and was able to win the match against the world champion.

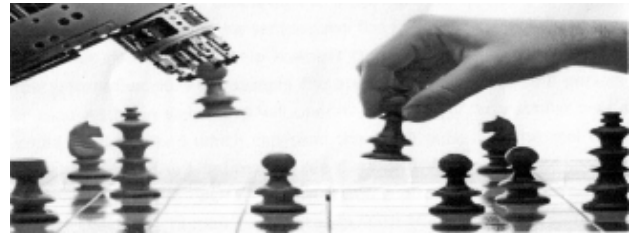


Fig. 1 : AI machine playing a chess match with a human

Many of these AIs have been made with a definite purpose to serve like industrial robots or the driverless car etc. In order to carry out the functions more than that of the specified the AI system has to be learnt by itself which obviously requires a complex algorithm. Our brains consist of neurons which are connected to each other by dendrites and axons. It learns from the past events and responds when the similar event happens. For example, a person learns from the surroundings that fire is dangerous. So the person's intelligence guides him not to go near fire. In a similar way the AI system consists of the artificial neural networks which create the learning platform for the AI. The complex algorithms enable the AI machine to respond to a problem and generate the feedback. The machine will remember the problem and can approach in a similar way to another problem. The number of approaches may be optimised to give a valuable output which in turn is capable of solving different tasks like a human. Recent example of the humanoid robot Sofia (shown in figure 2) which was a big hit in social media is definitely a great achievement in the field of the AI. It is forecasted that by 2030 AI will contribute \$15.75 trillion to the world economy.

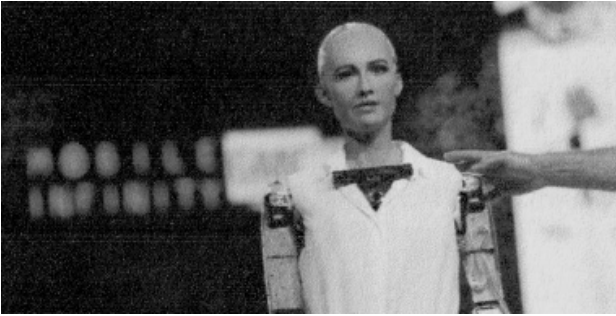


Fig. 2

In human brain the communication between the brain and the neuron system is carried out by the electric pulse generated by the differences in electric potential carried by ions on the neurons. The communication in the computer system is also made by electric signals though it is vastly different from the biological communication system. The task is now to detect the brain signal i.e. the exact pulse being sent to the brain from the sensors and the feedback signal being produced by the brain. This decoding will help scientist capable of making brain communicate with the external world. For example the artificial limb of a disable person will be able to read his brain signal and will operate accordingly. In a similar way artificial eyes could be developed which can send the exact pulse like the real eyes to the brain which will help the blind man to see the world. A man with the smart artificial organs is called a cyberg. So, the cyberg contains both biological and artificial body parts. In a cyberg the human brain interact with the synthetic organs of his own body. This is generally done by the brain machine interfacing device or shortly BMI. BMI is basically a unit consist of a neural signal sensors and an external processors (shown in figure 2). This whole cyberg system may be termed as cyberg

intelligence. Also by the evolution of this technology a person with damaged bodily function will be able to operate various gadgets like TV, computers or fans etc and this is known as the brain gate theory.

Going one step ahead, neuron-chips has been developed for memory restoration and enhancement. In future the neuron-chips will replace the memory cortex and connects to the neurons. After the death of the person the neuron-chip may be unaltered and must have stored all the memory of the person. This chip may be planted in another's body or in an artificial intelligence machine and all the memory will be downloaded and stored there for eternal use like the computer data. In the way the same person may live the life in the body of the AI device. So theoretically the person never dies only the biological body will be decomposed. Now the difficulties of the future generation lie in the identification of the man against the machine with both having the same memory. A person will become a cyberg when the neuron chip is fixed in his body and then an AI machine when the neuron chip is reintroduced in it. So, whether it is a human, a cyberg or an AI will be a question similar to the earlier said "ship of theses" paradox.

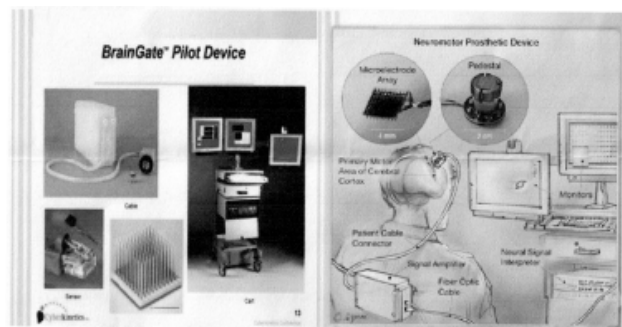


Fig. 3 : Cyberg intelligence components

The adaptability is an inherent property of the nature's animals. Hence with changing conditions we will become better than what we are today. However the technology discussed above is under research today and requires many folds of discoveries. The infrastructure for the same also needs to be developed by many folds. The idea is to learn to make the AI learn. During the process there is always a chance that the AI will become super intelligent and may form their own world. The concept seems to be like a science fiction movie like " matrix", but nothing can be said impossible. Therefore utter care must be taken to avoid this kind of circumstances and the technology should be utilised towards the benefit of the mankind.

Reference

IEEE Journals from artificial intelligence to cyberg intelligence.

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“Computers can, in theory, emulate human intelligence, and exceed it. Success in creating effective Artificial Intelligence (AI), could be the biggest event in the history of our civilization. Or the worst. We just don't know. So we cannot know if we will be infinitely helped by AI, or ignored by it and side-lined, or conceivably destroyed by it. AI could be the worst event in the history of our civilization. It brings dangers, like powerful autonomous weapons or new ways for the few to oppress the many. I feat that AI may replace humans altogether. If people design computer viruses, someone will design AI that improves and replicates itself. This will be a new form of life that outperforms humans.”

- Stephen Hawking

HYDROGEN : A “GREEN FUEL” FOR FUTURE ROAD TRANSPORT



Prof. Gopendra Kishore Roy

Introduction

Energy demand is expected to increase due to rapid population growth, expanding urbanization and better living standards. Fossil fuels remain the dominant source of energy though it is non-renewable and has negative impact on global climate. As India is a fast-growing economy with a GDP growth rate of 7% per annum already achieved and growing at 10% is a possibility, the road transport sector is poised for a growth rate of 10-15%. Transport heralds the development of a region. The demand for infrastructure augmentation increases with the region's pursuit of development goals. The basic infrastructures required for the economic growth of a region are roads, railways, water and air connectivity.

The transport sector, which heavily depends on oil-derived liquid products such as gasoline and diesel, globally occupies the third place when total energy consumption and greenhouse gas (GHG) emissions are considered (after the industry and the building sectors). This consumption level is predicted to increase by 60% by 2030. With the increase in economic activities, the dependence on fossil fuel- based energy sources and

consequent Green House Gas emissions have increased rapidly in recent times. Transport sector consuming a sizeable fraction of the fossil fuels, contributes about 14% of the total GHGs emitted from different human activities.

Hydrogen as potential source of 'green energy'

Rapid increase in both global energy demand and carbon dioxide emissions associated with the use of fossil fuels have driven the search for some alternative form of energy such as green energy which are renewable as well as have a lower environmental impact. In this context, hydrogen has an important role to play.

Hydrogen is considered as a secondary source of energy, commonly referred to as an energy carrier. Energy carriers are used to move, store and deliver energy in a form that can be easily used. Electricity is the most well-known example of an energy carrier. Similar to electricity, hydrogen is also an energy carrier. It can be produced from various domestic renewable resources. In the long-term, hydrogen will simultaneously reduce the dependence on foreign oil and the emission of greenhouse gases and other pollutants.

As an important energy carrier Hydrogen has a number of advantages:

- A large volume of hydrogen can be easily stored in a number of different ways e.g. under high pressure in liquid form hydrogen fuel cell etc..

- Hydrogen is also considered as a high efficiency, low polluting fuel and that can be used for transportation, heating, and power generation in places where it is difficult to use electricity.
- In some instances, it is cheaper to ship hydrogen by pipeline than sending electricity over long distances by wire.

Hydrogen fuel can be used in many different types of transportation either with a fuel cell or in an internal combustion engine to eliminate or significantly reduce emissions. Fuel cell powered vehicles that turn hydrogen into electricity are quiet, efficient and offer the environmental benefit of only emitting water.

Currently, hydrogen is mainly used as a fuel in the NASA space program. Liquid hydrogen is used to propel space shuttle and other rockets, while hydrogen fuel cells power the electrical systems of the shuttle. The hydrogen fuel cell is also used to produce pure water for the shuttle crew.

