SCIΣNCΣ
association

PEBBLES
2020

A TRANSIT THROUGH TIME

A TRIBUTE TO

DR. STEPHEN WILLIAM HAWKING

1942 - 2018

"Intelligence is the ability to adapt to change."

DISCLAIMER

TEAM PEBBLES 2020

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MESSAGE FROM THE PRINCIPAL

I hereby take great pride in announcing that, following its legacy, St. Xavier's College Science Association publishes the 12th edition of its Annual Magazine, "Pebbles" – an arena for science enthusiasts all across the country to add to their scientific personality, dissolving all boundaries to learn and grow in close communication with science and its transit through time.

We believe that, in the field of education, every stakeholder is a learner and every day is an active opportunity to learn and discover. "Pebbles", therefore, is a quality endeavor and a beautiful initiative, which does commendable work in promoting and supporting innovation, science and creativity.

I extend my heartiest congratulations to the Deputy President, Dr. Arup Kumar Mitra, for his unparalleled guidance, and to the Pebbles Committee, whose commitment and labour has culminated in this magazine.

I wish all success to Science Association, for "Pebbles", for its annual fest "Sigma" and all its future endeavors.

Rev. Dr. Dominic Savio, S.J.

Rector and Principal,
St. Xavier's College (Autonomous), Kolkata

MESSAGE FROM THE VICE PRINCIPAL

Department of Arts and Science

St. Xavier's College Science Association has constantly striven to encourage students to explore science beyond the classroom. One of the many endeavours undertaken by the association includes 'Pebbles', their Annual Scientific e-Magazine.

I am delighted that this magazine is now in its 12th year of publication, as a collection of original scientific ideas and articles by students from around the country and abroad. This form of scientific expression makes the magazine an excellent platform for showcasing the students' scientific prowess and passion.

The Science Association's annual fest, 'Sigma', further urges students to participate in activities and explore the various fields of Science.

I would like to extend my heartiest congratulations to the Editorial Board, for successfully publishing the magazine and carrying forward its legacy of prodding the unknown and articulating scientific temper.

Prof. Bertram Da' Silva

Vice Principal (Arts and Science),

St. Xavier's College (Autonomous), Kolkata

MESSAGE FROM THE DEAN

Department of Science

The Annual e-Magazine of St. Xavier's College Science Association, 'Pebbles', has given opportunities to several young minds to express their scientific thoughts through articles over a decade since its inception.

The magazine allows students to imbibe knowledge from all branches of science, reinforcing the current-day need for interdisciplinary research.

I applaud the efforts of the members of St. Xavier's College Science Association for continuing to showcase science as the driving force in our lives.

I congratulate the Editorial Board for successfully publishing this e-Magazine!

Dr. Tapati Dutta

Dean of Science,
St. Xavier's College (Autonomous), Kolkata

MESSAGE FROM THE DEPUTY PRESIDENT

St. Xavier's College Science Association

I take immense pride in presenting the latest issue of St. Xavier's College Science Association's Annual e-Magazine, 'Pebbles'.

In this modern age of technological breakthroughs and scientific discoveries, there is an urgent need to encourage and showcase the talents possessed by the young students who are going to step into this huge scientific community and shape our future in the days to come.

As a result, it gives me utmost joy in witnessing how 'Pebbles' is attempting to fulfill this mission by giving these budding scientists a platform to display their passion and a medium to present their ideas.

I am very happy that unlike other years, 'Pebbles' is coming in e-version, a positive step towards conservation of forests.

The magazine becomes a success due to the relentless efforts of our diligent Editorial Board members and the constant encouragement from the Principal, Vice-Principal and the Dean of Science, who have been an indispensable guiding light for this endeavour.

Amitra.

Dr. Arup Kumar Mitra

Deputy President,
St. Xavier's College Science Association

MESSAGE FROM THE VICE DEPUTY PRESIDENT

St. Xavier's College Science Association

The Science Association upholds its name as one of the most reputed societies at St. Xavier's College, Kolkata.

On that note, I would like to extend my heartiest congratulations to the Science Association on publishing the 12th edition of their Annual Scientific e-Magazine 'Pebbles', with ever impressive content for young minds to brainstorm upon.

The magazine continues to pose itself as a brilliant medium that allows students to express their imagination onto a canvas of scientific thoughts brewing in them.

I take immense pride and pleasure in joining hands with the students to create this edition. It has been a delightful experience, working with the students who possess such passion for the subjects involved and have so much to contribute in shaping our future.

I wish the Association all the very best for their upcoming event 'Sigma', and hope to see them thrive and encourage scientific exploration and research in the years to come.

Mr. Rana Biswas

Vice Deputy President,
St. Xavier's College Science Association

"Stay hungry, stay foolish."

- Steve Jobs

These words have kept us motivated for years now. So, back in 2018 when we were given the opportunity to be the leaders of St. Xavier's College Science Association (SXCSA), it was equally thrilling and also kind of nerve racking. It would be exciting for sure, but we never thought that the journey will be this beautiful. Nothing would have been possible without the support and guidance from Rev. Dr. Dominic Savio (S.J.), our Principal, Dr. Arup Kr Mitra, our Deputy President, Mr. Rana Biswas, our Vice-Deputy President. The amazing team- the Core Committee, the Organising Committee, the Event Heads and the Volunteers who have been an integral part of SXCSA and the pillar to success.

 St. Xavier's College Science Association is one of the oldest societies of the college that has been working for the students for years now and our job was to take this forward. We would like to thank the former Secretary, Ms. Henna Palta and Asst. Secretary, Mr. Rittik Bose for trusting us. Our Committee of 2018 - 2019 has always worked as a team, giving their best. The aim has always been to create a community within the college, focusing on science and technology- a forum for students to share their ideas, a space where everyone can and are

willing to learn from each other. To foster this very thought we conducted programmes like Google India MLCC in 2018, which introduced students to the field of Machine Learning, regularly updating the students on significant dates in the field of science, hosting interesting seminars, and sending students to various science and innovation exhibitions where they can showcase their ideas on a bigger platform. Throughout we have tried to take various initiatives- failed in a few, succeeded in many- but the main aim was to create a community where students would be benefited.. "Sigma 2019", whose theme was "A Myriad Of Minds", has been an end-of-tenure celebration for us with the best of minds coming together and joining us for a two-day long science fest. Everything cannot be summed up in one single message, every effort cannot be framed in words. We thank the college authorities, who have been an absolute support in the smooth conduct of all the events. Somebody who has always supported the Association and never refused to any proposal is Arup Sir. We thank Sir for backing the Team in our one-year journey. We have learned a lot as being the leaders for SXCSA.

Lastly, every community needs support from its members and we would like to thank everyone who has been a part and has supported us throughout. We hope this support will continue and will increase in the coming years. Best wishes to the upcoming Committees to keep up the good work, and most importantly work for the students so that they can take something back from SXCSA and take the Society, and thus, St. Xavier's College, Kolkata, to newer heights.

Mr. Avijit Chakraborty
Secretary (2018-2019),
St. Xavier's College Science Association

Ms. Aryaa Dattamunsi
Assistant Secretary (2018-2019),
St. Xavier's College Science Association

'Always question, always wonder.'

It is often said that answers lie with those who have the courage to ask. It is precisely with this outlook towards life that a group of science enthusiasts started the journal of Science Association – Pebbles, a conflation of recent scientific developments, infused with a simple, yet earnest approach of generating awareness about the same, within the readers. Science is not only about facts and figures. Science is about innovation, it is about the power to imagine and hence, create. Keeping this in mind, the approach has been to avoid the toning down of articles by the black and white representation of facts, but instead, add vibrant strokes of the authors' own opinion and imagination to the canvas, thus, making it unique and original.

We would also like to take this opportunity to thank our dynamic core committee without whose hard work and support, this publication would have been a difficult milestone to reach. We also thank the zealous members of our editorial committee, led by Ms. Arunima Bhattacharya and Mr. Anweshan Mukherjee who have worked tirelessly to put this e – journal together, page by page. Finally, our heartfelt gratitude to the many members of our association who have been scientists, in the truest sense of the word, delving deep into the many mysteries of science, attempting to provide solutions for pressing issues of the day using

novel methods and technology and above all, channelizing their passion towards the correct exploitation of science.

The contents of this e – journal are not mere articles, but the embodiment of the passions, creative expression and outlook of an entire generation of budding scientists who are sure to revolutionize the world, with their work, in the years to come. Every person who has contributed an article to this e – journal has already advanced on his or her journey to make the world a better place than it is now. The selection process has been exceptionally trying; every article in it being worthy of publication. However, the few articles that have featured in this e – journal are those, whose words have left a profound imprint on our minds and hence, have carved a special niche for themselves. Yet it is you, the reader, who reserves the right to judge our creation, so allow us to leave that part of this publication to you. We wish all our readers some of their most pleasurable hours, as they browse through our creation. Happy Reading!

Mr. Nabhonil Chatterji
Secretary (2019-2020),
St. Xavier's College Science Association

Ms. Sneha Das
Assistant Secretary (2019-2020),
St. Xavier's College Science Association

MESSAGE FROM THE EDITOR'S DESK

The most precious knowledge the Xaverian life has gifted us is to remain focused and perform each and every work with passion. Pebbles 2020 is one such passion which has been made possible with sheer hard work of the Editorial Board under the unconditional guidance and support of the Deputy President of St. Xavier's College Science Association, Dr. Arup Kumar Mitra and the Vice Deputy President, Mr. Rana Biswas.

"A Transit through Time" stands for the element of human progress and achievement, the continuous process without which the human race and the world we live in would not be as advanced and connected throughout.

This e-Magazine consists of how Science has developed and made our lives easier over the ages, described meticulously in the form of articles, crosswords, doodles, paintings and photographs. Through Pebbles 2020, the Editorial Board pays tribute to Dr. Stephen William Hawking, the person who gave us an insight on almost every aspect of Science in the coming ages, from the Origin of Black Holes to the Era of Superhumans, opening an array of possibilities for research and development in Science and Technology over the years to come.

We would like to thank Mr. Nabhonil Chatterji, Secretary, St. Xavier's College Science Association; Ms. Sneha Das, Assistant Secretary, St. Xavier's College Science Association; and,

Ms. Poulomi Mukherjee and Mr. Kobid Deb Roy, Core Committee Members, St. Xavier's College Science Association for their persistent support.

Our biggest and most heartfelt thanks goes to each and every member of the Editorial Board and the Chief Designer, Mr. Spandan Mazumder for their immense hard work and tireless effort in making Pebbles 2020 a success.

Arunima Bhattacharya

Ms. Arunima Bhattacharya
Editor-in-Chief,
Pebbles 2020

Mr. Anweshan Mukherjee
Associate Editor-in-Chief,
Pebbles 2020

ABOUT SXCSA AND SIGMA

"A function to each organ, and each organ to its own function, is the law of all organization."

— Herbert Spencer

Science is not only about facts and figures. Science is about innovation, it is about the power to imagine and hence, create.

The idea of St. Xavier's College Science Association is to bring together a group of scientific minds from various fields, so that the unified mind can bring about wonders.

All throughout the year, the Association conducts programmes across different fields of Science, ranging from Machine Learning Crash Course to seminars on Actuarial Sciences.

The Association has also actively encouraged research activities and blogging, and has commemorated scientific discoveries and great scientists by way of the same.

On the 11th and 12 of February, 2019; the Science Association organised its annual fest SIGMA, with the focal theme being "A Myriad of Minds". As all departments of science converged together, to collaborate and conduct a variety of events ranging across all disciplines, be it, technology, biological sciences or pure sciences, the theme did indeed seem befitting.

The fest hosted 15 events participated by students all through West Bengal. SIGMA has broken barriers and has given the opportunity to reach beyond textbooks, not only to students from the departments of Science, but also to students belonging to other disciplines of the college.

While general events included treasure hunt, debate and quiz; events requiring specialisation in a particular field included an intriguing integration battle and coding.

Sigma 2019 served as a platform for manifestation of the scientific aptitude of the students of this city, while indulging in healthy competition and other festivities.

COVER STORY

"Who controls the past controls the future. Who controls the present controls the past."

— George Orwell, 1984

Time, through the indefinite continued progress of existence and events in the past, present, and future, is the fundamental that took life evolving from single cells to complex multicellular organisms, and the Earth, from a burning ball of lava to a life-sustaining biosphere. Such is the transition of science through time, that it transformed time from an unexplained entity to just one element of four-dimensional space-time. Time evolved from Descartes to Einstein and with time, science evolved. Existence evolved. This brings us to one of the most magnificent phenomena in the history of Earth - Evolution.

What is evolution? It is easy to say that it is the change in the heritable characteristics of biological populations over successive generations but simplifying it would be putting the entire phenomenon to shame. Evolution has made us believe that each and every different species of organisms have originated from one single cell. Hence, in a way, all of us are related – from the highly intelligent apes to the smallest of microorganisms. We differ from one another because of variations in our genetic material but the proof of homology is overwhelming. To the many years that have gone into understanding and establishing evolution, it is safe to say that it just might be the greatest show on Earth!

As human beings evolved from Homo Habilis through Homo Erectus, and Homo Heidelbergensis to the modern-day humans - Homo Sapiens - they underwent active encephalization and subsequently, significant growth in the size of their brains. They learned to control fire, grow their own food, invented wheels, and learned the use of language to express themselves.

We say that today, civilisation stands at the peak of scientific and technological progress, but we don't really know what the future has for us. All we can do is to feel the exponential growth and keep attempting to quench our thirst for knowledge and information.

In this beautiful reality, human beings began their journey towards achieving great heights by learning how to count. Counting led to numbers, which led to operations on numbers, which led to the creation of Mathematics. Mathematics is everywhere. It is the cradle of all creations without which the world cannot move a single step. Everyone has the simple yet beautiful complexities of Mathematics ingrained in their day-to-day lives.

Mathematics led to the invention of everything. This is because, it does not change with the area where it is used. An equation stands true on the Earth, Saturn, and even if the Sun goes down.

As scientists engulfed themselves in the study of Mathematics, it led to the invention of the modern-day Computers. Fundamentally conceived as a storage and organisational solution to the huge amount of information handled completely manually, computers have evolved and advanced to become an indispensable part of modern-day human life. What was initially devised for storing bytes of textual and numeric data can now be used to work in place of human beings themselves. The modes and principles remain the same – storing and processing data. Not only has the hardware aspect undergone immense sophistication but programming languages have also evolved from machine level languages to user friendly ones.