How Hydrogen can be obtained ?

Because hydrogen does not occur naturally in the environment, it must be derived from other substances that contain hydrogen. About 96% of hydrogen is made from fossil fuels: half from natural gas, 30% from liquid hydrocarbons and 18% from coal. Electrolysis of water accounts for only 4%. Natural gases can provide hydrogen, but it becomes expensive and there are constraints on carbon dioxide emissions. So non-fossil

sources of hydrogen will become necessary. Hydrogen can also be produced from water through electrolysis, but this method is much more energy-intensive. Renewable sources of energy, such as wind or solar, can be used as the source to produce hydrogen thus avoiding harmful emissions from other kinds of energy production.

When hydrogen is made from water the only byproduct is pure water. If fossil fuels are used as the original source of hydrogen production then there will be more by-products, including carbon dioxide. Each tonne of hydrogen produced gives rise to 11 tonne of carbon dioxide as its by-product. When hydrogen is produced from water electricity is used to split the water molecule. If that electricity comes from a renewable energy source such as wind or solar power, then the resulting hydrogen is a renewable one and will not have any harmful gas emission problem.

Hydrogen as a clean transport fuel

Hydrogen vehicle is a vehicle that uses hydrogen as its onboard fuel for motive power. Hydrogen vehicles include hydrogen-fueled space rockets, as well as automobiles and other transportation vehicles. The power plants of such vehicles convert the chemical energy of hydrogen to mechanical energy either by burning hydrogen in an internal combustion engine, or by reacting hydrogen with oxygen in a fuel cell to run electric motors.

The energy in one kilogram of hydrogen gas is about the same as the energy in one gallon (2.8 kilogram) of gasoline. Because hydrogen has a low volumetric energy density, it can be stored as onboard fuel in the vehicle in the form of a compressed gas to achieve the driving range of conventional vehicles. Most current applications use high-pressure tanks capable of storing hydrogen at either 5,000 or 10,000 psi (Pound per square inch). Retail dispensers can fill these tanks in about five minutes. Other storage technologies are under development, including bonding hydrogen chemically with a material such as metal hydride (eg. Nickel hydride), or low-temperature sorbent materials. (eg. Molybdenum, Pentalum, Tungsten & Others).

However, for transport purposes the main use of hydrogen will be in the form of fuel cells.

A Fuel Cell

A fuel cell is a device that generates electrical power through a chemical reaction by converting a fuel (say - hydrogen) into electricity. Although fuel cells and batteries are both considered as electrochemical cells and consist of similar structure, but the fuel cells require a continuous source of fuel and oxygen to run the cell in a manner i.e. identical to an internal combustion engine which needs a continuous flow of gasoline or diesel to run.

Hydrogen Fuel Cell (Fig.-1)

Hydrogen fuel cells directly convert the chemical energy in hydrogen to electric energy, with pure water and heat as the byproducts. Hydrogen-powered fuel cells are not only pollution-free, but have two to three fold increased efficiency in comparison to traditional combustion technologies.

Fuel cells can power almost any portable devices that normally use batteries. Fuel cells can also provide power for the transportation of vehicles such as trucks, buses, and marine vessels. It can also provide auxiliary power to traditional transportation technologies. Hydrogen can play an important role in the future by replacing the imported petroleum we currently use in our cars and trucks.

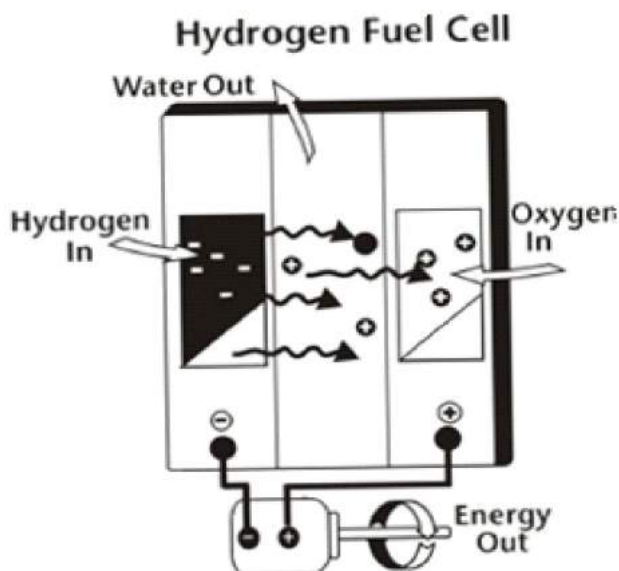


Figure 1. Hydrogen Fuel Cell
(Image source U.S. Dept. of Energy)

Conclusion

In the future, hydrogen will join electricity as an important energy carrier, since it can be made safely from renewable energy sources and is virtually non-polluting for use in the transportation sector.

Although the use of hydrogen as a source of fuel is in its infancy, but its future is incredibly bright. The technology behind the construction of hydrogen fuel cells is improving day by day and its viability as an alternative/replacement to the internal combustion engine seems more. Hydrogen is already being used in some special vehicles such as forklifts and buses. Around 1500 fuel cell electric vehicles were on the road by the end of 2016. It is only a matter of time before the proper infrastructure is in place to serve the consumer automotive market. Hydrogen fuel cell has great potential for use in future transportation because its only byproducts are heat and water vapor thus making it a truly zero-emission locomotive technology.

Methanol, and dimethyl ether (DME) which contains hydrogen, are also good energy carriers, and DME in particular can work as a substitute for diesel fuel.

With consistent R & D efforts and viable energy conversion technologies there is no doubt, that hydrogen is going to play a major role as a 'green fuel' for the years ahead.

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REVERSE OSMOSIS



Prof. Basant Kumar Mohapatra

Osmosis

Spontaneous flow of solvent molecules to the solution or from a less concentrated solution to a more concentrated solution through a semi permeable membrane is called osmosis. This is the normal osmosis process shown in Fig. 1.

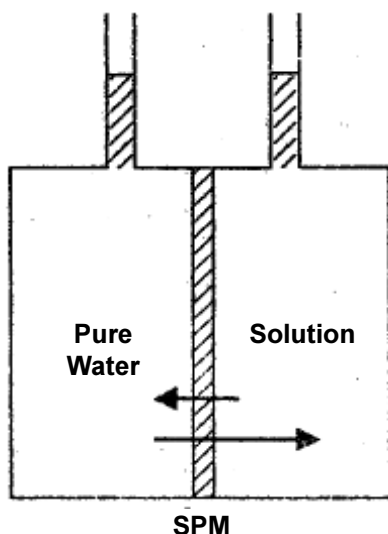


Fig.1 : Normal osmosis

The flow of solvent molecule will continue till sufficient hydrostatic pressure is developed due to rise of level of liquid by a column 'h' called osmotic pressure. Then a hydrostatic equilibrium is attained and there will not be further net flow from either side. This is a dynamic equilibrium state shown in Fig. 2. " P_o " in the figure indicates osmotic pressure of solution.

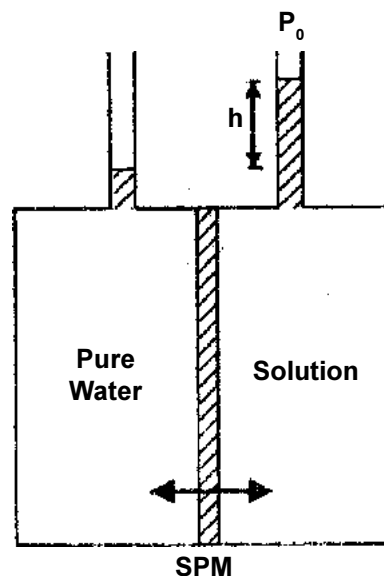


Fig. 2 : Osmotic equilibrium
 P_o - osmotic

Osmosis is a natural process and very important in plants and biological systems (human and other animal body). In other words during the osmosis process, if a pressure 'P' is applied in solution column which is equal to the osmotic pressure of solution ' P_o ', then osmosis process is stopped. In this process, examples of the semi-permeable membrane (SPM) used are cellophane paper, parchment paper, pig's blades, fish blades and thin white membrane present under the shell of an egg. These are natural membranes. Artificial membranes can be prepared by depositing copper ferrocyanide on a porous pot. Demonstration of "egg magic" exhibited in science exhibitions is an example of osmosis process.

Egg Magic

Immerse a raw egg in a container containing dilute hydrochloric acid. Outer shell of the egg containing calcium carbonate will dissolve in

acid and the egg will become soft. Immerse the soft egg in a beaker of water. Water will flow into the egg through the white thin SPM into the egg and the size of the egg will increase. Next immerse the egg in a beaker containing sodium chloride solution. Water will come out from the egg through the SPM and the size of egg will shrink. This shrunken egg can be entered through the small mouth of a bottle. On adding water to the bottle, size of the egg will increase as water will enter into the egg through the SPM. Thus, it can be shown that a big egg is present in the bottle whose mouth is small. This process has been shown in Fig. 3.

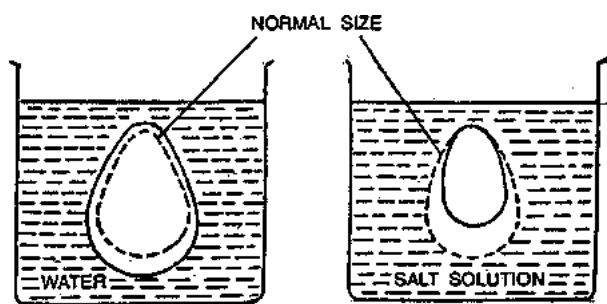


Fig. 3 (a) : Egg in Water Fig. 3 (b) : Egg in Salt Soln.

Reverse Osmosis

When a pressure 'P' much greater than osmotic pressure (P_o) of the solution is applied on the solution column, the flow path will be reversed, that is there will be net flow of solvent molecules from the solution (or more concentrated solution) to pure solvent (or less concentrated solution). This reverse flow of solvent is called reverse osmosis which is shown in Fig. 4 below.

The practical application of reverse osmosis is the desalination process in which

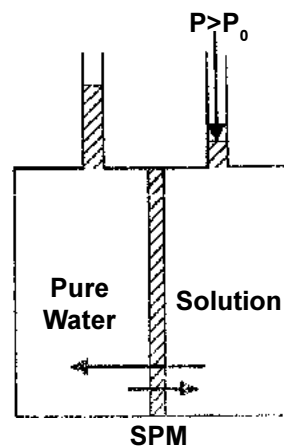


Fig. 4 : Reverse osmotic (Desalination Process)

pure water is extracted from sea water. In countries, where water is not available (may be in gulf countries or in desert countries) water is obtained by desalination process which is much less expensive than the distillation process.

Desalination of sea water

Reverse osmosis is used for the desalination of sea water for getting fresh drinking water. This is done with the help of hollow fibers (nylon or cellulose acetate) where the wall acts as semipermeable membrane. It is shown in Fig. 5.

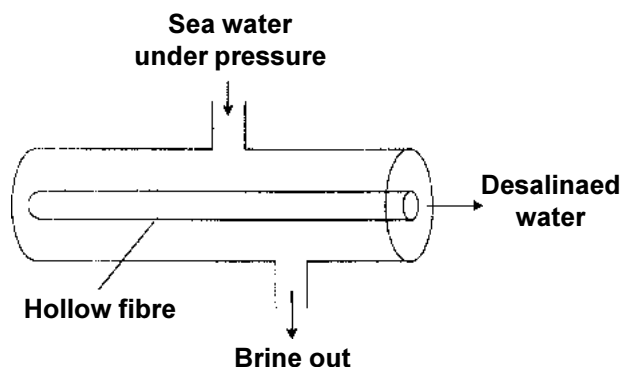


Fig. 3 : Desalination of sea water by reverse osmosis in a hollow fibre unit.

Researchers of Lawrence Livermore National Laboratory (USA) have created membranes made of carbon nano-tubes and silicon that may offer, among many possible application of a less expensive desalination process. A nano-tube membrane on a silicon chip, the size of a rupee coin may offer a cheaper way to remove salt from water. The nanotubes are special molecules made of carbon atoms in a unique arrangement are hollow and more than 50,000 times thinner than human hair. Billions of these tubes act as the pores in the membrane. The super smooth inside of the nanotubes allow liquids and gases to rapidly flow through while the tiny pore size can block larger molecules. Membranes that have carbon nanotubes as pores could be used in desalination, salt removal from water. Commonly performed reverse osmosis uses less permeable membranes which require large amount of pressure and is quite expensive. However, these less permeable membranes could reduce the energy costs of desalination by upto 75% compared to conventional membranes.

By reverse osmosis, inorganic salt, organic compounds, bacteria, pathogens and dissolved gases are removed. Now-a-days for purification of water, different companies have produced R.O. such as Pureit, Kent, Aquaguard etc. which are now the household product names.

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‘BARE FOOT COLLEGE’ FOR DEMYSTIFYING TECHNOLOGY



Er. Ramesh Chandra Sahoo

(Writer of this article came across reports in technical journals that demystifying technology in the hands of illiterate ladies is possible. That too in rural areas without having any modern training facility. It created inspiration in him to visit the institute and gather fast hand knowledge on the activities.)

Scientific investigation always starts with a problem. A scientist has to feel the problem of others deeply as his own. Only then he would be able to find its solution. One such case is of Sanjit Roy later known as Sanjit 'Bunker' Roy. Leaving his studies from prestigious institutions, he has devoted himself on some problem located by him from Bihar's severe drought of the last century. Over the period of forty years he has found the solution. Later he used it for the benefit of illiterate and semi educated women irrespective of age.

The experiment started sometimes in Sixties of the previous century when a severe drought in Bihar occurred. Sri Roy along with a volunteer team came to Bihar for relief work. He got fully involved in the work and saw the fate of the people with poverty during his work. After the team returned to college Sri Roy visited his native place to spend some time with his parents. There he brooded over what he saw and felt. Then he took a firm decision to do some thing for the suffers'

relief. In spite of his parents objection he did not like to continue his further studies.

His inner feeling was to do some thing for this poor class as our country is having majority in this category. Their poverty and lack of education should not stand in their way for earning. If these women could be trained to earn, then their condition would improve along with the country's fate. He searched various places in northern belt of the country and found TILONIA most suitable for his purpose. It is a place in Tribal belt of Rajsthan near Kisangunj at a distance 12 kilometres from town head. The village is surrounded with other tribal villages. He purchased a sizable plot of land to start his activities. The work started in seventies.

Policy of Establishment

Firstly Sri Roy was interested to train only ladies having aptitude to work and earn. Prior education is a demerit for such training. There is no age bar. Even old ladies are being trained. Focus was given on Mahatma Gandhi's principles, walk barefoot, work on the floor, sleep on the floor, learn by seeing only without verbal exchange. That is why the college has been named as **Bare Foot College**. For construction, all local materials like stone slabs, surkhi and lime pest have been used. All local architects and masons are put to work. Even the whole roof have been constructed using large stone slabs. For production purposes local skills have been used as far as possible.

Genaeral Set Up

A few ladies from the local villages were selected. Their aptitude test for skill development was taken. The stress was given on the know how for creation of useful artifacts learnt from their day to day activities. Use of local available materials was another aspect for this training. Puppet making and puppet shows started, being a traditional craft. Another aspect of conducting puppet shows in villages, is to deliver the messages to ladies to take up professional training of their choice. Slowly different sections with local know how and materials were added in the centre. Those are nutritious midday meal for schools, mosquito net for rural villages, wooden toys for children, music section with instruments to support poppet shows, medicinal plants garden to help plantation in nearby villages. The response from the women was encouraging.

Techno-Development :

Next step is to introduce technology based production for use of items in rural sector, to improve their life style. Those are sanitary napkin, solar to panel assembly and installation, solar hot water system, solar parabolic cookers, potable water testing and metal welding. Most of these items are fabricated in the campus.

Area Devalopment ment and Support

To help the people in the villages some social work was taken up. Those are health camps in village schools, mobile water testing



in the villages, garment marketing of products woven in local villages, night school for children. F.M. radio transmission to local villages is also managed in a thatched cottage by two ladies.

Returns

The college started its work in 1975. The work schedule of training is only for six months. During this short period, the trainees could gather working knowledge. They are then relieved to go to their villages and start working in their field. In an average each woman worker earns adequate return to support his family. Till now 195000 have completed their training and left for their places. Some of them are women from South Africa and Arabian countries also.

Awards and achievements

In 1998, it was awarded the Indira Gandhi Paryavaran Puraskar (Indira Gandhi Environment Award), by the Ministry of Environment and Forests, Government of India. In 2003 Ashden award for solar development in rural villages, Clinton global citizen award in 2013 jointly. This Institution returned the Agakhan award for architecture as the authorities insisted in including a qualified architect, who actually did not work with them.