As the amount of data in the world increased, the need for efficient algorithms for maintaining them increased – which gave birth to the study of Analysis of Algorithms and Statistics. The various algorithms paved the way for invention of every device that we see which uses Real-Time data. Today, statistical methods and the algorithms on which they are based are

applied in almost all fields that has decision making as one of its major tasks. Modern day computers have made it possible to make models involving large-scale statistical computations which would have been impractical and error-prone to perform manually.

The data bloom resulted in many Application software to be developed, which would analyse data given to it as input. But, as processing with Real-Time data started to be used on a larger scale for greater accuracy, the data sets became too large and complex to be analysed by traditional data-processing application software. This gave birth to the study of algorithms for handling such big data sets, known as Big data.

As research developed, scientists realized that applications such as email filtering and Computer Vision could not depend just upon the conventional algorithms for effective performance, since they change with respect to the given scenario. The only way that these could be efficient and accurate was by figuring out the patterns in previously used data. This study of algorithms and statistics used by computer systems to perform a specific task without using any explicit instructions and just relying on patterns in the previously used data (known as 'training data') is known as Machine Learning.

Human beings have always been on the quest of making their lives easier. Thus, the idea of letting machines do most of the work for us did not take very long to turn into reality. Various Artificial Intelligence algorithms began to be incorporated into computer systems to make them Intelligent Systems; use of robots – the science of Robotics; inter-relating all the devices around us to be able to transfer data among themselves over a network without requiring any human interaction – the Internet of Things, all these have combined to make our lives easier than ever. And so, we kept yearning for more information, more data.

We started gathering information not only from the planet we live in, but also from beyond. Humans, in their unending curiosity for unveiling the mysteries of space and time, started reaching into outer space, looking for answers and explanations. This led to the invention of a revolutionary machine that has, as of yet, seen as far as 10-15 billion light years away into space. This endeavour changed the way humans have historically viewed the universe and paved its way towards a thorough and detailed research in the field. This machine is the Hubble Space Telescope.

Atlas Robot: a humanoid robot designed to aid emergency services in search and rescue operations

To observe the stars and to attempt to decipher meaning from them is an act as old as civilisations. We have come a long way from the belief that celestial bodies are manifestations of the divine and that the Milky Way is the only galaxy in existence. In the age of the Renaissance, when Copernicus proposed a mathematical model proving heliocentrism and Galileo used his telescope to further prove that the

The Hubble Space Telescope in orbit as seen from the departing Space Shuttle Atlantis, flying Servicing Mission 4 (STS-125), the fifth and final Hubble mission

earth was not the centre of the Universe, these were radical ideas. Despite the immense backlash from The Catholic Church, science prevailed over unfounded beliefs, thus opening the door to Kepler and Newton's work explaining space phenomena through laws of motion, the

earth was not the centre of the Universe, these were radical ideas. Despite the immense back-lash from The Catholic Church, science prevailed over unfounded beliefs, thus opening the door to Kepler and Newton's work explaining space phenomena through laws of motion, the discovery of spectral lines and years of ground-breaking research and inventions. Scientists and inventors became fearless of religion, putting forth one ground-breaking hypotheses after another, many of which still remain unproven yet undisputed.

One such unproven hypothesis, is the concept of 'Time Travel'. No practical experiments or theoretical explanations have been attempted to describe this paradoxical concept. However, the idea is definitely intriguing.

Across the ages, physicists have tried to delve deep into the concept of passage of time. Some physicists argue that time is like a flowing river, slow at some places and faster at others. This corresponds to Einstein's theory of general relativity which explained the relativistic nature of passage of time due to the distortion of the neighbouring space-time fabric by massive ob-jects, better known as gravitational time dilation. Scientists have used distortions in space-time to think of possible ways time machines could work. Some like the idea of "worm-holes", also known as Einstein-Rosen bridges, which may be shortcuts through space-time. The idea of meeting one's past self may sound intriguing but certain paradoxes arise which make us question its unimaginable effects. One such is the consistency paradox or grandfa-ther paradox, which occurs when the past is changed in any way, thus creating a contradic-tion. This paradox suggests that, if one were ever to go back in time and kill one's grandfather in his childhood, it would result in the time traveller's parents, and ergo the time traveller,

not being born. If the time traveller weren't born, then he never went back in time to kill his grandfather in the first place. Therefore, he lives to offspring the time traveller's parents, and therefore the time traveller. There is, thus, no predicted outcome to this.

The concept of time travel will become more comprehensible as science and technology advances. As the layers of mystery surrounding the passage of time unravel "over time", these paradoxes may be resolved by propositions and hypotheses, and perhaps, someday, time would also be just another physical entity, at our disposal.

Diagrammatic representation of a Wormhole

The idea of travelling through time might sound ridiculously unscientific, but we can never predict that it is impossible, for we have borne witness to such explanations and inventions which were heretofore unthinkable. Certain fields of science were such that we had no means back then to explain the theoretical 'hunches' and hypotheses of the inventors of that time. One field which required tremendous labour and time, and advanced apparatus to work with, was Chemistry, also called "the study of change". It was extremely difficult to study in its primitive forms due to lack of means. Slowly, scientists, after conducting laborious experiments over centuries, discovered the true nature of matter, formed the periodic table by classifying elements, discovered the gas laws and the fundamental laws of thermodynamics. We

have come from a time when Kekule helped ascertain the true structure of benzene to now, when molecular quantum mechanics helps us understand the true picture inside an atom and to knowing how a protein folds.

We have come a long way and time has been in our favour. However, like every other thing, scientific and technological progress, too, has unforgiving effects on the world.

If economic prosperity and time could be personified, then their relationship would have been the most dynamic yet perplexing one. As the global civilization grows over time booming science, technology is being used for higher economic growth, often without acknowledging the social costs of those changes. As a result, the society faces a trade-off between climate change and better economic growth. But with the global and technological expansion, we should make the optimum choice for the world. This optimal choice should be made between usage of the same technology for both economic growth as well as for saving the world. So, it's high time to let our choice go through metamorphosis with an aim to balance the cost of using technology and economic development over time. It is, indeed, to be noted that hundreds of tech-companies all over the world have started paying heed to the ecological effects of their products and inventions and have taken steps accordingly.

Therefore, science and its transit through time will only get better as we move forward into new eras of inventions and discoveries. Internet has enabled scientific research to be publicized more rapidly than ever before. Journals and articles are often made available online even before they are printed. This unrestricted distribution of information can speed the pace of scientific progress, since the latest findings can be inspected, referred to, and/or built upon with very little lag time. With easy communication over the internet, many more scientists can provide feedback on a particular article, thus facilitating collective research.

With the progress of science, unknown got relatively known and new errors replaced existing errors. Today mankind holds his ground firm, looks out towards the horizon where science meets human, embraces the blazing light of knowledge and yet yearns for more. What lies ahead of us is an endless stretch of possibilities waiting to be explored.

Human beings, through evolution, inventions, discoveries, failed attempts, miraculous revelations and lucky errors have come a long way, steadily treading the path of Science and Reason. We can only hope that this magnificent chronicle of our Transit Through Time will lead us into a world of reason, logic, progress and perfection.

A TRIBUTE TO DR. STEPHEN WILLIAM HAWKING

(1942 - 2018)

A TRIBUTE TO DR. STEPHEN WILLIAM HAWKING

$$T = \frac{\hbar c^3}{8\pi GMk}$$

This simple equation holds answers involving one of the deepest mysteries of the Universe, the Black Hole. Aptly enough, it lies engraved on its creator's epitaph, housed quietly between the graves of Sir Albert Einstein and Charles Darwin, in the tomb of one of the most revolutionary Scientists of the 20th century, Sir Stephen William Hawking.

Strapped in his automated wheelchair with tracheal pipes and wires running through his body, this man's mind went further into outer space than any other man had been. He could

see the Universe in a way that nobody had ever perceived before, and hence, his contributions to the world of theoretical physics has carried us decades ahead of our time.

Born on 8 January 1942 in Oxford, to Frank and Isobel Eileen Hawking, Stephen William Hawking has always had a somewhat eccentric upbringing. Both his parents were academically brilliant and attended the University of Oxford, where Frank studied Medicine and Isobel studied Philosophy, Politics and Economics. Quite naturally, the family placed a high value on education. They lived a frugal life in a large yet disorderly house where each member remained engrossed in their books at all times.

Hawking attended one public school and two private schools, and passed his eleven-plus a year early. Due to lack of financial means, he could not attend the prestigious Westminster school, and hence remained at his previous school, St. Alban's. He was regarded as "Einstein" by his friends, although he did not show signs of academic brilliance in his early school days. However, he gradually developed tremendous aptitude in science, decided to study Mathematics in college, but settled for Physics in the Oxford University. At the age of 17, in October 1959, Hawking started his University education, which was later followed by graduate study in Cosmology at Trinity College, Cambridge, in October 1962. While in University, Hawking transformed from an aloof 17-year old undergraduate to a popular, witty and confident boy who took interest in sports and the fine arts. He proved to be a prodigy in rowing and was often heard appreciating classical music. He was starting to appreciate and enjoy his life as a University student when in 1963, in the second year of his graduate study, he was diagnosed with a slow-progressing neurodegenerative disease, ALS (Amyotrophic Lateral Sclerosis). He had difficulty walking, his speech became unintelligible and doctors gave him a life expectancy of two years. Hawking immediately fell into depression. It was at

this time that his Graduate supervisor, Dennis William Sciama, one of the founders of modern cosmology, dedicated his time and efforts into bringing Hawking back on his feet. With Sciama's efforts and encouragement, he started working again.

Hawking, back on track, started to develop a reputation for his arrogance and brashness. He went about publicly challenging the theories of leading cosmologists and physicists. During 1965, he wrote his first thesis on spacetime singularity in the centre of black holes, which was approved in 1966. Following his thesis, he was awarded a research fellowship at Gonville and Caius College, Cambridge. He completed his PhD in applied mathematics and theoretical physics, with specialisation in general relativity and cosmology. His essay "Singularities and the Geometry of Space-Time" won him that year's prestigious Adams Prize, thus paving the way for his scientific career which would eventually lead him into becoming one of the greatest theoretical physicists of his time.

He co-authored essays and papers on singularity theorems, physical cosmology, quantum gravity, gravitational physics and quantum physics with his colleagues and supervisors, winning awards and fellowships from the world's leading universities and institutions. He delved into an extensive study and research on Black Holes and its properties. In 1970, he proposed the four laws of Black Hole mechanics, drawing an analogy with thermodynamics. In 1971, he won the Gravity Research Foundation for his essay "Black Holes". In 1973, he published his first book, 'The Large-Scale Structure of Space-Time' which he co-authored with George Ellis, a British theoretical physicist. In his thesis, in 1974, he claimed that black holes emit radiation, later known as Hawking radiation, which continue until they exhaust their energy and evaporate. Consequently, Hawking was elected a Fellow of the Royal Society (FRS) in 1974 and was the youngest scientist to bag a Fellowship at that time. By the

end of the decade, his discovery was widely recognised as one of the most significant break-throughs in theoretical physics.

Throughout his career, Hawking had dedicated a considerable amount of his time towards professorship. He had been a lecturer and a professor in several esteemed Universities throughout England and the USA, including the California Institute of Technology (or, CalTech) and the University of Cambridge, where he was the Lucasian Professor of Mathematics. In his lifetime, he supervised 39 successful PhD students. He received immense academic recognition for his revolutionary works in the field of theoretical physics, including the Adams Prize, the Eddington Medal, the Pius XI Gold Medal, the Dannie Heineman Prize, the Maxwell prize, the Franklin Medal, the Hughes medal, the Albert-Einstein Medal and the Presidential Medal of Freedom. He received honorary doctorates from the University of Oxford and from the Imperial College, London in 1978 and 2017 respectively.

Hawking was always known for his decisive opinions and his unique perception of Science. He identified as an atheist and his views on the existence of God had always been extremely intriguing:

"If we discover a complete theory, it would be the ultimate triumph of human reason – for then we should know the mind of God."

In his book, 'A Brief History of Time', he suggested that the existence of God was not necessary to explain the origin of the Universe. He firmly believed that there is no God, since there is no Science to prove the existence of God. He would say that the concepts of afterlife and of God being the creator of the Universe were unaccounted for and unproven. In his opinion, "the Universe is governed by the laws of Science".

Towards the end of the 1990s, Hawking started dedicating a lot of his time towards writing

and publishing books. His awards and medals, though prestigious, did not benefit him financially and he decided to write scientifically relevant books for a wider audience. To his annoyance, his scientifically precise and factual language had to be cut short and simplified for the sake of universal approach. However, the results were overwhelming. His books, 'The Universe in a Nutshell', 'A Briefer History of Time', and 'God Created the Universe', gained immense popularity and were widely appreciated. His first book for the common audience, 'A Brief History of Time' created a huge impact on his readers. It became a bestseller, selling more than 10 million copies in 20 years, and was on the London Sunday Times bestseller for more than five years. The book was translated into 35 different languages by the end of 2001. After a lifetime of ground-breaking discoveries, countless mistakes and still more achievements, defiance against a fatal illness and unapologetic candour, Stephen William Hawking died on 14 March, 2018 at his home in Cambridge, at the age of 76. Rightly called, *'The Master of the Universe'*, this man went closest to understanding time and space than any human had ever been. He was ahead of his time, as many would rightly believe, and he was not afraid to ask questions. He would question the fate of humanity and the meaning of life. Throughout his time on Earth, he actively endorsed scientific progress and refused to believe that the fates of human beings are controlled by a superior being. Instead, he often spoke about the emergence of a new race of 'superhumans' in future, who would be able to design their own evolution.

Stephen Hawking defied time despite his illness and lived with it for more than 50 years, after having a life expectancy of two years at the time of diagnosis. He was more than just another theoretical physicist. He was an educationist, a realist, and a futurist. His defiance against failure made him one of the greatest humans to tread on Earth.

THE PROFESSORS' COLUMN

THE INVISIBLE WORLD OF MICROBES: OUR FRIENDS AND FOES

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We cannot see them, hear them or feel them, they are intangible, but always with us. Micro-organisms, the oldest forms of life on Earth, are invisible but an indispensable part of the human body and the environment. They have diverse roles, some of them are our friends and some are foes. This world of microbes was serendipitously discovered by Antony Van Leeuwenhoek in the late 17th century. However, with the dawn of 19th century, microbes became synonymous to disease, when cholera, tuberculosis and leprosy causing bacteria were discovered in a quick succession. Microbes were looked down upon as villains, which needed to be destroyed before they destroyed us (Fig 1).