By creating Barefoot College, Sanjit Bunker Roy has made service-learning his livelihood - he has become an entrepreneur by making his job for helping the community. He is teaching people in the community the basic skills they need to survive and be effective in their community - without having to hire people to do simple jobs. The college also provides women with training to learn how to do things normally dominated by men. It gives the women equality with the men and helps them to become more self-sufficient. The "professionals" that extended helping hands to Sri Roy are geologists, economists, doctors, social workers, chartered accountants, graduates, and post graduates. It enables the citizens to feel that they were doing their part to help their community. They are now more efficient, effective, resourceful and knowledgeable citizens who are fighting to have a productive and profitable society, thanks to the brainchild of Sanjit Roy's Barefoot College.

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ANTIBIOTICS-START TO END : TIME TO RETHINK

Dr. Debdutta Bhattacharya
Dr. Sanghamitra Pati

"The time may come when penicillin can be bought by anyone in the shops. There is the danger that the ignorant man may easily underdose himself and by exposing his microbes to non-lethal quantities of the drug make them resistant."

-Alexander Fleming at his 1945 Nobel Prize lecture

What are antibiotics?

Among the very few remarkable events in the history of microbial diseases, antibiotic discovery is the one. With the advancement of scientific research, one is almost free from deadly infectious diseases and the surgery of medical science is no longer a desperate gamble with human life. This is primarily due to the antibiotic discovery. As a result of it people can live safely and healthily for a longer period. The meaning of the word antibiotic in Greek is "against life".

Antibiotics are chemical substances produced by various species of microorganisms and other living systems that are capable of inhibiting the growth of or killing bacteria and other microorganism. The term antibiotic is originally used to denote a chemical substance produced by one microorganism that kills or inhibits the growth of other microbes, the term now applies to both naturally produced substances and those synthesized in the laboratory. Most are produced by either fungi (e.g., penicillin, cephalosporins), *Bacillus* species (e.g., polymyxin, bacitracin), or *Streptomyces* species (streptomycin, tetracycline, erythromycin, kanamycin, neomycin, nystatin).

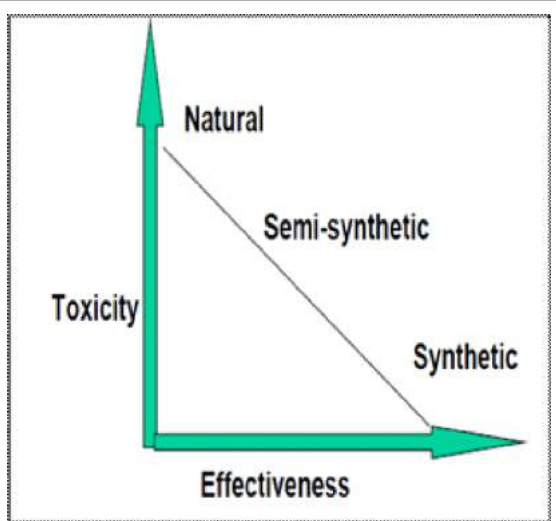
Probably many of us are familiar with the somewhat serendipitous event on the September 3, 1928 that led to the penicillin discovery by Fleming (1929). Although the antibacterial properties of mold had been known from ancient times, and researchers before him had come upon the similar observations regarding the antimicrobial activity of *Penicillium* from time to time, it

All antibiotics agents have 3 major origin

- **Natural:** mainly fungal sources like Gentamicin.
- **Semi-synthetic:** chemically-altered natural compound like Ampicillin
- **Synthetic:** chemically designed in the lab like Norfloxacin

Organisms develop resistance faster to the natural antimicrobials.

Natural antibiotics are often more toxic than synthetic antibiotics.



was his formidable persistency and his belief in the idea that made the difference. The discovery of penicillin from the fungus *Penicillium notatum* perfected the treatment of bacterial infections such as, syphilis, gangrene and tuberculosis.

Various types of antibiotics work in either of the following two ways:

- **Bactericidal** antibiotic kills the bacteria generally by either interfering with the formation of the bacterium's cell wall or its cell contents. Some examples are Penicillin, fluoroquinolones, metronidazole, nitrofurantoin and co-trimoxazole.

- **Bacteriostatic** antibiotic stops bacteria from multiplying by interfering with bacterial protein production, DNA replication, or other aspects of bacterial cellular metabolism. Some Bacteriostatic antibiotics are tetracyclines, sulphonamides, spectinomycin, trimethoprim, chloramphenicol, macrolides and lincosamides.

Global antibiotic production and sales, total more than 50 million pounds annually of which 25 million pounds are prescribed for human use and the rest used on agriculture,

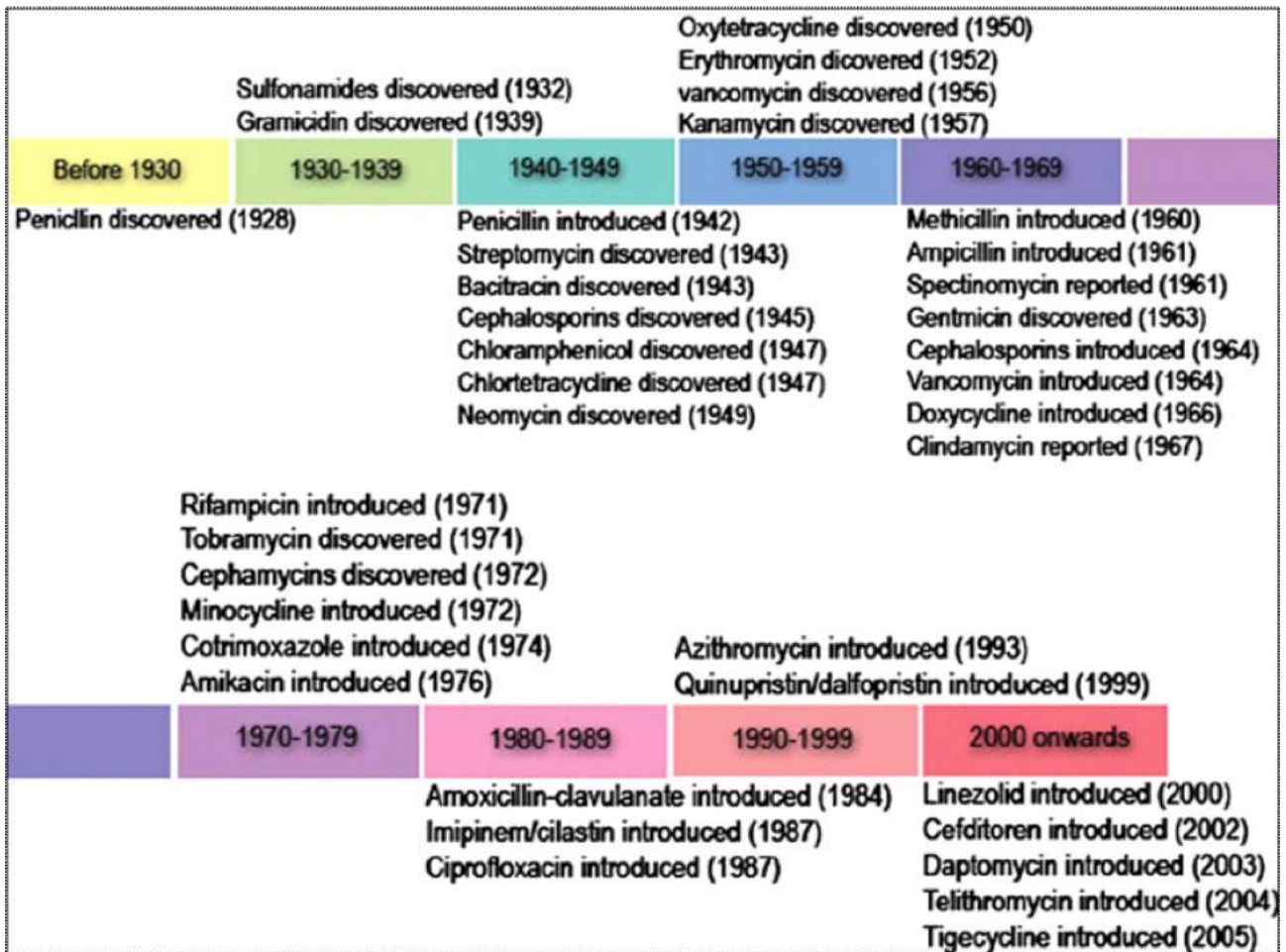


Figure 1. Golden age of antibiotic/antibacterial agent discovery (Adopted from cvm.msu.edu, 2011)

veterinary practice, food industries and commercial ethanol production.

In 2010, India was the world's largest consumer of antibiotics for human health at 12.9×10^9 units (10.7 units per person). The next largest consumers were China at 10.0×10^9 units (7.5 units per person) and the US at 6.8×10^9 units (22.0 units per person).

Classification of Antibiotics and their site of action

Garrod, Lambert and O' Grady have classified Antibiotics on the basis of general similarity of chemical structure.