If we imagine a scenario, where an antimicrobial wand was to be waved resulting in the complete elimination of all the microbes comprising of bacteria, fungi, viruses and others from the world, there would be an immediate jubilation over conquest of the innumerable microbial illnesses like malaria, dengue, athlete's foot and so many others. But this euphoria would be very

Fig 1. Microbes: Our foes

short-lived. A microbe free world would be disease free yet calamitous. There would be a myriad of environmental impacts.

The consequences of a world devoid of microbes would be as follows:

1) The recycling of biogeochemical wastes would come to a standstill resulting in an accumulation of human and animal wastes.

2)Ruminants (like cows, goats, sheep) would be unable to derive the benefit of a cellulose-rich diet

3)Plants would be left without their biological nitrogen fixing partners

4)Humans would be unable to obtain essential microbial vitamins and amino acids (Fig 2)
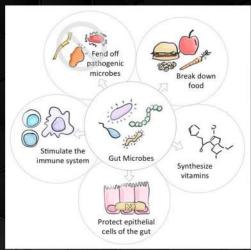

Fig 2. Gut microbes: Our friends

Microbes have a pivotal role to play in governing the existence of all the life forms including plants, animals and human beings. In their absence, life would eventually get extinguished.

"Life would not long remain possible in the absence of microbes."—**Louis Pasteur**

PROSTATE CANCER

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Prostate is a small walnut-shaped gland in men which produces the seminal fluid that helps to nourish and transport sperm. The cancer which occurs in the prostate gland is known as prostate cancer (PCa). PCa is the most commonly diagnosed solid organ non-skin cancer in males and the sixth leading cause of cancer death among men worldwide. In India, the 5-year survival rate for PCa is 64% and this is one among the top ten leading cancer sites in India. The life time risk of a diagnosis of PCa is 15.9 % while the life time risk of death is 2.8 %. In 2015, PCa was the cancer with the highest incidence for men in 103 countries or territories.

Many risk factors including endogenous (age, ethnicity, hormones, family history, oxidative stress) and exogenous factors (diet, environmental agents, lifestyle) have been attributed to PCa. In males of African ancestry, the incidence of PCa is highest among all populations. However, racial disparity may be subsequent to healthcare access dissimilarity, delay in seeking medical attention and follow-up, and variations in allelic frequencies of microsatellites at the androgen receptor (AR) locus.

Molecular genetics has also proved to be an invaluable tool in the understanding of PCa. Differentiating between aggressive and non-aggressive PCa is required for effective intervention in the treatment of PCa. Patients at high risk will be promptly identified and treated appropriately. The many prediction tools of PCa survival which are being utilized currently have limitations. They are all generally poor prognosticators. Genetic susceptibility studies as well

as gene expression panels can provide additional tools for the status of PCa progression

The indolent course of many tumors and the potential for adverse treatment effects have generated controversy regarding the utility of screening and early detection. Common treatments include radical prostatectomy (RP), active surveillance, radiotherapy, and androgen-deprivation therapy (ADT). Radical prostatectomy and radiation are effective treatments for men with more significant cancer, such as those with a PSA level greater than 10 ng/mL and those with nodules palpable on digital rectal examination. Although these two options are widely used to cure the majority of patients, approximately 30-40% of patients will relapse.

Androgen receptor (AR) is a nuclear transcription factor, which plays important role in signal transmission. Androgen signaling through AR plays an overriding role in epithelial cell proliferation and differentiation of the epididymis, prostate, and other male traits. Dysfunction of AR signaling is well-established to be a central problem in prostate carcinogenesis. The inhibition of AR activity through mechanisms in addition to androgen ablation, such as modulation of signal transduction pathways, may delay PCa progression.

Most of the PCa begin in an androgen-dependent state and ADT results in improved clinical outcomes. Unfortunately, some cancerous cells develop resistance during course of time resulting in androgen-independent PCa. Each year, an estimated 25,000 men will find out their prostate cancer has changed enough to become resistant to standard androgen-deprivation therapy, also called hormone therapy.I n this particular condition, several mechanisms enhancing AR signal transduction pathways, such as, amplifications or mutation of AR genes, alteration of AR co-regulatory proteins take place. Any of these changes can lead to PCa cells to gain androgen-independent properties. Androgen-independent type of PCa is found to me more aggressive, metastatic, and lethal by nature.

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LIFELONG LEARNING
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Lifelong learning is a continuous, self motivating way of knowledge acquisition for development at both professional and personal end. Even though we frequently associate formal education at academics (school, college, university etc.) with learning, but modern day learning needs are much more than good education. So learning is all about reaching one's full potential, achieving self-actualization and is the continuous process to succeed in the competitive world.

In this article, author has tried to summarize some skill which students should acquire in the current day scenario to succeed and sustain(Figure 1). These skills are broadly divided into three categories as follows -

A. Character Qualities - These qualities help to face the changing environment

B. Foundational Literacies - These core skills are applied to everyday tasks

C. Competencies - These expertise approaches helps to face complex challenges

as gene expression panels can provide additional tools for the status of PCa progression

Character Qualities	Foundational Literacies	Competencies
Curiosity	Literacy	Problem Solving
Initiative	Numeracy	Creativity
Persistence	Scientific Literacy	Communication
Leadership	ICT (Information and Communication Technology) Literacy	Collaboration
Adaptability	Financial Literacy	
Social and Cultural Awareness	Cultural and Civic Literacy	

From figure 1 it is clear that pillar/ column 2 (Foundational Literacies) can be acquired to an extend from academic institutions, while skills under other two pillars are acquired by getting exposed to more and more challenges and by self determination and motivation. Hence mastering lifelong learning skills helps work and live better in this changing world.

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CRISPR/Cas9 TECHNOLOGY: APPLICATIONS AND FUTURE PROSPECTS IN CROP IMPROVEMENT

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The most critical challenge faced by human race in the present scenario is to ensure food security for the rapidly growing human population, which is projected to reach approximately nine billion by 2050, requiring crop productivity to increase by 60–100%. The food crises are being aggravated by several factors like reduction in agricultural land area and frequent occurrence of environmental stresses, in addition to increasing population. Conventional breeding approaches are mostly time-consuming and lead to the transfer of undesirable characteristics via crossing. Genetic manipulation techniques using physical, chemical and biological (T-DNA insertion/transposon) mutagenesis have played a major role in studying the role of genes and improving the crop species. The integration of single or multiple alien genes within the target species through transgenic approaches also gained a lot of momentum for crop improvement since the last three decades. However, such integration of transgenes is non-specific, sometimes unstable and is a matter of public concern when it comes to edible crop species, which has practically delayed the commercial release of genetically-modified crops in the market. The latest wave of innovations in plant breeding has emerged from site-directed genetic modification techniques, based on the activity of Site-Directed Nucleases (SDNs) such as Zinc Finger Nucleases (ZFNs), Transcription Activator-Like Effector Nu-

cleave (TALENs) and Clustered Regularly Interspaced Short Palindromic Repeats (CRIS-PR)/CRISPR-associated (Cas). The discovery of CRISPR/Cas9 gene editing system has revolutionized research in plant science. In contrast to the transgenic approach, which leads to random insertions and very often unpredictable phenotypes, such genome editing methods produce defined mutants, thus becoming a potent tool in functional genomics and crop breeding. Genome edited crops have an additional advantage over transgenic plants, since they carry their edited DNA for the desired trait. 'CRISPR' actually refers to tandem repeats flanked by non-repetitive DNA stretches, found to be homologous with foreign DNA sequences derived from plasmids and phages. The CRISPR cleavage methodology requires (i) a short synthetic guide RNA (gRNA) sequence of 20 nucleotides, complementary to the DNA stretch within the target gene, which therefore binds to the target DNA, and (ii) Cas9 nuclease enzyme that cleaves 3–4 bases after the protospacer adjacent motif (PAM). Cas9 nuclease creates a double-strand break at the target DNA sequence, which becomes modified during DNA repair through the Non-Homologous End Joining (NHEJ) or Homologous Recombination (HR) pathway. The Cas9 nuclease is composed of two domains, (a) RuvC (an endonuclease domain named for an Escherichia coli protein involved in DNA repair)-like domains and (b) a HNH domain (an endonuclease domain named for characteristic histidine and asparagine residues), with each domain cutting one DNA strand. In order to implement a CRISPR project, it is necessary to (i) identify the PAM sequence in the target gene, (ii) synthesize a single gRNA (sgRNA), (iii) clone the sgRNA into a suitable binary vector, (iv) introduce within host species/cell lines, and (v) screen and validate the edited lines. Although most genome editing has been applied to Arabidopsis, tobacco and rice, other crop species can also be targeted using this technology.

One of the promising strategies for crop improvement involves elimination of negative elements or undesirable genes via knock-out mechanism which includes the most common application of CRISPR/Cas9. Using this technology, several plant traits have been improved like quality, yield, and abiotic or biotic stress tolerance. Rice variety with more enhanced aroma content has been generated via TALEN-targeted disruption of OsBADH2 that increased the content of 2-acetyl-1-pyrroline, the primary fragrant compound in aromatic rice. Rice with low amylose content, and hence improved eating and cooking quality, has been generated by knockout of Waxy. The shelf-life of tomato has been increased by editing a T317A replacement into the ALC gene. Several negative regulators affect the yield-determining factors like grain size (OsGS3), grain number (OsGn1a), grain weight (TaGW2, OsGW5, OsGLW2, TaGASR7), panicle size (OsDEP1, TaDEP1) and tiller number (OsAAP3). Grain weight in rice has been increased by simultaneous knockout of three grain weight–related genes (GW2, GW5, and TGW6). Even plant architecture can be changed via this technology, e.g., knock out of the gene CAROTENOID CLEAVAGE DIOXYGENASE 7 (CCD7), controlling a critical step in strigolactone biosynthesis, generates rice plants with ideal phenotypes like high-tillering and dwarf habit. Recessive homozygotes of maize for the dominant gene, LIGULELESS1 (LG1), produce upright leaf architecture that can capture more light and grow at higher field densities than maize with conventional leaf structure. Using CRISPR/-Cas 9 system, flowering time can be regulated by modifying flowering genes and their interactions. Mutation of flowering genes like FLOWER LOCUS T (FT) and SELFPRUNING 5G (SP5G) has been used to change the flowering time of soybean and tomato. Thermosensitive male-sterile tm5 lines in rice and maize, as well as photosensitive genic male-sterile csa rice and ms45 wheat have been produced. Knockout of genes like OsARM1, OsNramp5, and

OsHAK1 has enabled development of rice accumulating low levels of cadmium, radioactive cesium and arsenic respectively. The ARGOS8 (that encodes a negative regulator of ethylene response) expression has been enhanced by substituting or knocking in the GOS2 promoter in place of the native ARGOS8 promoter via Homology-Directed Repair (HDR) that is known to improve drought tolerance in maize with increased yield. Triple knockout of Ospyl1/4/6 (OsPYL being the abscisic acid receptor gene family) could visibly improve grain yield under high temperature stress. With respect to pathogen resistance, CRISPR/Cas9 technology has also shown desirable results. Rice plants resistant to blast disease caused by Pyricularia oryzae has been generated via knockout of OsERF922, an ethylene responsive factor gene. Deletion of the OsSWEET13 promoter can generate rice plants resistant to bacterial blight caused by Xanthomonas oryzae pv. oryzae. Serotonin biosynthesis can be blocked in plants by disrupting OsCYP71A1, leading to increased level of salicylic acid conferring plant resistance to insects like stem borers. Many other plant traits have also been improved through genome editing like overcoming self-incompatibility, improved haploid breeding, shortening of growth periods, etc.

The unprecedented capacity of genome editing to generate targeted, sequence-defined, and genome-wide genetic diversity has further prospects in future in plant science. To reduce our dependence on inorganic fertilizers, the CRISPR/Cas system could be used to transfer the genetic elements of the Nod factor signaling pathway from legumes to cereals, allowing the latter to fix atmospheric nitrogen. C4 rice can be generated by fine-tuning the expression of genes involved in C4 photosynthesis, so as to optimize the protein levels, thereby increasing the efficiency of carbon fixation. CRISPR/Cas-enabled mimicry of domestication events in wild or semi domesticated plants could lead to the production of new crops and sources of

diverse germplasm for breeding. Modifications of genes that control seed dormancy (DOG1), oil quality (FAE1 and FAE2), glucosinolate accumulation (HAG1 and GTR2) and oil content (DGAT) would greatly facilitate the development of elite domesticated varieties of pennycress (Thlaspi arvense L.), that has a short growing season, extreme cold tolerance and high productivity of seed oil. In agriculture, CRISPR/Cas-based gene drive could be used to suppress or eliminate invasive species like pests and weeds, alter pathogens and introduce new traits into the existing populations. Pigweed (Amaranthus) could be engineered by gene drive in such way to become susceptible to the widely used herbicide glyphosate.

In 2017, successful CRISPR-mediated genome editing was reported for approximately 20 crop species, pointing to the widespread use of this system for crop improvement. Crop Biotech Update News Archive (http://www.isaaa.org/kc/cropbiotechupdate/default.asp) highlights the recent reports on the use of this technology in crop science. The US Department of Agriculture (USDA) has recently made it clear that they will not interfere with the introduction of new traits in crop species via genome editing and will not impose any stringent regulatory procedures on such crops, as are being followed for the conventional genetically-modified or transgenic crops. This will enable smooth and easy commercial release of such crops with more acceptability/consumption and their ready acceptance to the society. However, prior to that, genes, controlling molecular mechanisms underlying crop development and physiology, need to be identified and sufficiently characterized in order to exploit the immense potentiality of this technology. The efficiently transferring technologies from the bench to the field requires rapid discovery of the genetic bases of the important traits, enhanced efficiency of gene targeting (gene insertion and replacement), effective delivery of CRISPR/Cas reagents to plant cells and subsequent plant regeneration, with or without the

need of the current tissue culture methods which are long and laborious processes. Improving the existing delivery systems and developing new systems will be the key factors in reducing barriers to inexpensive application of gene editing in plants. To expand the range of delivery systems, both Agrobacterium and plant genes could be manipulated to improve Agrobacterium-mediated transformation. The presence of cell wall also makes efficient delivery of genome-editing reagents to plant cells quite challenging. Current delivery systems are therefore limited to specific plant species, genotypes and tissues. Fortunately, fine-tuning the expression of developmental genes such as Baby boom and Wuschel2 has dramatically increased the transformation efficiency of certain monocot crops, increased the range of elite genotypes that can be transformed, and substantially reduced the time required for plant regeneration. Harnessing the concepts of both synthetic as well as systems biology and advances in functional genomics, coupled with the development of genome-editing technology and next-generation sequencing, will enable engineering of advanced crops with highly improved qualities. To conclude, the simplicity, versatility and robustness of CRISPR/Cas systems altogether make multiplex genome editing a potential tool not only in model plants, but also in major crops, enabling precise and efficient base replacement at the target locus, rather than stochastic disruption of the gene.