- a) *Penicillin and related Antibiotics*:- All members of this group have a β -lactum ring in their structure. This group includes the natural penicillins the semisynthetic penicillins and cephalosporins.
- b) *Aminoglycoside Antibiotics*:- All members of this group have amino sugars in glycoside linkage. This group comprises the streptomycins, neomycin, kanamycin, gentamycin, tubramycin and amikacin.

c) *Macrolide Antibiotics*:- All these consist of a macro cyclic lactone ring to which sugars are attached. This group comprises of erythromycin, oleandomycin and spiramycin.

d) *Tetracycline Antibiotics*:- The Tetracyclines are derivatives of the poly cyclic naphthacene carboxamide. This group consists of tetracycline, chlortetracycline, demeclocycline, oxytetracycline and minocycline.

e) *Chloramphenicol*:- This antibiotic is a class in itself. It is a nitrobenzene derivative of dichloroacetic acid.

f) *Peptide Antibiotics*:- These antibiotics form a large group but very few have found therapeutic application. These antibiotics are composed of peptide-linked amino acids which commonly include both D-and L-forms of isomers. Antibiotics of this category include bacitracin, gramicidin and the polymyxins.

Based on the mechanism of action, the antibiotics are classified into 5 groups as described below and in Figure 2.

Antibiotic target	Antibiotic family
Cell Wall synthesis	Beta-lactams and vancomycin
Cellular membrane	Daptomicin, Polimixin
Inhibiting Protein synthesis	Linezolid, Tetracyclins, Macrolides, Aminoglycosides, Chloramphenicol
Inhibiting synthesis of DNA/RNA	Quinolones, Fluoroquinolones, Rifamycin
Folic acid metabolism inhibitors	Sulfonamides and Trimethoprim

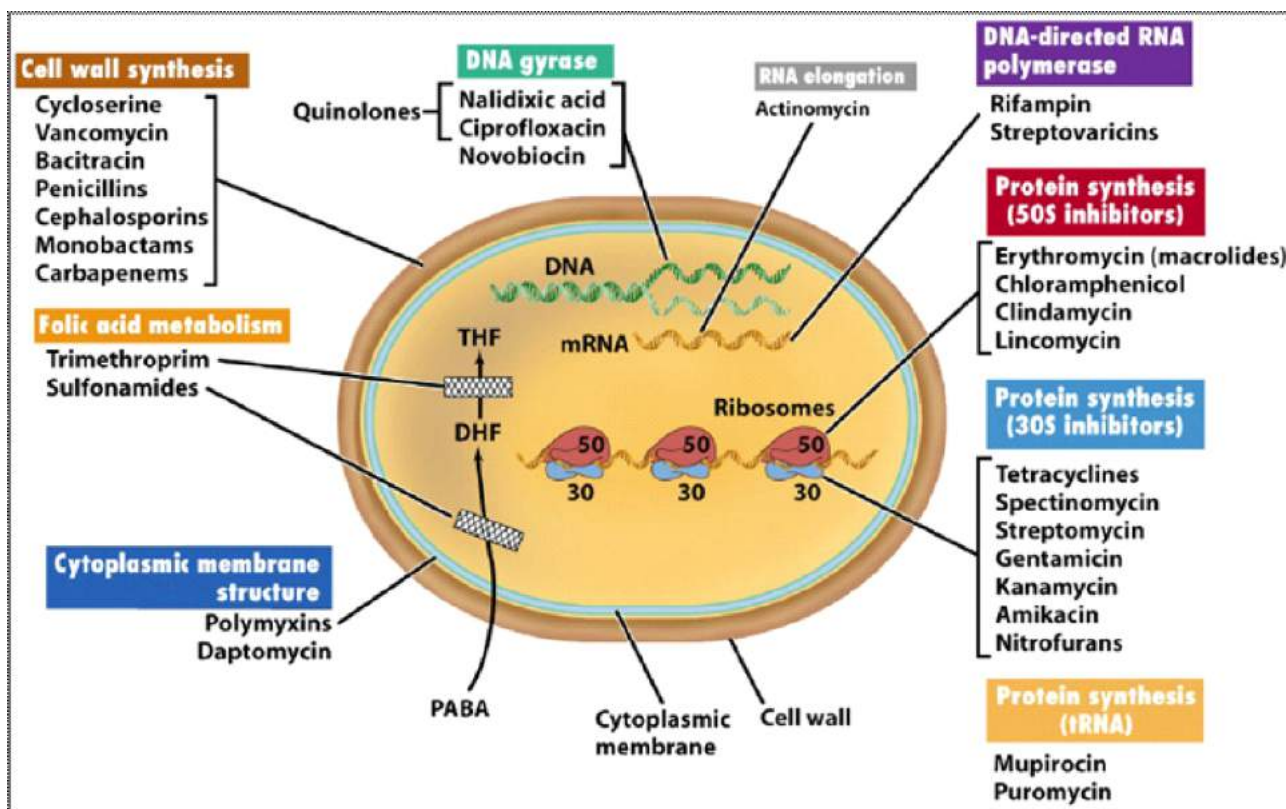


Figure 2. The mechanism of action for different antimicrobial drug targets in bacterial cells (Adopted from Lab notes week 4, 2013)

Antimicrobial resistance

Antimicrobial resistance is the ability of a microorganism to survive and multiply in the presence of an antimicrobial agent that would normally inhibit or kill this particular kind of organism. Antimicrobial resistance is just one of the many adaptive traits that resilient bacterial sub-populations may possess or acquire, enabling them to out-compete and out-survive their microbial neighbors and overcome host strategies aimed against them. This phenomenon is nearly as old as the discovery of antimicrobials themselves. Even before the extensive use of penicillin, some observations suggested that bacteria could destroy it by enzymatic degradation.

Mechanism of resistance development in bacteria

To survive in the presence of an antibiotic, bacterial organisms must be able to disrupt one or more of the essential steps required for the effective action of the antimicrobial agent. The intended modes of action of antibiotics may be counter-acted by bacterial organisms via several different means. This may involve preventing antibiotic access into the bacterial cell or perhaps removal or even degradation of the active component of the antimicrobial agent. No single mechanism of resistance is considered responsible for the observed resistance in a bacterial organism. In fact, several different mechanisms may work together to confer resistance to a single antimicrobial agent.

There are three ways for bacteria to become antibiotic resistant (Figure 3)

- **Target resistance (Change the LOCK, the KEY will not fit) :** There is change in the active binding site of the antibiotic, where in the antibiotic is not able to identify the active site and rendered inactive. Natural variations or acquired changes in the target sites of antimicrobials that prevent drug binding is a common mechanism of resistance. Target site changes often result from spontaneous mutation of a bacterial gene on the chromosome.
- **Enzymatic degradation (Change the KEY, that will not fit into the LOCK):** Inactivation of antimicrobial agents via modification or degradation. There are 3 main enzymes such as β -lactamase, aminoglycoside modifying enzyme and chloramphenicol acetyl transferases that inactivate the antibiotics.
- **Efflux pumps :** Membrane proteins that export antibiotics from the cell and maintain their low-intracellular concentrations are called efflux pumps. At the same speed, where these antimicrobials are entering the cell, efflux mechanisms are pumping them out again, before they reach their target. These pumps are present in the cytoplasmic membrane, unlike porins which are present in outer membrane. Antibiotics of all classes except polymyxin are susceptible to the activation of efflux systems.

How does antibiotic resistance spread?

The antibiotic resistance basically spreads by 3 modes (Figure 4), via

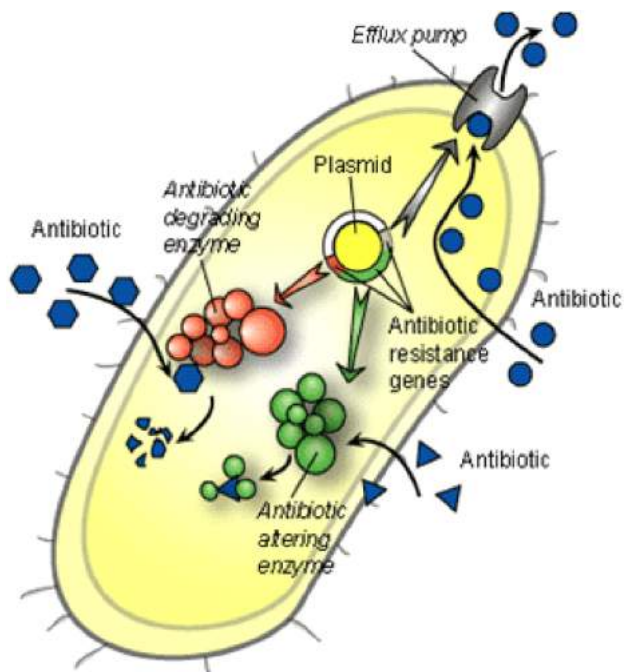


Figure 3. Different mechanisms responsible for development of drug resistance in Bacteria.