REVISITING HINDU MYTHOLOGY IN THE LIGHT OF SCIENCE

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Our existing generation may be highly progressive in terms of science and technology, but our Hindu mythology may leave even our scientifically oriented youth awestricken and bewildered. Hindu mythology speaks of flying chariots or vehicles (Vimana), which are nothing but similar to our modern aeroplane. The aircrafts, capable of interplanetary travel and invisibility, but having radar systems and other sensors, existed in mythological era. According to 'Vyamanika Shastra' (Science of Aeronautics) of Maharishi Bharadhwaj, aircrafts of those period were much more advanced than our present generation transport. The epic Ramayana mentions about the famous 'Pushpaka Vimana' of King Ravana, who stole it from Lord Kubera, the God of wealth and it was Lord Rama who returned it back to Kubera. The aircraft was originally made by Lord Vishwakarma for Lord Brahma, the Hindu god of creation. The Sanskrit 'Samarangana Sutradhara' discussed the construction strategy of vimanas. Pushpaka Vimana literally means an aircraft shaped like a flower. Pushpaka Vimana had a special capability of expanding or contracting in size, in accordance with the number of passengers. The special feature of vimana, soaring the skies for long distances is that, If N people sit in the vehicle, there will always be (N+1) seats. Beside this, another well-known aircraft that supposedly belonged to Ravana was 'Dandu Monara' (an aircraft resembling a peacock).

According to the sacred scriptures of the Vedas, Lord Sun, Lord Indra and several other Vedic deities used various modes of transport in the form of flying chariots pulled by animals, such as horses. The 'Agnihotra-vimana' had two engines while the 'Gojo-vimana' had more engines. The legendary Indian epic, the Mahabharata mentions the fact that during the Vana Parva, Arjuna arrived at Amaravati, the city of Indra, through vimanas. The Rig Veda includes references to various modes of transportation. 'Jalayan' was a vehicle designed to operate both in air and water while 'Kaara' used to operate on ground and in water. 'Trichakra Ratha' was a three-wheeled vehicle for operation in the air. 'Tritala' was a vehicle consisting of three stories. 'VaayuRatha' was the wind-powered chariot while 'Vidyut Ratha' was the power-operated vehicle.

The Hindu scriptures enlighten us about the basic concept of modern evolution. Many Hindu texts mention about the cycle of birth or creation and destruction. The concept of 'Dashavatara' of Lord Vishnu can be viewed as having some resemblances to Charles Darwin's theory of evolution. British evolutionary biologist J. B. S. Haldane opined that they are a true chronological depiction of the story of evolution. The first incarnation of Vishnu in the form of a fish (Matsya) resembles the evolutionary origin of fish in the geological time scale called Devonian Period. This is followed by the appearance of Kurma, the aquatic reptile turtle and then Varaha, a mammal. Thereafter came Narasimha, a human-lion hybrid being, followed further by Vamana, the dwarf and then the remaining incarnations were of human. The tenth avatar Kalki is yet to arrive with the goal of annihilation. The science of zoological taxonomy is diverse and vivid. It is interesting to note that the ancient law book of Hindus, 'Manu Smriti' provides the basic scheme of animal classification, based on the presence of hooves, whether being carnivorous or herbivorous, whether living in villages or forests (habitat), etc.

Ramayana mentions about 'Vanaras', an ape-like species possessing human intellect, who existed along with modern human.

Excerpts from the Mahabharata indicates the possibility of application of nuclear weapons being used in war (Brahmastra). There has been recent discovery of green glass and radioactive samples apparently used in the Mahabharata war in certain excavation sites in India. It is to be noted that green glass is produced as sand melts at very high temperatures, common in nuclear explosions. As mentioned in the Mahabharata, the total death toll was around 1.6 billion in only eighteen days. The fact clearly raises the possibility of mass scale annihilation that is only possible with highly powerful weapon like nuclear weapon. The huge amount of destruction found at the site of the famous ancient Indus Valley Civilization city Mohenjo Daro almost corresponds to the devastation of the city of Nagasaki during World War II.

The epic Ramayana speaks of 'Ramasetu', also known as Adam's Bridge, an engineering masterpiece constructed by Lord Rama and his monkey (Vanara) army under the strict guiding principle of Nal and Neel, civil engineers or architects of that era. Studies have found that the time of Ramayana and the carbon dating analysis of the bridge, especially sea beaches near Dhanushkodi and Mannar Island almost coincides and so we may admit that the bridge is the only historical evidence of Ramayana. The advanced technology was used to make stones float on water building the bridge from India to Sri Lanka within only five days. Surprisingly, such floating stones are found scattered across Rameswaram even today.

There have been instances of live telecast during Mahabharata days. Dhritarashtra, the King of Hastinapur, was physically blind, but wanted to obtain live information from the battlefield of Kurukshetra. Lord Krishna gifted Sanjay with a superpower of distant vision called 'Dibyo Drishti' to perceive the live telecast. The narration can even be comparable to a central

computer unit having wireless connections that can accept various commands with cameras in the heaven. The access permission was granted by Lord Krishna, the so-called 'System Administrator' of that time.

Instances of biological cloning can be found in our mythology. There has been revolutionary advance in the field of genetic engineering and cloning has been an integral part of the genetic technology. Biological cloning may refer to cloning of genes, cloning of cells, and cloning of whole individuals. In 'Srimad Bhagavatam' or 'Bhagavata Purana' that depicts the story of Lord Krishna, there was the story of King Nimi. When the king died, the fortune-teller created a new baby 'Janaka' from his dead body through a process of 'Mantha', that may be comparable to human cloning. Since the baby was created via Mantha, he was named 'Mithila' and his subsequent kingdom was also named as Mithila. In Hindu mythology, Raktabija was a buffalo-demon with a blessing that whenever a drop of his blood fell on the ground, a duplicate Raktabija would be born at that spot. Markandeya Purana mentions that Raktabija along with other demons, Shumbha and Nishumbha had a battle with Goddess Parvati or Ambika and was wounded. However, whenever his blood drops fell on the ground, innumerable Raktabija individuals were created. At this point, it was Goddess Kali or Raktheshwari who came to the rescue and licked up each drop of blood pouring from the demon's body. The character of Raktabija may be another instance of human clone. The science of biological cloning was even practised during the Mahabharata days. In Mahabharata, it has been mentioned that Kauravas were hundred sons of Dhritarashtra. Kauravas were created by simple splitting of the single embryo into hundred parts and then growing each part in a separate container. It seems from the description that the concept of In Vitro Fertilization (IVF) or test tube babies as well as efficient embryo transfer technology was highly in practice.

Organ transplants and plastic surgery are wonderful aspects of modern medical science. Head replacement can be the most complicated organ transplant one can imagine. Hindu mythology narrates the story of Lord Ganesha. When Lord Ganesha lost his head, mother Parvati pleaded to Lord Vishnu who flew off in search of a substitute head. He found a sleeping elephant on the bank of a river and severed its head and affixed it on to the body of Lord Ganesha, often referred to as elephant-headed god, thereby rendering a perfect functional head. In modern times, scientists are attempting to regenerate cells in both animals and plants, as part of regenerative biology. We must not forget the instances of Maricha of Ramayana who got himself converted into a beautiful deer, exemplifying a complete transformation. Lord Hanuman was said to have mastered the great eight arts of transformation (Ashta Siddhi), such as, anima, mahima, laghima, garima, etc, whereby he could transform his body to be as large as a mountain, or as tiny as an ant; as heavy as boulder, or as light as a feather. The evolution of this branch of science called Wave Genetics has the capability to give an absolutely new dimension to evolution of life on earth, ignoring the concept that random mutations are the most important driving force behind evolution.

None can contend against the accurate calculation of the distance of our Earth from the Sun. The very two lines of famous 'Hanuman Chalisa' computes such astronomical distance with great simplicity and perfection. It says, "Yug Sahashra Yojan Par Bhanu, Lilyo Taahi Madhur Phal Jaanu" which means Sun (Bhanu) is at a distance of Yug SahashraYojan (distance unit). Lord Hanuman did jump to the Sun (Bhanu), thinking Sun as a sweet fruit (Madhur Phal). According to Hindu Vedic Literature, 1 Yug= 12000; Sahashra= 1000; 1Yojan=8 Miles. Thus 12000 X 1000 X 8 = 96,000,000 miles. 1 mile= 1.6 kms. This means 153,600,000 Km, very close to the current officially declared figure by NASA. Our own 'Gayatri Mantra' discovered

by Saint Viswamitra is considered the most powerful hymn (sloka) in the world. Studies reveal that the hymn produces about 110,000 sound waves per second, that has great positive influence on spiritual and cognitive health of human. The lines of the hymn, "Om Bhoor Bhuvah Swaha, Tat Savitur Varenyaam, Bhargo Devasya Dheemahi, Dhiyo Yo Nah Prachodayaat" means "O Divine mother, our hearts are filled with darkness. Please dispel this darkness and promote illumination within us."

The present scientific tempo must excavate the mythological treasure and the combinatorial knowledge is sure to find out solution to many existing problems in various spheres of science.

THE ARYAN INVASION THEORY

DID THE ARYANS REALLY INVADE INDIA? TRUTH VS. MYTH

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The Harappan Civilization has fuelled our curiosity right from our days in school. Textbooks have taught it to be one of the earliest civilizations, spread over northwestern South Asia from 2600 to 1900 BCE. Archaeological evidences have shown Harappa to be one of the first civilizations with intricate urban planning, detailed drainage systems, proper trading policies and a cosmopolitan outlook with people of different cultures co-existing together in unison.

As every civilization reaches its end following the destined passage of time, so did the Harappan Civilization, broadly known as the Indus Valley Civilization. Archaeologists followed a gradual disappearance of seals, script and distinct jewelry to finally the decline and abandonment of cities. However, the cause behind the civilization getting wiped out has since remained a mystery, with numerous theories having been circulated.

The most common theories that have surfaced include:

- Climatic change – starting from deforestation and overuse of landscape to excess floods
- Shifting and/or drying up of rivers, with special reference to the river Sarasvati
- A probable invasion by Aryans – the Aryan Invasion Theory

And the battle between the last two theories has kept historians and archaeologists divided since time immemorial.

The Aryan Invasion Theory refers to the concept that the Vedic people, referring to those who wrote the Vedic literature, viz. Rigveda, Yajurveda, Samaveda and Atharvaveda, were not indigenous to India, but had invaded the same around 1500 BCE, originating around the Caucasus Mountains. The point of controversy first arises as there has been no historical, textual or archaeological evidence to verify this theory and all that exist are linguistic speculations which date back only to the relatively recent 19th century AD. And many scholars bear the opinion that linguistic evidence is not really enough to confirm the place of origin of the Vedic Aryans.

But then how and why did such a theory come up all of a sudden?

The Revolt of 1857 against the British rule in India had reinstated the fact that the colonial rule could be continued only with the support and collaboration of the Indians in large numbers. The chosen pathway of attempting to turn more natives into supporters of the British rule was via education. The Macaulay's Mission was one such move aiming at introduction of English education in India. The pioneering proponent of this mission was the British politician Thomas Babington Macaulay, who had been serving on the Governor General's Council in India. Now, besides imposing education in English, he also believed in conversion of Hindus to Christians to be instrumental for easier establishment of supremacy in the colony. As such, he is alleged to have aimed at translating and interpreting the Vedic texts in a way that could convince the newly educated Indians that the Bible was superior, and hence recruited the German Vedic scholar, Friedrich Max Muller for the job. Max Muller came up with the Aryan Invasion Theory while translating the Rig Veda and it is believed that the East India Company had further sponsored the development and spread of this theory to meet their political agenda. A few years later, after the unification of Germany in 1871, Muller diplomatically refuted his own theory on the superiority of the Aryans, stating that by Aryan he meant language and not race, and started promoting the eastern spiritual wisdom in Europe. But the damage had already been inflicted upon India by then.

While Muller referred to the linguistic aspect later on, the British used the theory as a weapon to divide the Indian masses by race, pitting the North Indian 'superior' Aryans against the South Indian Dravidians, the high-caste against the low-caste, the Vedic supremacy against indigenous principles, all aiding the British strategy of Divide and Rule.

The objections to the theory started coming up only later with advances in archaeological

evidences, and the discovery of the remains of the Indus Valley Civilization, in the early years of the twentieth century.

Geological and oceanographic studies have revealed that the Harappan civilization had been supported by the lower part of the Sarasvati river, fed by the Sutlej, among others – the change in the course of the Sutlej and its effect on Sarasvati coincided temporally with the disappearance of the civilization, both dating back to approximately 2200 – 1900 BCE. The drying up of the river had led to the people diverging towards different areas of the eastern Gangetic plains to settle in. The date of the Aryan invasion as per the theory stated was 1500 BCE, but then how could one invade a population that has ceased to exist 400 years earlier? But then, where did the Aryans actually come from? Do the initial Vedic scriptures mention them? Or were the Vedas written by the Aryans themselves?

Deciphering the pictographic script on the Indus seals brought but little clarity to the confusion. As David Frawley of the American Institute of Vedic Studies points out, it is a paradox: we have a history about Harappa without a literature, and a literature about the Aryans without history, archaeology and geography.

While historians have had innumerable debates trying to solve this, science has tried its own way out. Genes define every organism and genetic studies have helped us unravel the mystery around this theory slightly:

1. Mitochondrial DNA (mtDNA) and Major Histocompatibility Complex (MHC) genes serve as markers in denoting gene pools of different populations. There has been a distinct lack of similarities in these genes among the gene pools of the Indians and the Europeans.

2. Tissue antigens of the north and south Indians are relatively uniform and completely distinct from the Europeans.

These results from June 2006, pointed to the fact that north and south Indians, in all probability, had the same origin, but the Aryans had probably never invaded Harappa.

One of the most recent publications about this controversy in Cell re-instates the same. In an ambitious project conducted by archaeologists, palaeontologists and scientists, it has been proved genetically that ancient Harappan genome lacked any ancestry with steppe pastoralists or Iranian farmers — a discovery that can perhaps lead to the ultimate dismissal of the Aryan Invasion Theory. The authors managed to extract enough DNA from the pinna from a female skeleton that lived during the Indus Valley Civilisation from Rakhigarhi (Haryana). The Cell paper analysed this DNA.

Figure 1: Archeological Context
(location of Rakhigarhi, Haryana and skeletal remains of the Individual studied)
(Source: Shinde et al. 2019, Cell)

Another analysis by an overlapping team has been published in Science. This paper considers the problem at a macro level, which is probably the largest human paleogenetics study conducted. This project has analysed the genetic data from 523 ancient people across Central and South Asia right up to the European Steppe.

The Impact of Yamnaya Steppe Pastoralists
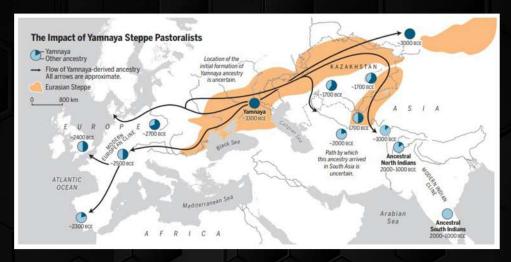
Figure 2: The Bronze Age spread of Steppe pastoralist ancestry into South Asia.

(Source: Narasimhan et al. 2019. Science)

The broad conclusion that we can arrive at this stage is that the Indian subcontinent population has a diverse origin. The constituent races during the Bronze Age were: the ancient ancestral South Indians, Indus Valley population and a significant migration from the Steppe pastoralis. The interbreeding amongst there population is what makes most of the modern Indian population today.

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INQUISCITIVE

BEING INQUISCITIVE

InquiScitive (inquiscitive.wordpress.com) was started by a few students of the Postgraduate Department of Biotechnology, St. Xavier's College, Kolkata in March, 2017. But it grew well beyond the college and people from different parts of India have gradually become active participants.

 InquiScitive believes in writing scientific articles in a way that would be appealing to the masses and would inculcate an interest in science in even people who are not directly related to the scientific field. So , in short, it believes in being 'inquisitive' about science and relating it to our daily lives, and definitely sharing knowledge.

 At InquiScitive, a team of dedicated bloggers earnestly present to you the marvellous aspects of science and technology. Here, beyond the margins of books and the boredom of terminologies, science is portrayed as the most intriguing and attractive field to venture. The aim of this blog is to spread scientific awareness,explore the scientific mysteries and expose myths and fads which continue to confuse the people at large. As for making the blog better, a close watch is kept on evolving for the better with new ideas and suggestions from the members and followers!

Till date, two electronic journals titled InquiScitive Journal: An e-magazine of latest scientific developments, Vol. I and II, have been published by InquiScitive.

Currently, Arunima Bhattacharya (Editor-in-Chief, Pebbles) and Ankur Rao are the Joint Heads of InquiScitive. Nabhonil Chatterji (Secretary, St. Xavier's College Science Association) is the Chief Editor. Arkopriyo Banerjee and Sanjana Banerjee are the Joint Associate Chief Editors with Rituraj Bhattacharjee as Analyst. Nilanjan Das and Ankur Rao are the founding members and advisors.

A number of articles published in Pebbles cite references from InquiScitive and the editorial board remains grateful and appreciates such a collaboration between Pebbles and InquiScitive.

Sleep Learning – A Student's Delight

Suravi Mukherjee --- Published in January. 2019

Hypnopedia, the ability to learn while sleeping was much popularized by fiction in the '60s but was soon abandoned due to lack of reliable scientific evidence. However, recent findings tell a different tale.

Our sleep comprises of two drastically different phases. The early part of the night is governed by slow wave sleep (SWS) during which some memories spontaneously get reactivated. During the latter part of the night, rapid eye movement (REM) prevails and this is the period where dreams are the most frequent and vivid.

In 2007, Björn Rasch and his colleagues at the University of Lübeck in Germany, conducted a sleep experiment by preparing people to memorize the locations of certain objects while simultaneously smelling a rose. Later they were allowed to sleep in beds in the laboratory, and the same smell was provided. Electrical recordings confirmed that the smell activated an area of the brain called the hippocampus, which is critical for learning navigation and storing new knowledge. After waking up, people recalled the learnt locations more accurately. This observation, however, was only seen when the smell was provided during the course of slow wave sleep.

In 2009, another experiment was carried out using sounds instead of smells. It was found that that sounds played during SWS could enhance remembering individual objects separately, not a collection of objects. This procedure, termed targeted memory reactivation (TMR), made participants learn the designated spots of 50 objects on a computer screen

while hearing a sound corresponding to that object. After this, the participants took a nap and EEG recordings verified that each one was soundly asleep. The sounds related to the subjects were again played softly during slow wave sleep. On awakening, they remembered the locations cued during sleep better than those locations not flagged. So, sounds and smells thus appeared to reactivate the spatial memories and prevented forgetting. Functional magnetic resonance imaging highlighted the areas of the brain that take part in TMR, and EEG results gave an insight into the synchronized activity of networks of neurons in the cerebral cortex. thus appeared to reactivate the spatial memories and prevented forgetting. Functional magnetic resonance imaging highlighted the areas of the brain that take part in TMR, and EEG results gave an insight into the synchronized activity of networks of neurons in the cerebral cortex.

Anat Arzi and her colleagues, now at the University of Cambridge, used smells to create relatively simple memories. In one of such experiments, they were successful in curbing the desire to smoke in people who were eager to quit. When asleep, the participants were made to smell both tobacco smoke and rotten fish simultaneously. These people, in the following week, reduced smoking by 30%, having been conditioned to associate smoking with the smell of rotten fish.

Brain rhythms provide an insight to how memories stored during sleep are later retrieved. One type of neural signal, called slow wave, consists of a "down" phase, where neurons are silent and an "up" phase where they regain activity. This pattern ensures multiple cortical regions remain in an up state simultaneously, reinforcing recently formed memories. Sleep spindles, which are brief increase in rhythm upto 12-15 cycles per second and can coincide with the up phase. Spindles originate in the thalamus, a centre that controls information

transmitted to almost all parts of the cerebral cortex. The rhythm of the spindles recurring at approximately five-second intervals, coordinate the activity of sharp-wave ripples in the hippocampus. During this time, slow waves take up the role of orchestra conductor, coordinating the pace of sleep spindles and sharp-wave ripples. This intricate coupling of oscillations underlies not only memory reactivation but also the altering of neural connections to strengthen memory storage. This complex network interaction, known as consolidation, allows new information to be integrated with existing ones. The intertwining of memories creates a gist of recent experiences that makes sense of a complex world. Acquiring complex memory is not easy but given that Karim Benchenane and his colleagues in the French National Center of Scientific Research (CNRS) have been able to actually change the mind of a mouse, even that may be a possibility, albeit distant. Neurons called place cells within a mouse fire when it explores a new environment and also during sleep. The researchers stimulated the mouse brain, activating place cells while the animal was asleep. Amazingly, immediately after waking up, the mice headed to the locations corresponding to the stimulated place cells.

So, sleep is not just needed for rejuvenation but also to enhance memories initially acquired while awake. This research establishes a normal component of learning that is slightly off-line, but the boundaries of what is possible still remains to be tested. This knowledge might help in creating programs of sleep learning to preserve memories, speed up new knowledge acquisition and even change bad habits like smoking.

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A Tour of the Event Horizon

Malyadeep Bhattacharya ---- Published in August. 2019

Black holes are undoubtedly interesting, terrifying, but beautiful and one of the most powerful objects in the universe. They have been a topic of speculation and extensive study by astronomers as well as the common people. In recent years these mysterious celestial bodies have been on the news quite often. So, what exactly are they? Why are we so interested in them? Why are they so frequently discussed?

Black holes, in simple terms are the remains of a dead star. When a star having a mass well above the Chandrasekhar limit dies from a supernova explosion, it ejects all the matter contained within it into space leaving behind a collapsing core. The strong gravitational pull of the collapsing core starts attracting all matter nearby. The gravitational pull is so intense, it fuses protons and electrons together to form neutrons. All the attracted matter is compressed inside a very small volume resulting in the formation of a very dense object. If the neutron degeneracy rate can resist further collapse, a neutron star is formed, or else, a Black hole is born. A black hole's gravitational pull due to its density is so strong, the escape velocity of an object at the event horizon (the point of no return) exceeds the velocity of light. The centre of the black hole is called Singularity. This point has infinite density and anything which falls into singularity is said to be crushed, atom by atom, by a process called Spaghettification, adding to the mass of the black hole. No theory to date can explain what happens beyond the event horizon. Physics just seems to go crazy there. The radius of the event horizon is known as Schwarzschild radius, named after Karl Schwarzschild. For the first time in history, an image of a black hole was released earlier this year. The star of the picture was the central supermassive black hole of the galaxy M87 which is about 53 million light years

away. It was considered a suitable candidate since it has an active galactic nucleus, matter in its accretion disc travels at near relativistic speeds, it is nearby and large, and its orientation would allow us to take a better picture.

The image showed a shadow surrounded by a bright orange accretion disc which gets dimmer as we move to the upper half. The reason behind this dimming is due to a phenomenon called Relativistic beaming. Due to this effect, light moving away from us appear dimmer and light coming towards us appear brighter. The accretion disc consists of matter and superheated gases which glow due to immense friction as it revolves around the black hole. The shadow seen in the picture is not the black hole. It depicts the Innermost Stable Circular Orbit in which matter can revolve around the black hole without being sucked in. It has a radius 2.6 times the Schwarzschild radius. Inside the shadow lies the Photon Sphere which has a radius of about 1.5 times the Schwarzschild radius. In the photon sphere, photons are forced to revolve in orbits, i.e., a photon will graze the orbit around the black hole and will then be ejected out, which means, if that photon would reach our eyes, we would possibly be able to see what resides behind the black hole. This results in Gravitational Lensing. Due to this phenomenon the image of any object behind the black hole gets distorted. This also implies that if we could stand in the photon sphere, we would be able to see the back of our head in front of us! A Black hole curves space-time around it so much that light waves from the same object bends extensively and reaches our eyes from different directions thus creating multiple images of the same object. Thus, in the image we can't see the black hole because light simply cannot reach us from there. It is only the shadow that we see. However, it should be noted that black holes do emit radiation as a consequence of Quantum Field Theory, due to which matter and antimatter can pop into existence from nowhere and again annihilate each other. Near the event horizon antimatter is sucked into the black

hole and matter is released as radiation. This radiation is of the order of billionths of a Kelvin and is termed as Hawking Radiation. Thus, a black hole loses mass and eventually dies. But as the radiation is so small it cannot be detected with present-day instruments and it would take billions of years for a black hole to die. The picture shows the existence of the black hole since the behavior of matter around it and the radiation from it (mostly X-Rays) demands the existence of such a powerful object. This image has huge importance since it provides concrete evidence about the existence of black holes which again verifies the solutions of Einstein's General Theory of Relativity.

More evidence include, the first ever successful detection of gravitational waves due to the merging of two black holes, detected by LIGO and Virgo in the year 2016. Gravitational waves are generated when accelerated masses having huge gravitational pull move in an inward spiral path and merge with each other. This results in the generation of transverse waves in the curvature of space-time which travel in all directions at the speed of light. The existence of these waves was first predicted by Henri Poincare in 1905 and was subsequently predicted by Einstein in 1916. Astronomers recently received another strong gravitational wave signal named S190814bv which indicated that a black hole swallowed up a neutron star in an event called Tidal Disruption. Our galaxy too contains a Supermassive Black Hole at its center. The black hole is named Sagittarius A* and is a powerful and complex radio source. It was first detected when a variable and luminous X-Ray flare was observed from it, which could have been released from nothing else other than a black hole of such size. The black hole is about 26,000 light years away and has a mass of about 4.1 million solar masses. It is harder to detect since it is quite inactive in terms of gobbling up matter and giving out radiation. It gives out only small periodic bursts. The large cosmic dust clouds near the galactic centre effectively hide the radiation from the black hole making it even harder to

detect. It was for the first time on 13th May, 2019 that Scientists observed the radio source grow 75 times brighter than usual and then again return to its normal state when viewed in near infrared regions. Scientists were astonished by this weird event and are working on it to find answers. Astrophysicist Tuan Do who observed the event stated that there are two possibilities till date; either a star named S0-2 passed too close to the black hole resulting it in being swallowed up or an object named G2 went too close to the black hole. Scientists believe that finding out the cause will reveal many facts about how black holes evolve and will also reveal more about our galaxy's evolution. Recently, scientists also found evidence that our central black hole merged with an intermediate mass black hole and just got bigger. A computer simulated image of Sagittarius A* was released along with the image of the black hole of Galaxy M87.

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The Other Side

Dr. Arup Kumar Mitra

⊠ **Which school did you go to and what were your favourite memories there?**

I went to South Point High School and I remember my music classes in Nursery where we were taught the songs of Goopy Gyne Bagha Byne by Anup Ghoshal's sister.

⊠ **Who is your favourite superhero?**

Aranyadeb (Phantom)

⊠ **Which is the best place you have ever been on a vacation?**

I cherish seeing the entire Himalayan range from Tungnath, after trekking 6 kilometers.

⊠ Have you ever owned or would like to own any pets?

I have adopted dogs...

⊠ Which is your favourite sport/ indoor game?

My favourite sport is cricket but my favourite indoor game is table tennis.

⊠ What are some of your favourite movies?

Sonar Kella. Apu Trilogy

⊠ Which songs do you know all the lyrics to?

Most of Rabindra Sangeet...

⊠ What are your must-have smartphone apps?

Paytm. Uber. Grofers. BookMyShow. Google. WhatsApp. Facebook

⊠ What would be a hidden talent you have?

I do not have any 'talent' but I like to perform in drama. in character roles.

⊠ Where would you go if you could time travel?

To my school days...

STUDENTS' CONTRIBUTIONS

ARTICLES

Statistical Analysis of the Literary works of Rabindranath Tagore

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The article strives to provide a brief overview of the statistical analysis of the literary works of Rabindranath Tagore. I hope this will provide a brief idea of how one can use statistical tools to observe differences in languages.

Dataset Description

The data we collected for our analysis consist of the literary works of Rabindranath Tagore. Rabindra Nath Tagore was an eminent Indian philosopher, poet, and polymath whose literary works have received universal acclaim and admiration. He was the first non-European artist to win the Nobel Prize in Literature and the only person to compose the national anthems of the two countries, India and Bangladesh. His legacy has been immortalized through his work and hence it may be interesting to observe his works from a statistical perspective. We also distinguish two specific genres of his work, poems, and stories, each of which can be considered to be a sub-language of its own. Both the works span over the last quarter of the 19th and first half of the 20th century. Hence the sub-languages under consideration remain invariant across time and since they are from the same era, from the same

author, the sole difference in the sub-languages would be the genre of the literary work itself, i.e. the differences between poetry and narratives.