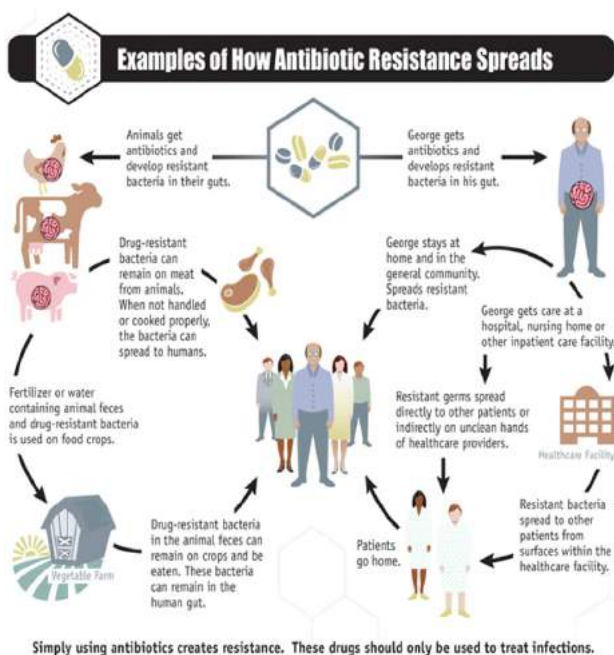


Figure 4. Mode of spread of antibiotic resistance

- Environment (Air, Water, Soil): When the resistant bacteria comes into the environment.
- Fomites
- Infected individuals: through hands, cough

Implications of Anti-microbial resistance

The anti-microbial resistance pathogens results in

- Higher morbidity and mortality caused by these agents.
- Higher burden of healthcare cost for the patients
- Increase economic loss in agricultural sector, especially in the animal husbandry sector and industry.

The mortality rates due to multidrug-resistant bacterial infections are high. Each year, about 25,000 patients in the EU die from an infection with the selected multidrug-resistant bacteria (ECDC/EMA Joint Working Group, 2009), and more than 63,000 patients in the United States die every year from hospital-acquired bacterial infections. The crude infectious disease mortality rate in India today is 416.75 per 100,000 persons and is twice the rate prevailing in the United States when antibiotics were introduced (roughly 200 per 100,000 persons). A mix of poor public health systems and hospital infection, high rates of infectious disease, inexpensive antibiotics, and rising incomes is coming together to increase prevalence of resistant

pathogens and is increasing the burden of untreatable neonatal sepsis and health-care-associated infections. Although accurate estimates of the overall burden of resistance are not available, it is estimated that 58,000 neonatal deaths are attributable to sepsis caused by drug resistance to first-line antibiotics each year.

Conclusion

The antibiotic/antibacterial drugs significantly improved the health of both humans and animals and they have revolutionized the control and treatment of bacterial diseases for more than 50 years during the golden age of antibiotic. However, the massive use of antibiotic/antibacterial drug in the fields of medical, veterinary practice, food industries, agriculture and commercial ethanol production in breweries, self-medication and increased pharmaceutical marketing and promotion lead to increased production of these drugs globally. All these factors have contributed to the environmental pollution of antibiotics leading to the destruction of useful bacteria and favouring the selection of resistant bacteria which ultimately affects the global health. The current state of affairs in the fields of antimicrobials, microbial resistance, and chemotherapy are certainly not limited to the clinical microbiology as it was in the early years of the antibiotic era. Thus, it is not a single big challenge; it is rather a complex problem requiring concerted efforts from people of different walks of life such as :

microbiologists, ecologists, health care specialists, educationists, policy makers, legislative bodies, agricultural and pharmaceutical industry workers, and the society as a whole to deal with the ensuing threat. In fact, everyone should remain concerned about this. Because, there is always a probability that each one of us at some or other stage of our life may get infected with a pathogen that has developed resistant to all the known antibiotic treatments. Thus it needs a pledge from all of us.

Pledge for tackling AMR

- Only use antibiotics as prescribed to me by my health care provider.
- Always complete the full course of medication.
- Use good hygiene practices to prevent the spread of germs and to limit the need for antibiotics.
- Encourage my friends and family to use antibiotics responsibly.

• Antibiotics do not work against viruses!

• Examples of viral infections:

- The common cold
- The flu (influenza)

**COLD? FLU?
TAKE CARE
NOT ANTIBIOTICS**



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BIO-REMEDIATION



Sri Arun Kumar Bharati

The oil spill that contaminated Chennai's beaches in January this year had an unusual ecological takeaway. The spill was cleaned up using a technique called bioremediation. The technique works by making use of the natural ability of certain microorganisms to break down toxic compounds using enzymes. Enzymes are molecules present in these microorganisms that do the job of breaking down pollutants into non-toxic compounds, essentially getting rid of them by eating them.

Possibly considered one of the most inert and harmless of environmental clean-up techniques due to its use of near-natural processes, various techniques of bioremediation have gained considerable attention both in academic circles as well as with the public in the past three decades.

How it works

In a study published in *Nature* on March 27, researchers from the University of Wisconsin-Madison captured the process of one such enzyme attacking and breaking down toluene, an organic pollutant. Says Thomas Brunold, author of the study: "Broadly, these types of natural reactions are environment-friendly and cheap. In industry, researchers often perform challenging reactions with complex chemicals in harsh conditions, which

are energy intensive and can result in lots of waste. Investigating how enzymes, like the one we studied, catalyse their reactions can help us find more efficient ways to perform these challenging reactions."

There are various methods of bioremediation. In Chennai, researchers from the Indian Oil Corporation Limited (IOCL) used the ex-situ (off site) method. Ex-situ cleanup involves transporting the contaminated material for safe treatment away from the site of contamination. Bioremediation can also be carried out in-situ, making use of microorganisms at the site. Another method is bioaugmentation, where non-indigenous microbial species are added to a contaminated site to enhance the breakdown process (see 'Clean acts').

Bioremediation first got into popular scientific parlance following the Exxon-Valdez oil spill in Alaska in 1989, when millions of gallons of oil was spilled. When conventional methods failed to show any significant results, bioremediation trials, specifically the addition of fertilisers, were carried out. This resulted in enhanced activity of indigenous bacteria that biodegraded hydrocarbons, but the process slowed down once the readily available hydrocarbons were exhausted. Following successful field trials, bioremediation was deployed on a large-scale to clean up the spill. While an actual quantification is difficult, beaches that were treated with fertilisers were observed to be cleaner than those that weren't.

Natural cleaners

Bioremediation is not just limited to cleaning oil spills. It has far-reaching applications in cleaning up contaminated soils, industrial wastewater, groundwater, mines, pesticide accumulated sites and fly ash disposal sites.

The use of microorganisms in bioremediation is not limited to bacteria. Scientists have achieved considerable success in using fungi species such as *Aspergillus niger*, *Aspergillus terreus*, *Cladosporium oxysporum* and *Mucor thermohyalospora* to break down endosulphan, a highly toxic insecticide, into a non-toxic isomer.

Says Geoffrey Gadd of the University of Dundee, who has conducted extensive research on bioremediation, "Fungi are important components of the soil microbiota and are, therefore, involved in all the natural processes that may affect the chemical state of metal pollutants, as well as being very important in the degradation of xenobiotic compounds. Much of the current work is being done using fungi (and bacteria) for metal biorecovery and the production of useful biomineral or nanoparticle forms, but commercial exploitation has not happened yet."

Indian researchers are also finding new pathways in bioremediation.

A team from the Indian Institute of Technology (IIT), Madras, succeeded in

degrading samples of crude oil by up to 80 per cent within 10 days using *Bacillus subtilis*, a bacteria derived from a polymer dump site. While a combination of different groups of bacteria is generally required to break down crude oil-since each group is limited in the kinds of hydrocarbons they can act on-it was observed that *B. subtilis* could be used to treat a wide range of hydrocarbons in the oil. The team was led by N Sakthipriya from the Environmental and Water Resources Engineering Division, IIT-Madras.

Laboratory trials have also demonstrated the successful use of electro-remediation in denitrification of soil, such as an experiment conducted on nitrate-rich soil in South Korea. The trials succeed in achieving 100 per cent efficiency in removing nitrates from soil samples, a significant finding especially for areas that practice input-intensive agriculture, where hyper-nitrification of soil and water due to overuse of fertilisers is a critical issue.