Dataset Collection

The dataset for collecting the literary works of Rabindranath Tagore has been publicly-scraped from the website . The publicly available website is maintained by the Department of Information Technology and Electronics Government of West Bengal and hosts a vast plethora of literary works of the author. We automate the process of scraping the information from the web pages hosted on this site and dump the text scraped from these pages into the two categories, stories, and poems. We note that there are other genres of literary work available such as drama, songs, and essays but for simplicity, we consider only stories and poems. We were able to categorize the web pages based on the presence of certain HT-ML-markers which encodes the genre of the page.

Preprocessing :

Since the dataset for the literary works was obtained by scraping web pages, we make sure to remove any unnecessary characters like punctuation, Unicode characters, romanized numbers and letters. There is no need for performing case-folding since distinct cases do not exist for Bengali. We separate sentences on the basis of the three delimiters, '|' which is equivalent to the full-stop '.', question marks (?) and exclamation marks (!). These are used to chunk sentences for both the prose and poems in the corpus.
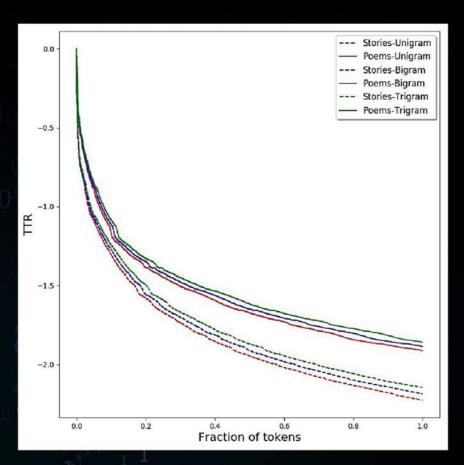
Preliminary statistics:

Categories	#Webpages	#Sentences	#Unigrams	#Tokens	#Bigrams	#Trigrams
Stories	1062	33783	42413	393148	238451	298596
Poems	3562	27927	51655	349609	243519	270818

We perform an initial analysis of the number of sentences, unigrams, bigrams, trigrams and tokens in the vocabulary for both the stories and poems. The most striking analysis from the preliminary results is that the poems have a much higher Type (Unigrams) to Token Ratio (hereby called TTR). We hypothesize that since poems are intrinsically more artistic and expressive, their linguistic characteristics would exhibit departure from proses. One of them would be a tendency to use less frequent words that occurs in prose which can be measured by the variation of TTR over the entire corpus. This gives rise to the first hypothesis.

H1: Are Rabindranath's poems more expressive than his stories?

Since it is difficult to define expressiveness, we resort to the TTR value to characterize it. We thus plot the Type to Token Ratio (TTR) curves for unigram, bigram and trigram for the entire corpus of both stories and poems. It is evident from the graph that the TTR values for poems are larger than that of the stories. Likewise, unsurprisingly, the TTR ratios for the higher-order n-grams are monotonically greater than the lower-order ones. Here, we represent the y-axis (TTR values) in a log scale to make the differences more distinct.

However, one might question that observing the TTR over the entire corpus might not be indicative of individual stories or poems itself. We emphasize that due to the arbitrary nature in which the webpages were labeled, we are unable to ascertain the distinct number of poems and stories available. Hence, to observe the variation in TTR across poems and stories, we used a simple heuristic. We divided the corpus of poems and stories into chunks of 100 sentences. This leaves us with 337 chunks of stories and 279 chunks of poems. We observe the

TTR ratios of unigrams, bigrams, and trigrams for these chunks and report its mean and variance below. The mean TTR values of unigrams for poems is greater than that of stories as expected; however the TTR values of trigrams and bigrams is higher in stories than that of poems. We postulate that the difference arises since the poems of Rabindranath are building upon common themes of beauty of nature and have a common rhythmic flow, as will be discussed below, there is expected to be overlap between adjoining poems. Nevertheless, we demonstrate that in general, the poems are more expressive in terms of words; but lesser for higher n-grams. However, if we consider the entire corpus, stories tend to use more stop-words and common phrases and hence the TTR values of poems are greater than stories as evident from the above figure. However, it is very interesting to note that the TTR values for both stories and poems are very high, indicating the rich use of vocabulary and the expressiveness of the author.

	Mean value of TTR			Variance of TTR		
	Unigram	Bigram	Trigram	Unigram	Bigram	Trigram
Poems	0.666	0.925	0.941	0.011	0.022	0.023
Stories	0.605	0.946	0.968	0.006	0.015	0.016

Characters and Vocabulary

Bengali has the following characters in the alphabet:

1) **Vowels** - 'অ', 'আ', 'ই', 'ঈ', 'উ', 'ঊ', 'ঋ', 'এ', 'ঐ', 'ও', 'ঔ'

2) **Consonants** - 'ক', 'খ', 'গ', 'ঘ', 'ঙ', 'চ', 'ছ', 'জ', 'ঝ', 'ঞ', 'ট', 'ঠ', 'ড', 'ঢ', 'ণ', 'ত', 'থ', 'দ','ধ', 'ন', 'প', 'ফ', 'ব', 'ভ', 'ম', 'য', 'র', 'ল', 'শ', 'ষ', 'স', 'হ', 'ড়', 'ঢ়', 'য়

3) Diactrics - া, ি, ী, ু, ূ, ৃ, ে, ৈ, ো, ৌ,ঁ, 'ং', ঃ, ্, ৎ

4) Numbers - '০', '১', '২', '৩', '৪', '৫', '৬', '৭', '৮', '৯'

Diacritics are used in conjunction with consonants, i.e they modify the vowel. For example, a crow or (kak) is written as কাক. It is similar to Hindi and other Indic languages. These are the characters that appear for the literary works along with hyphens '-'.

We note down the most frequently occurring characters for stories and poems here.

	Stories	Poems
Characters	'০০া', '☐ে', 'র', 'িে☐', 'ক', 'ে☐়', 'ন', 'ত', 'ব', 'ল'	'০০া', '☐ে', 'র', 'িে☐', 'ন', 'ে☐়', 'ত', 'ক', 'ব', 'ল'
Unigrams	'না', 'কিরয়া', '☐স', 'আমার', 'তাহার', 'আিম', '☐য', 'এই', 'হইয়া', ' কের'	'না', '☐স', 'তার', 'আমার', '☐য', '☐তামার', 'কের', 'আিম', 'এ', 'তুিম'
Bigrams	'িছল না', 'মেন মেন', 'তা হেল', 'হয় না', 'হইয়া ☐গল', 'তার পের', 'কিরেত লািগল', 'এমন সময়', 'হইয়া উ_ল', 'যায় না'	'তার পের', '☐স ☐য', 'ক ☐র', 'চািরে িদেক', 'ধীেের ধীেের', 'হয় িন', 'মেন মেন', 'মােঝ মােঝ', 'বােের বােের', 'নব নব'
Trigrams	'হইত বািহর হইয়া', 'মেু খর িদেক চািহয়া', 'কিরেত পািরল না', 'পাওয়া যায় না', 'তা হেল ☐তা', 'চুপ কিরয়া বিসয়া', '☐তা ভাে◌লা নয়', '☐দখা যায় না', 'বচন ☐ে◌ন চড়', '☐☐র বচন ☐ে◌ন	'ব☐ িদন পের', '☐তামাে◌র জানাই নম_ে◌র', 'পিড় আেছ অিত', 'কিহ অেরণ☐র গান', 'িে☐_ সমীরণ লািগ', 'আেছ অিত অনােদর', 'বসেে◌র িে☐_ সমীরণ', 'মদৃ ◌ু মদৃ ◌ু বসেে◌র', 'মৃদু বসেে◌র িে☐_', 'গািে◌হত কিহ অেরণ☐র'

The observations might seem incomprehensible for those who cannot understand the language but one can readily identify a particular trend as one moves from characters to words (unigrams) to higher level n-grams, i.e. the commonality is decreasing. Some initial observations in this section include:
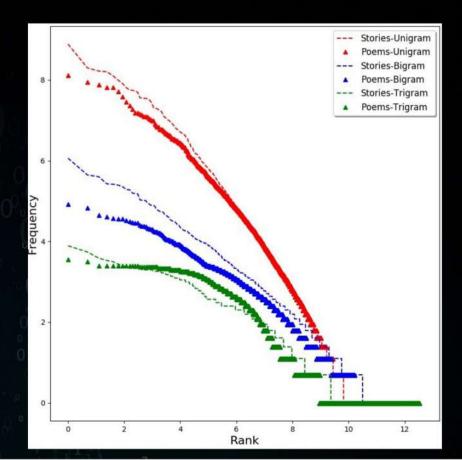
1) The most commonly characters used in poems and stories are the same.

2) The frequent unigrams also occur in both the sets albeit in different orthographic **notations**. The word 'তাহার' means the same as 'তার' The difference lies in the dialect. Bengali historically had two major dialects, chaste language (shadhu bhasha) meant for writing and colloquial language (chalita bhasha) meant for daily communication. It seems that poems due to their more expressive nature has more words in 'chalita bhasha' as opposed to stories.

3) Bigrams in poems also show the interesting phenomena of anadiplosis where the same word is repeated for emphasis or musicality. This is less frequent in proses.

4) The content of the trigrams also exhibit stark variation. While the trigrams in prose talks about an action ('হইতে বাহির হইয়া', 'মুে খর দিকে চাহিয়া'), the ones in poems refer to nature and beauty (অরণে□র, বসে□র, সমীরণ means forest, spring and breeze). The main take-away is that the languages in poems and prose are expected to have significantly different word-distributions not only due to content, but also due to the difference in dialects. This forms the second hypothesis.

H2: How similar/ different are the distribution of words, characters and other n-grams in poems and proses written by the same author?

Firstly, we look at the Zipf's law for the unigrams, bigrams and trigrams for both poems and prose, the distributions of which plotted below. The curves for unigrams, bigrams and

trigrams follow a similar fashion as shown in [5]. Both axes are represented in the log scale so as to observe whether the general form of Zipf's law holds true in this case. $f = k/r\beta$ where f is the frequency of a word with rank r. β indicates the slope in a log-log scale while k denotes the value of the intercept. Here we consider only the slope.

	Unigrams	Bigrams	Trigrams
Stories	-1.13	-0.42	-0.15
Poems	-1.03	-0.33	-0.12

The value of the slopes clearly show that apart from the Poems-unigram, Zipf's law does not hold true. In fact, as we progress from unigrams to bigrams to trigrams, the values of the slopes decreases significantly, much more than those reported in [5] for WSJ and Mandarin corpus. The greater slope of proses as opposed to poems in the early stages can be explained via the observation that frequently occurring words or stop-words occur more frequently for proses than poems.

Distribution	KL (Poems||Stories)	KL (Stories||Poems)	KL (Total)
Character	0.02148	0.01914	0.04063
Unigrams	0.82799	0.80357	1.63157
Bigrams	0.68269	0.72572	1.40842
Trigrams	0.42869	0.49333	0.92203
Word length	0.15416	0.17113	0.32530

We also note the differences/ divergences between the different distributions between the proses and poems. We specifically observe the symmetric KL-Divergence scores of the following distributions between prose and poems : character distributions, word distributions, bigram and trigram distributions and word-length distributions. The observations are given in the table above.

It is unsurprising that the KL Divergence of characters is small as opposed to words and higher-order n-grams. However, it is indeed interesting that the KL-Divergence values of lower-ordered n-grams are greater than the higher-order ones. This observation can be explained when we consider the number of common terms that occur as unigrams, bigrams and trigrams among the stories and poems. It is astonishing to note that only 34.03% of unigrams, 6.83% of bigrams, and only 0.53% of trigrams in stories are found in the poems. This suggests that there are several n-grams that are common to stories and not in poems The reverse also holds true with only 27.95% of words, 6.69% of bigrams and 0.58% of trigrams that occur in poems are also found in proses.

Consequently, we thus inspect the most-frequent n-grams which occur distinctly in each.

	Stories	Poems
Unigrams	'বিলেলন', 'তাঁহাকে', 'লািগেলন', 'নের', 'নায়', 'এমন-িক', 'কিরেতন', 'কিলকাতায়', 'হরলাল', 'খাইয়া', 'চার', 'দিখেলন', 'পাকরন', 'হইবার', 'অমেলর', 'তৎ_ণাৎ', 'শশধর', 'অধাপক', 'খাইত', 'এইজন'	'তামাের', 'মাকের', 'লািগ', 'আঁিখ', 'কিরেছ', 'মম', 'যথায়', 'আপনাের', 'ব', 'তাহাের', 'রিব', 'দাঁড়াকয়', 'কমেন', 'পরান', 'সিখ', 'মারা', 'উ_েছ', 'সাগেরর', 'তাকহ', 'নাকচ'

Bigrams	'হইয়া উ_ল', 'হইেত লা িগল', 'মেন হইল', ' িজাসা িকরল', 'চুপ িকরয়া', ' িজাসা িকরেলন', ' িদক চা িহয়া', 'িকরবার জন', '_ েবশ িকরল', 'িকরেত িকরেত', 'িকরয়া তাহার', 'এবং তাহার', 'তাহার পর', 'িকরেত লা িগেলন', 'ভা েলা িকরয়া', 'এই িবলয়া', 'আসয়া উ িপত', 'বি ঝেত পা িরল', 'উ িপত হইল', ' িনকট হইেত'	'না িহ জা েন', 'বল', 'কখন বা', 'দর হেত', 'িবদন', 'সা েথ সা েথ', 'দয় আমার', 'রবীনাথ ঠার', 'না িহ জা িন', 'আিজ এ', 'এক রেয়ছ', 'সােগরর জেল', 'হ', 'চা ির পা েশ', 'ধী ির ধী ির', 'তামা ের জানাই', 'জানাই নম_র', 'ঊঁ েয় ঊঁ েয়', 'ি_ সমীরণ', 'অিত অনােদর'
Trigrams	' েম খর িদক চা িহয়া', 'িকরেত পা িরল না', 'পাওয়া যায় না', 'চুপ িকরয়া িবসয়া', 'তা ভা েলা নয়', 'চড় খেয় মরা', 'র বচন েন', 'মেধ _ েবশ িকরল', ' েন চড় খেয়', 'বচন েন চড়', 'ভা েলা নয় পড়ানা', 'করা— র বচন', 'হেল তা ভা েলা', 'ঘর হইেত বা িহর', 'পড়ানা করা— র', 'নয় পড়ানা করা—', 'শা িই যিদ হয়', 'এই শা িই যিদ', 'যিদ হয় তার', 'তার শষ তা'	'ব িদন পের', 'তামা ের জানাই নম_র', 'এলাইয়া িপড় আেছ', 'মদৃ ু বেসর ি_', 'িপড় আেছ অিত', 'িকহ অরেণর গান', 'আেছ অিত অনােদর', 'পাথীের গা িহেত িকহ', 'মদৃ ু মদৃ ু বেস র', 'গা িহেত িকহ অরেণর', 'বেস র ি_ সমীরণ', 'ি_ সমীরণ লা িগ', ' িত লরা িশ গীর', 'ব েলর ডা েল মদৃ ু', 'জাছনা যেব কাঁ েপ', 'অথবা জাছনা যেব', ' ীবা-পের এলাইয়া িপড়', 'পৃ িথবীেতল অিপ_ েব চরণ', 'কাঁ েপ বেলর ডা েল', 'লরা িশ গীর ীবা-পের'

The observations are similar to the ones we had observed for even the most frequent n-grams, i.e the proses tend to use more formal words ('shadhu bhasa') whereas the poems use their colloquial variants. Likewise, the bigrams and trigrams in poems call upon references to breeze, forests, spring-time and other aspects of nature.

We also decide to inspect another feature, i.e whether the words in poems or stories are similar in terms of length as well.

It is observed that the average length of words in stories is 4.927 while that of poems is 4.768. We hypothesize whether the expected values of the distribution of word lengths between poems and stories will be different. Hence we consider the null hypothesis that these two distributions have the same expected value and perform two statistical tests, namely the Welch's test [7] (where we assume the population variance is different) and the Student's T-test [6] (where the two populations have the same variance). In both cases, we perform the tests on the entire distribution as well as randomly drawn samples of size 10000. In all the cases we observe that the p-value is less than 0.001, implying that they are statistically significant.

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The Undefined Division

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To understand why division by zero is undefined, let us first take a look at what multiplication is.

Let us take an example.

4x5 = 20.

We can also write this as 4+4+4+4+4 = 20.

So we can say that multiplication is repeated adding.

Also, let us look at the multiplication, the other way round.

So, 5x4 = 20

It is pretty obvious that we think of them as the same but in reality, they represent different ideas.

Here, it means 5+5+5+5 = 20.

This also proves that multiplication is commutative.

Now let us look at what division is.

Similar to multiplication, it is repeated subtraction. But however it works a little different when compared to multiplication.

To understand this, let us consider an example.

6/3 = 2

When we talk about repeated subtraction, one may ask how we subtract here.

What division actually means is how many times one can subtract the divisor from the dividend until they get 0.

So to show the working, we take the same example.

$6/3 = 2$.

$6 - 3 - 3 = 0$

Since we are subtracting 3 (divisor) from 6 (dividend) twice to get 0, the quotient here is 2.

Now, this brings us to our topic. So, let us take an example of $1/0$. Here, the dividend is 1 and the divisor is 0. According to the definition of division, we subtract the divisor from the dividend until we get zero. So if we do that,

$1 - 0 - 0 - 0 - 0 \ldots\ldots$

And this keeps going on and on and on.

Which brings us to what we have been listening since our childhood, that is, it goes to infinity.Now most ofus know more than simple subtraction. It is more than just simple subtraction. Let us now take another way to approach the problem.

So we consider certain numbers.

What division actually means is how many times one can subtract the divisor from the dividend until they get 0.

$$\frac{1}{1} = 1$$

$$\frac{1}{0.1} = 10$$

$$\frac{1}{0.01} = 100$$

$$\frac{1}{0.001} = 1000$$

$$\frac{1}{0} = \infty ?$$

So this is another argument and you can see here we're approaching zero in the denominator from 1.

But does it mean that $1/0$ = infinity?

To answer that question, let us look at another example

$$\frac{2}{1} = 2$$

$$\frac{2}{0.1} = 20$$

$$\frac{2}{0.01} = 200$$

$$\frac{2}{0.001} = 2000$$

Similarly, should also be, $2/0 = \infty$.

This brings us to the conclusion that, $1/0 = 2/0 = \infty$.

Therefore, from the above it allows us to say $1=2$, which is an absolute contradiction because they are two sets and of different sizes.

Thus, $1 \neq 2 \neq \infty$

Similarly, this can be done with other numbers as well therefore causing more contradictions.

Therefore, we state $1/0$ as undefined.

But why undefined? Are mathematicians that lazy? They didn't find out?

No. There is a reason. And, here's why. Let us look at an example mentioned before,

$$\frac{1}{1} = 1$$

$$\frac{1}{0.1} = 10$$

$$\frac{1}{0.01} = 100$$

$$\frac{1}{0.001} = 1000$$

$$\cdot$$
$$\downarrow$$
$$\cdot$$

$$\frac{1}{0} = \infty\,?$$

Keeping this example in mind, we can clearly see that we had started from a bigger number 1 and we approached 0. But is this the only way one can approach it?

What if we approach zero from -1?

$$\frac{1}{-1} = -1$$

$$\frac{1}{-0.1} = -10$$

$$\frac{1}{-0.01} = -100$$

$$\frac{1}{-0.001} = -1000$$

$$\cdot$$
$$\downarrow$$
$$\cdot$$

$$\frac{1}{0} = -\infty$$

As you can see, this is not going to ∞. Instead, it is going to -∞.
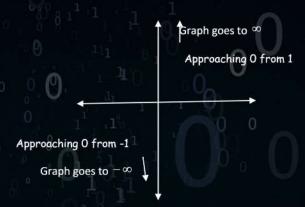
Here, we get to the main situation.

Why undefined? Why do calculators give "math error" when we punch in a calculation of dividing a number by 0?

The reason for calling it undefined is that it is indefinable.

What it means is that if Mathematician A uses the first method of approaching zero from 1, Mathematician B can use the second method of approaching zero from -1.

Looking at the problem graphically,

Graph goes to ∞

Approaching 0 from 1

Approaching 0 from -1

Graph goes to $-∞$

In technical terms, one can say the limit doesn't exist. Therefore, since the value of any number divided by 0 cannot be defined, we write "undefined".

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The Link Between Mathematics And Islamic Art

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Art is the mirror of a civilisation's culture and its world view.

The Islamic Golden Age, was a period of cultural, economic and scientific flourishing in the history of Islam, traditionally dated from the 8th century to the 14th century. During this time, science, made incredible progress due to the translation of Greek and Indian Texts by the scholars in Baghdad. There were advancements in trigonometry, astronomy and medicine. Al-Khwarizmi wrote the first book on algebra, Ibn Al-Haythm invented the first camera and the Hindu-Arabic numeral system was adopted, which developed into the modern Arabic numerals, used throughout the world today.

Islamic Art and Architecture is famously composed of elements that bear significant meaning and were developed through meticulous practice. The presence of domes, arches, walls decorated in arabesque art, calligraphy and colourful repeating patterns distinguish an Islamic monument from the rest.

Art and architecture evolved due to various factors. Mathematical progress, verses in the Quran that emphasize the importance of acquiring knowledge, heavy funding, and certain Islamic principles.

The most important principle governing art was Aniconism - the religious prohibition of figuration and representation of living creatures. Except in Mughal Palaces, adherence to this rule was observed in mosques, tombs and minars of India. Figures, in paintings, were re-

stricted to hold little representational meaning and be mostly decorative. Due to this prohibition, artists and architects, employed geometry to create intricate geometric patterns to decorate the walls and ceilings. These specific patterns are known as Tessellations. In geometrical terminology, a tessellation is a pattern, usually repetitive, resulting from the arrangement of identical polygons over a plane, without leaving any gaps or overlapping portions.

The tessellations, commonly seen in Islamic Art, is the tiling of polygons in 2 dimensions, and these interlocking shapes can be extended infinitely. This bears similarity to the arabesque design that consists of repeating motifs, vegetal and floral patterns. The concept of a repeating, infinite form of expression is used to symbolise the transcendent, infinite and indivisible nature of Allah. In order to use tiling as a technique, artists relied on their foundations in geometry.

In the 3rd Century, Euclid, a Greek mathematician, published a book entitled "Elements" in which he listed five postulates describing geometry. The modern reformulation of Euclid's postulates are:

• Any two points can be joined by a straight line.

• Any straight line segment can be extended indefinitely in a straight line.

• Given any straight line segment, a circle can be drawn having the segment as radius and one endpoint as center.

• All right angles are congruent.

• The Fifth Postulate: Given a line and a point (not on that line), there exists only one line, passing through that point and parallel to the original line.

Muslim geometry descended directly from principles set forth by Euclid. Tessellations of the

Euclidean plane, are generally formed with copies of a single polygon, also called tile, and the transformations of the copies of the tile by isometries creating a pattern over the plane. An isometry of the Euclidean plane is a transformation which preserves length.

Isometries include:-

- Reflection: Infinitely many points remain fixed along the line of reflection.
- Rotation: One point remains fixed about which the tile rotates.
- Translation: No points remain fixed.
- Glide Reflection: No points remain fixed.
- The identity map: All points remain fixed.

Figure Translation, rotation and reflection operations on octiamonds.

The shape of the tile depends upon the number of the sides meeting at one vertex. The angles can only add up to 2π at a vertex i.e., the meeting point of different tiles.

Therefore, for a more mathematical explanation, let p be the number of sides of a polygon, and q be the number of polygons meeting at a single vertex.

By the formula for polygons, sum of all of the interior angles = $\pi(p-2)$

Hence, each interior angle is = $\pi \, (p-2)p$

$pq\pi - 2q\pi = 2p\pi$
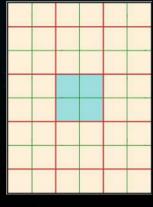
$pq - 2q - 2p = 0$

$pq - 2q - 2p + 4 = 4$

$(p-2)(q-2) = 4$

The only possible ways to factor $(p-2)(q-2) = 4$ are as follows:

$p = 4$ and $q = 4$, which is a square, $p = 6$ and $q = 3$, which is a hexagon and $p = 3$, $q = 6$, which is a triangle. We can further prove that this triangle would have to be equilateral as there would be 6 other polygons meeting at that vertex. These are also called regular polygons.

The complex tileworks were analysed and it was concluded that they had been derived from similar frameworks of regular polygons i.e., a square, triangle or hexagon and from the 12th century onwards, octagon and dodecagon.

Fig 1 illustrates the orthogonal grid made from squares, with the dual grid (green) being the same orthogonal grid. The vertices of this grid have four-fold symmetry. This is due to the four coincident squares meeting at the vertex at 90°.
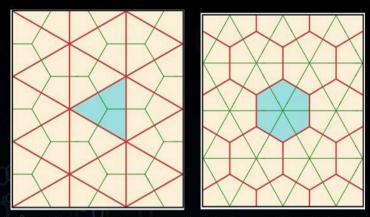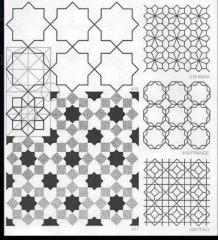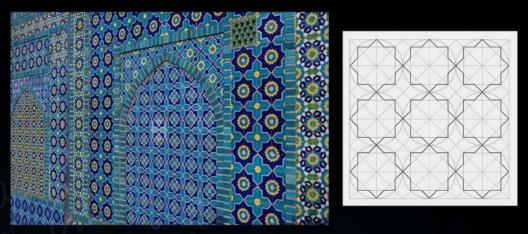
fig 2 (left to right) shows the isometric grid made from equilateral triangles, along with its hexagonal dual (green) and the opposite. The vertices of the isometric grid have three-fold symmetry.

The construction of complex geometric patterns from tessellations, made up of simple regular polygons, which serve as a sub-structure or framework is referred to as the system of regular polygons.
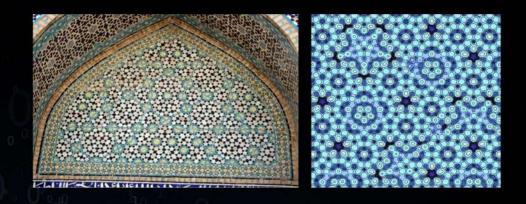
The shapes were used to decorate ceilings, doors, walls and for the Mughals, window screens or jalis. The example below, shows the use of regular hexagons in the jalis at Agra Fort.

With the development of this form of art as well as advancements in geometry, Islamic artists of the 12th century began to produce a more sophisticated form of tilework, now called quasi-periodic tiling. (Example given below- Darb-i Imam Shrine, Iran).

"Quasicrystals is a pattern that fills a space but does not possess the characteristic of translational symmetry that is typical in true crystals. In two dimensions, this means that sliding an exact copy of the pattern over itself will never produce an exact match, though rotating the copy will often produce a match." Quasicrystals were a complicated phenomenon that remained mathematically unexplained until the 1970s, when Sir Roger Penrose, described them. About a decade later, the Nobel Prize for chemistry went to the discovery of quasicrystalline structure in the positions of atoms in a metallic alloy. (The image on the right is of "potential energy surface for silver depositing on an aluminium-palladium-manganese (Al-Pd-Mn) quasicrystal surface"). Despite its complexity, it was discovered that the Islamic Artists had managed to create almost perfect examples of quasicrystals with rudimentary tools.

Apart from tessellations, artists also created work including the Arabesque. The role of geometry for the construction of Islamic floral patterns, in the arabesque style, was primarily structural: providing symmetrical order upon which the tendrils and flowers rested. There are innumerable examples of floral design with reflective symmetry. Within architecture, these were frequently used for dome ornamentation. In such cases, it was noted, the number

of radial lines of symmetry will invariably be divisible by the number of side walls of the chamber that the dome is covering: e.g., if the plan of the chamber is a square, the reflected symmetry will be a multiple of 4. For the styling of domes, radial symmetry was of key importance.

The Mughals frequently used Arabesque style floral motifs to ornament their tombs and mosques. For example, Tomb of Akbar at Sikandra (below) has a radially symmetrical dome.

During the sixteenth and seventeenth centuries, floral ornamentation grew increasingly popular and the use of geometrical patterns declined. Apart from some exceptional geometric innovations such as the Mughal domes, the interest in developing geometric design was faint. Mughal architecture, developed into a bold new form, combining Persian elements with Indian touches.

Since then, tessellations have been studied in much greater depth by several mathematicians and artists, most notably M.C. Escher. The artist's ability to use the most basic tools to cut tile, marble and stone into mathematically precise and aesthetically pleasing patterns is laudable. The sub-structure of the patterns, may be simple regular polygons, but its construction into a more intricate symmetrical design, serves as a testament to their geometric

knowledge.