There is another technique that combines electrokinetics and bioremediation. Here, in-situ treatment of soil pollutants known as Hydrophobic Organic Compounds (HOCs), which include hard-to-remove compounds such as petroleum byproducts, herbicides and byproducts in chemical manufacturing, can be cleaned up. It remains to be seen if governments across the world fund further research, and more importantly, whether industries, both large and small, will use bioremediation to clean up their sites.

Clean acts

Techniques used in the past to clean contaminated sites

In-situ (On Site) Method - Uses microorganisms to treat contaminated material at the site, as was done in the Exxon-Valdez oil spill in 1989

Ex-situ (Off Site) Method- Transporting the contaminated material from the site of contamination and using microbes for treatment. Used by the Indian Oil Corporation Limited to clean up the Chennai oil spill this year

Bioaugmentation - Non-indigenous microbial species added to a contaminated site to enhance the breakdown process. Villalba de los Barros, a municipality in Spain, has been using this technique since 2012 to treat wastewater

Electro-remediation - Using microbes to remove nitrates from soil. Trials conducted in South Korea in 2009 to treat nitrate-rich soil.

Electrokinetic Bioremediation - In-situ treatment of soil pollutants known as Hydrophobic Organic Compounds. Denmark used this technique in 2012 to degrade PCE, or Perchloroethylene, a soil contaminant.

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In my school, the brightest boys did math and physics, the less bright did physics and chemistry, and the least bright did biology. I wanted to do math and physics, but my father made me do chemistry because he thought there would be no jobs for mathematicians.

- Stephen Hawking

**QUIZ ON
ORGANIC CHEMISTRY**

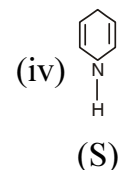
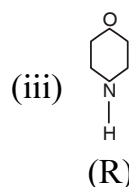
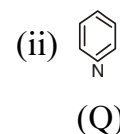
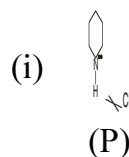
Dr. P. N. Gauda

Note: Choose the most appropriate choice for selecting your answer to the question.

1. The C - Cl bond is shortest in :

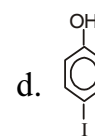
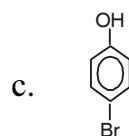
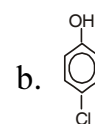
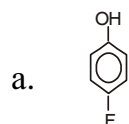
- $\text{CH}_2 = \text{CH} - \text{Cl}$
- $\text{CH}_3 - \text{Cl}$
- $\text{C}_6\text{H}_5 - \text{CH}_2 - \text{Cl}$
- $\text{CH}_2 = \text{CH} - \text{CH}_2 - \text{Cl}$

2. Write the order of basic strength.










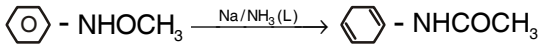
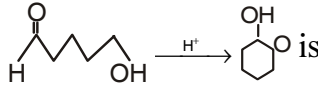




- $\text{Q} > \text{R} > \text{S} > \text{P}$
- $\text{P} > \text{R} > \text{Q} > \text{S}$
- $\text{R} > \text{P} > \text{S} > \text{Q}$
- $\text{P} > \text{Q} > \text{R} > \text{S}$

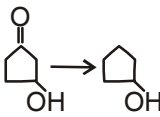
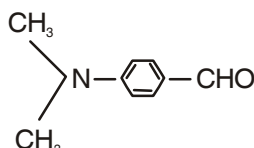
3. Which of the phenol derivative is most acidic ?



4. Which of the following behave both as a nucleophile and electrophile ?

- CH_3NH_2
- $\text{CH}_3 - \text{Cl}$
- CH_3CN
- CH_2OH

5. The smallest alkane which can show optical isomerism contains
- 5 carbon
 - 6 carbon
 - 7 carbon
 - 8 carbon
6. $(\text{CH}_3)_3\text{C MgCl}$ on reaction with D_2O , produces :
- $(\text{CH}_3)_3\text{CD}$
 - $(\text{CH}_3)_3\text{COD}$
 - $(\text{CD}_3)_3\text{CD}$
 - $(\text{CD}_3)_3\text{COD}$
7. The correct order of relative density of following alkanes is :
- (i)  (P) (ii)  (Q)
- (iii)  (R) (iv)  (S)
- $\text{P} > \text{S} > \text{Q} > \text{R}$
 - $\text{R} > \text{S} > \text{Q} > \text{P}$
 - $\text{R} > \text{Q} > \text{S} > \text{P}$
 - $\text{S} > \text{R} > \text{Q} > \text{P}$
8. Which of the following will not give addition reaction with RMgX ?
- CO_2
 - $\text{C}_2\text{H}_5\text{Br}$
 - SO_2
 - CH_3CHO
9. The order of solubility in water of
- (i)  (i) (ii)  (ii) (iii)  (iii)
- $\text{I} > \text{II} > \text{III}$
 - $\text{I} < \text{II} < \text{III}$
 - $\text{II} > \text{III} > \text{I}$
 - $\text{II} > \text{I} > \text{III}$
10.  is known as -
- Clemmenson reduction
 - Birch reduction
 - MPV reaction
 - Woff - Kishner reduction
11. $\text{C}_2\text{H}_5\text{Br}$ can be converted into $\text{C}_2\text{H}_5\text{-O-C}_2\text{-H}_5$ by :
- reacting with $\text{C}_2\text{H}_5\text{ONa}$
 - Heating with moist Ag_2O
 - Heating with dry MgO
 - Treating with $\text{C}_2\text{H}_5\text{MgBr}$
12. $1^\circ, 2^\circ$ and 3° can not be distinguished by:
- $\text{Cu}/573\text{ K}$
 - Victer Meyer test
 - ZnCl_2/HCl
 - $\text{Br}_2/\text{H}_2\text{O}$
13. In alcohols the hydroxyl group can not be replaced by - Cl group by following reagents.
- Cl_2
 - SOCl_2
 - PCl_5
 - ZnCl_2/HCl
14. Glycerol can be converted to acrolein by dehydration in presence of :
- Conc. H_2SO_4
 - Conc. NaOH
 - CaCl_2
 - anhydrous ZnCl_2
15. Arrange the following compounds in decreasing order of nucleophilic addition reaction :
- (i) HCHO (ii) CH_3CHO
 (iii) CH_3COCH_3 (iv) $\text{C}_6\text{H}_5\text{COCH}_3$
- $\text{II} > \text{IV} > \text{II} > \text{I}$
 - $\text{I} > \text{II} > \text{III} > \text{IV}$
 - $\text{IV} < \text{III} > \text{II} > \text{I}$
 - $\text{II} > \text{III} > \text{IV} > \text{I}$
16. Secondary amine reacts with carbonyl compounds to give :
- Imino
 - Schif's base
 - Hydrazone
 - Enamine
17. The reaction :  is an example of
- Intermolecular hemiacetal formation
 - Intramolecular hemiacetal formation
 - Intermolecular acetal formation
 - Intramolecular acetal for
18. Which carbonyl compound has maximum dipole moment ?
- 
 - 
 - 
 - 

19. Which halide gives Wittig reaction ?
 a. $\text{CH}_2=\text{CHCl}$ b. $\text{C}_6\text{H}_5\text{-Cl}$
 c. $\text{H}_2\text{C}=\text{CHCl}$ d. $\text{C}_6\text{H}_5\text{-CH}_2\text{-Cl}$
20. By which of the following reaction Cinnamic acid can be prepared from benzaldehyde ?
 a. Perkin reaction
 b. Reformatsky reaction
 c. Knoevenagel Condensation
 d. All of the above
21. The conversion  can be achieved by :
 a. Wolff-Kishner reduction
 b. Clemmenson reduction
 c. LiAlH_4
 d. NaBH_4
22. Which of the following does not react with Fehling's solution ?
 a. CH_3CHO b. $\text{C}_6\text{H}_5\text{CHO}$
 c. Glucose d. $\text{C}_6\text{H}_5\text{CH}_2\text{CHO}$
23. CH_3COOH and HCOOH can be distinguished by :
 a. NaHCO_3
 b. H_2SO_4
 c. Fehling's solution
 d. Litmus Paper
24. CH_3CHO and $\text{C}_6\text{H}_5\text{CHO}$ can be distinguished by :
 a. Tollen's Reagent
 b. Fehling's solution
 c. DNP
 d. NH_2OH
25. Which of the following does not give N-substituted amide from Ketoxime ?
 a. PCl_3 b. SO_2
 c. BF_3 d. NH_3
26. Acetaldehyde cannot be prepared from which of the following reactions ?
 a. $\text{CH}_3\text{CH}_2\text{OH} \xrightarrow{\text{CaO}/\Delta} ?$
 b. $\text{CH}_3\text{COCl} \xrightarrow[\text{H}_2, \Delta]{\text{BaSO}_4\text{-Pd}} ?$
 c. $(\text{CH}_3\text{COO})_2\text{Ca} + (\text{HCOO})_2\text{Ca} \xrightarrow{\Delta} ?$
 d. $\text{H}_3\text{C}-\underset{\text{OH}}{\text{CH}}=\text{C}-\text{Ph} \xrightarrow[\text{Zn-H}_2\text{O}]{\text{O}_3} ?$
27. Which of the following gives aldol condensation.
 a. $\text{Cl}_3\text{C.CHO}$
 b. HCHO
 c. $\text{C}_6\text{H}_5\text{CHO}$
 d. 
28. $\text{C}_6\text{H}_5\text{COOH}$ and $\text{C}_6\text{H}_5\text{CH}_3$ can be separated by :
 a. NaHCO_3
 b. NaHCO_3 (aq.) and n-hexane
 c. H_2O
 d. n-hexane
29. Which of the following reagents can be used for the reduction of carboxylic acid to alcohol ?
 a. NaBH_4 b. H_2/Pt
 c. LiAlH_4 d. NaBH_3CN
30. Find out the order of reactivity of the following diazonium ion towards diazo coupling ?
 (P) $(\text{CH}_3)_2\text{N}-\text{C}_6\text{H}_4-\text{N}_2^+$ (Q) $\text{O}_2\text{N}-\text{C}_6\text{H}_4-\text{N}_2^+$
 (R) $\text{CH}_3\text{O}-\text{C}_6\text{H}_4-\text{N}_2^+$ (S) $\text{H}_3\text{C}-\text{C}_6\text{H}_4-\text{N}_2^+$

- a. $P > Q > R > S$
 b. $Q > S > R > P$
 c. $P > R > S > Q$
 d. $S > R > Q > P$
31. What is the product formed when Ethanol is reacted with acidified $K_2Cr_2O_7$?
 a. C_2H_5OH b. CH_3COOH
 c. C_2H_6 d. CCl_3CHO
32. During reaction of acetaldehyde with hydrazine in presence of alkali and glycol, the first intermediate product formed is :
 a. CH_3CN
 b. CH_3CONH_2
 c. $CH_3-CH=NH$
 d. $CH_3-CH-NNH_2$
33. Which of the following compounds is formed when Acetaldehyde is reduced with H_2 in presence of Nickel ?
 a. Ethanol
 b. n-propanol
 c. Methanol
 d. Isopropanol
34. Stephen reacton is the reaction involving:
 a. Reduction of alkanoyl chloride with $Pd/BaSO_4$
 b. Reduction of alkyl isocyanide with sodium and alcohol.
 c. Reduction of ackyl cyanide with $SnCl_2$ and HCl and hydrolysed.
 d. Reduction of carbonyl compound with Zinc amalgam and HCl
35. The reagent useful for dehydration of Cyclohexanol is :
 a. H_3PO_4
 b. Conc. H_2SO_4
 c. Anhydrous $ZnCl_2$; Conc. HCl
 d. Al_2O_3
36. Acetaldehyde can be identified from benzaldehyde with
 a. Benedict's reagent
 b. Fehling's solution
 c. Tollen's reagent
 d. DNP
37. Calcium formate on dry distillation gives:
 a. $HCHO$ b. $HCOOH$
 c. CH_3COOH d. C_2H_5OH
38. Acetic acid can be prepared by :
 a. Oxidising CH_3CHO with $K_2Cr_2O_7$ and H_2SO_4
 b. Heating glycerol with Conc. H_2SO_4
 c. Oxidising CH_3OH with $KMnO_4$
 d. Distillating a mixture of calcium acetate and calcium formate.
39. When acetamide is hydrolysed by boiling with water the product is :
 a. ethylalcohol b. ethylamine
 c. acetaldehyde d. acetic acid
40. Which of the following on oxidation followed by hydrolysis gives pyruvic acid ?
 a. Acetone Cyanohydrin
 b. Acetaldehyde Cyanohydrin
 c. Formaldehyde Cynohydrin
 d. Both a and b

ANSWER

1. (a) 2. (b) 3. (b) 4. (c) 5. (c)
 6. (a) 7. (c) 8. (b) 9. (c) 10. (b)
 11. (a) 12. (d) 13. (a) 14. (a) 15. (c)
 16. (d) 17. (b) 18. (d) 19. (d) 20. (a)
 21. (a) 22. (b) 23. (c) 24. (b) 25. (d)
 26. (d) 27. (d) 28. (a) 29. (d) 30. (b)
 31. (b) 32. (d) 33. (a) 34. (c) 35. (a)
 36. (a & b) 37. (a) 38. (a) 39. (d) 40. (b)

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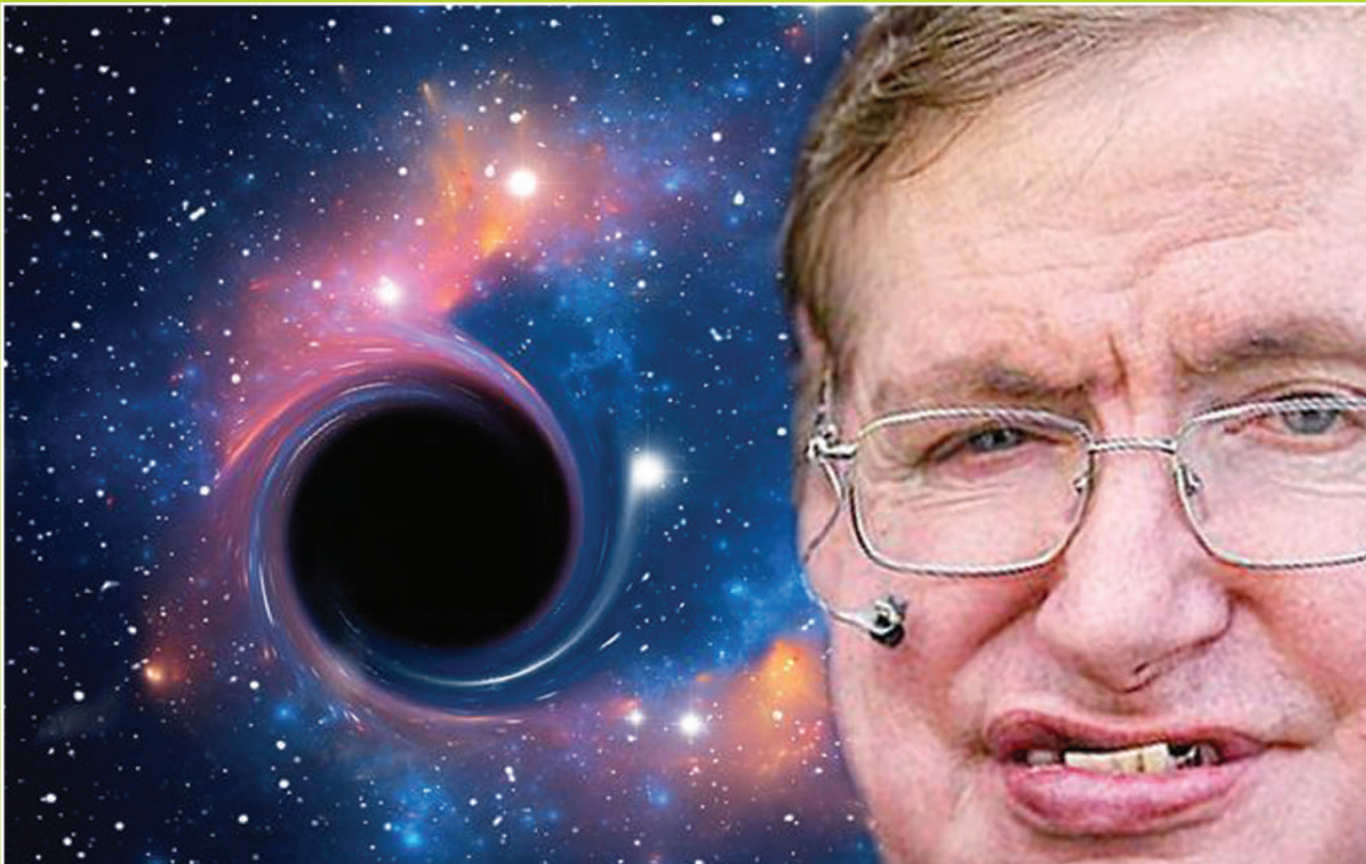
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6. At the end of the article the author should give the references and suggestions for further reading.
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