The link between Mathematics and Islamic art, due to the influence of one on the other, represents the interwoven nature of science, art and religion, that characterizes a culture.

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Leonardo Pisano, The Leonardo of Pisa

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Mathematics has always been (to most people) , just a subject, or in premium terms , just a methodology to pass some upcoming test. Most of my student comrades have always regarded Mathematics in that exact way till date. Infact almost every kid or student studies Math in order to complete some given syllabus or just in order to qualify some fore coming examination. But that is essentially just as absurd , as far as what Mathematics is to me; rather what Mathematics has always been to me... I don't really intend to become or pose as a so called 'NERD' to you (dear reader) but I have some little treats for you that might (mostly will) change your whole perspective of MATHEMATICS. And I prefer to do so, via my favorite topic over Mathematics, the FIBONACCI SEQUENCE. Finbonacci was known as the Leonardo of Pisa (Fun Fact).

Almost all computer students are familiar with that little program to print the Fibonacci sequence till some n-th term. But that's been it. Even I didn't really know what's after that (chuckle) , until I found out, and here's the revelation.

For those who don't really know what the FIBONACCI SEQUENCE is, it is a sequence of numbers that start with 1 and the second term is 1 too. And the 3rd term is the sum of the 1st and the 2nd term (2), the 4th term is the sum of the 2nd and the third term (3) and it goes on unending. That is in a nutshell, if I name the terms n1, n2, n3, ... then every n-k (k belongs to {3,4,5,6,.....}) so, the series goes as follows:

1, 1, 2, 3, 5, 8, 13, 21, ...and so it goes

To most people, probably it is just some ordinary sequence of numbers, but here are some fun facts regarding the Fibonacci Sequence

1. Birds always fly in clusters while migrating from one portion of the world to another. Each cluster always consists some number of birds and that number always belongs to the Fibonacci sequence.

2. Every possible flower in the world consists of a certain number of petals; and that number is always a member of the Fibonacci sequence.

3. The number of spirals in a sunflower always belongs to the Fibonacci sequence.

4. As we divide some nth Fibonacci number to the (n-1)th Fibonacci number, and as we go on dividing for such larger pairs, we get our quotient getting close to the number 1.61803398875. This number is called the Golden Ratio. And it's presense is kind of too REAL, to call Mathematics just 'theory'.

(As claimed by Da Vinci's sketch of the VETRUVIAN MAN) Take your arm for example. From the shoulder to the tip of your finger,measure it's length. Then consider the length from the elbow (approx mid point of the arm) and measure till the tip of your finger. Find the arm/elbow ratio. You'll find it to be approximately 1.618, that is the golden ratio. Do the same from your head to toe length and your navel to toe length. Divide, boom! Golden ratio. And such existence lies almost just throughout the body including places like your thigh-toe length and the knee-toe length.

Well it just doesn't stop right there. Take the Fibonacci sequence for instance.

1,1,2,3,5,8,13,......

Now let's square each element and note it down separately

1,1,4,9,25,64,169,...... (2)

Doesn't really seem much right?

Now see this.

Let's add the numbers of sequence 2 like this, and we denote the number as (f) if we find something special in it

$1+1= 2$ (f) $= 2 \times 1$ (both 2,1 are Fibonacci)

$1+1+4= 3$ (f) $= 3 \times 1$ (both 3,1 are Fibonacci)

$1+1+4+9= 15$ (f) $= 3 \times 5$ (Both 3, 5 are Fibonacci)

$1+1+4+9+25= 40$ (f) $= 5 \times 8$ (Both 5,8 are Fibonacci)

$1+1+4+9+25+64= 104$ (f)$= 8 \times 13$ (Both 8, 13 are Fibonacci)

and so on.....

Note that, everytime I add the squarred sequence consecutively, two at a time, I always get a number that belongs to the fibonacci sequence.

Well, here's why...

Consider the following set of squares of fibonacci length till 8. Now, it's area is $(1 \times 1)+ (1 \times 1)+ (2 \times 2) + (3 \times 3) + (5 \times 5)+ (8 \times 8)$ which is 104. But this is also a rectangle of length 13 and breadth 8 units. So, Yeah the area is totally 8×13 which are Fibonacci Numbers afterall.

So you see Math isn't just some ordinary subject . It's just we fail to gain inspiration from it. Well, essentially Math is Magic. We just need to live in Mathematics.

Calculation of the God's Number

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The notoriously difficult Rubik's cube was invented in the year 1974 by a Hungarian Professor of architecture, Erno Rubik. Ever since its invention, about 350 million units of this toy has been sold, and is considered to be the best selling toy ever made.

The funny story is, it was never meant to be a toy.

Being a professor, Mr. Rubik wanted to make it easy for his students to visualize 3D geometry. So he made something whose three different axes could be turned independently. He colour coded each of the sides and started turning the different faces of the cube. He soon understood this isn't what he had intended to create. After scrambling the cube, he realized that it was very difficult to bring it back to its original configuration. It took him approximately a month to solve the cube. How the cube became popular is a different story altogether. But what made the cube popular, sure is interesting.

Why is it so difficult?

There are approximately 43 quintillion (exactly 43 quintillion, 252 quadrillion, 3 trillion, 274 billion, 489 million, 856 thousand) different ways that a cube can be scrambled. How big a number is a quintillion? It has 18 zeroes in it. To put it into perspective, if we were to make a cube out of whatever material (wood, soil you name it) was at hand, there wouldn't be enough material on the island of Great Britain.

Out of all these combinations, there is exactly one prized combination - the one which has all the similar stickers on one side.

If you have never handled a Rubik's cube, I would recommend trying one out just to realize how twistedly difficult something can be (quite literally).

Learning to solve the cube is actually easy, it just takes some time (and tons of patience). Contrary to popular belief, being able to solve a Rubik's cube is not a measure of how intelligent a person is. Solving requires being able to memorize a bunch of different algorithms and being able to execute them. But solving a Rubik's cube does help in improving something called Spatial Awareness. The first time Erno Rubik ever solved the cube, it took him over a month to do so. Solving the cube in the least time possible has been a sport ever since, or popularly known as speedcubing. Currently the world record for solving a Rubik's cube stands at a mere 3.47 s by Yusheng Du. Some of the most notable speedcubers who have helped this evolve into a now proper sport are Yu Nakajima, Feliks Zemdegs, Mats Valk, Max Park etc.

So, what is this God's number?

The key to solving a cube fast is to figure out the most efficient solution that would solve the given scramble, and would also require the least number of moves to achieve that prized solved state of the cube. The current God's number stands at 20 moves (in half turn metric). We will see how it boiled down to such a small number.

It basically means no matter what the scramble, a sequence of 20 moves shall always suffice to solve the cube. And there shall be no exceptional scramble.

There are plenty of videos on the internet showcasing people solving the cube under 10s, which is pretty amazing. On an average, speedcubers (people who solve the cube really,

really fast) take anywhere between 40 to 60 moves to solve the cube.

The reason that this number is called the God's number because it is virtually impossible for a mortal to figure out the most efficient solution always, no matter what the given scramble is. For figuring out the solution in 20 moves, the person needs to be able to analyse each of the 43,252,003,274,489,856,000 different cases that the scramble could be, all at once. This is humanly impossible. So, it is as if God was to solve the cube, he would always come up with the 20 move solution. Thus the name, God's Number.

Evolution in the stages of calculating God's number:

Date	Lower bound	Upper bound	Gap	Remarks
July, 1981	18	52	34	Morwen Thistlethwaite proves 52 moves suffice.
December, 1990	18	42	24	Hans Kloosterman improves this to 42 moves.
May, 1992	18	39	21	Michael Reid shows 39 moves is always sufficient.
May, 1992	18	37	19	Dik Winter lowers this to 37 moves just one day later!
January, 1995	18	29	11	Michael Reid cuts the upper bound to 29 moves by analysing Kociemba's two-phase algorithm.
January, 1995	20	29	9	Michael Reid proves that the "superflip" position (corners correct, edges placed but flipped) requires 20 moves.
December, 2005	20	28	8	Silviu Radu shows that 28 moves is always enough.
April, 2006	20	27	7	Silviu Radu improves his bound to 27 moves.
May, 2007	20	26	6	Dan Kunkle and Gene Cooperman prove 26 moves suffice.
March, 2008	20	25	5	Tomas Rokicki cuts the upper bound to 25 moves.
April, 2008	20	23	3	Tomas Rokicki and John Welborn reduce it to only 23 moves.
August, 2008	20	22	2	Tomas Rokicki and John Welborn continue down to 22 moves.
July, 2010	20	20	0	Tomas Rokicki, Herbert Kociemba, Morley Davidson, and John Dethridge prove that God's Number for the Cube is exactly 20.

The three most important stages in the calculation of God's number could be the following:

- Of course, Morwen Thistlethwaite who started it all with his 52 move solution.

- Michael Reid, who showed that the superflip position of the cube could be solved in 20 moves.

(The superflip position: Notice how the pieces are flipped in their correct positions)

The superflip position of the cube is regarded widely as the most difficult scramble because, every piece is present in its correct location, but it is flipped in a wrong orientation.

- In July 2010, when Google finally steps in.

So, how did Google help solve this problem?

Computing all the 4.3x1019 positions of the 3x3 Rubik's cube is no joke. So, Tomas Rokicki (a programmer) needed the help of a company who had plenty of superfast computers with high processing capability and were willing to participate in a "fun experiment". And hence, Google.

How did they solve all 43,252,003,274,489,856,000 positions of the Cube?

- They partitioned the positions into 2,217,093,120 sets of 19,508,428,800 positions each.

- They reduced the count of sets they needed to solve to 55,882,296 using symmetry and set covering.

- They did not find optimal solutions to each position, but instead only solutions of length

20 or less.

- They wrote a program that solved a single set in about 20 seconds.
- They used about 35 CPU years to find solutions to all of the positions in each of the 55,882,296 sets.

In order to understand how they divided the scrambles into different sets, we would need to delve into a branch of Mathematics known as Group Theory. The study of a Rubik's cube is considered to be a fundamental in that field.

Google does not ever release information on the kind of hardware they use, but it still took a few weeks to run the algorithm to solve the problem, even though they had plenty of computing power and plenty of computers at their disposal.

To put it into perspective, it would take a standard Intel Nehalem quad core processor 1.1 billion seconds (or 35 CPU years) to run the same algorithm.

Conclusion:

As for now, the God's number stands at 20, and seems like it would continue to do so for quite some time. There are some excellent videos by Numberphile on YouTube, which is sure to get you hooked.

Oh, and a joke to conclude things:

Peeling the stickers off isn't the most efficient way to solve the cube after all!

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Gravitational waves : Understanding the true nature of reality

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Given our progress in explaining the working of the cosmos, our understanding has yet too many loopholes. There is currently no "Unified Field Theory" in existence and general relativity of Einstein still contradicts with quantum mechanics.

The immediate questions that arise in one's mind are :

-Why are we trying to unify them anyway?

-What is the main obstacle to uniting all the elementary particles and four forces?

Note that the convergence of the microcosm and the macrocosm is what physicists have sought to accomplish. Such two cosmological forces are described by quantum mechanics and general relativity respectively. The inherent incompatibility between quantum mechanics and general relativity is impossible to notice in everyday life, or at the vastness of the universe. The results of the calculations from the observations made by LIGO seems to bridge the gap between the two fields.

General relativity states that space-time is a fabric which becomes warped and distorted by the existence of matter and energy, which implies that any object having a mass which moves in the universe creates distortions in the fabric of space itself, called gravitational waves. This is one of Einstein's oldest predictions. The concept of gravity by Einstein remains a classical view, however, because space and time are continuous, not discrete entities; the predictions of the theory break up at very short distances and in very large fields; and the gravita-

tional domain for inherently quantum systems can not be calculated as it were, like an electron facing a dual slit. (Scardigli, and Casadio, 2015).

Theoretically, gravity may appear to be quantum in nature, although we do not yet have any experimental evidence. But with the latest clear observation by LIGO of gravitational waves, we are persuading to prove, for the very first time, that gravity is actually a physical force of existence. (Abbott et al. 2017).

Problems of Combining General Relativity And Quantum Mechanics

When one attempts to blend general relativity with quantum field theory, different problems emerge. In the calculation of physical quantities, a field theorist would point to the usual process for eliminating infinity. In these models, the short-distance nature of events is so abnormal that it is not possible to make accurate predictions. The principle of this approach is that of a "renormalization," where the hypothesis collapses. (Butler et al. 2018)

From a general relativistic point of view, problems regarding the causal structure of space-time when the geometry has quantum-mechanical excitations crops up. There are several problems linked to black holes, regarding the fundamental origins of it and the incompatibility of quantum mechanics with its thermodynamic properties. (Paschalidis et al.2017)

How String Theory Appearsd To Solve The Problem

Most theoretical physicists are convinced that superstring theory is the solution. String theory seems to promise that all of science can be incorporated into one supreme structure. This theory overcomes the problem of non-renormalizability by replacing point-like particles with one-dimensional extended strings as fundamental objects. While many different versions are present in practice, the essence of string theory is that every particle can be seen

to be a one-dimensional sequence with different modes of motion, depending on the basic forces of nature (gravity, electromagnetic and so on). Of purposes better explained than terms in mathematics, in addition to time and three spatial facets of daily life, the concept often demands that there be at least six specific spatial dimensions. Scientists, especially those operating the Large Hadron Collider, searched for the energy that vanishes into these dimensions, but none of these attempts was fruitful. The only drawback is that researchers have yet to provide experimental evidence for their validity—and sceptics doubt if their prediction is even testable.

In the absence of such evidence, three empirical predictions of superstring theory can be stated -

- The first is that gravity exists, as approximated by general relativity, at small energies. No other quantum theory can assert this property.
- The second is that superstring solutions typically include the gauge theories of Yang-Mills, like the ones that constituting the "standard model" of primary particles.
- The third general prediction is the presence of low energy supersymmetry (electroweak scale).

In the usual approach to quantum field theory (perturbation theory), the questions involving relativity cannot be properly addressed. But recent findings do not lead to perturbing understandings, which should help to address it. When a new theoretical idea is proposed, distinguishable experimental predictions are very desirable. Throughout superstring theory, there have been no comprehensive measurements of the properties, despite many valiant attempts, of the elementary particles or the composition of the universe.

A new paper has now suggested that calculations of gravitational waves can decisively conclude the future of string theory. This study might show the first visible proof of extra dimen-

sions, which can be described only by string theory, may be contained within the waves of gravity, but they will be squeezed so closely that they are practically imperceptible.

The string theory predicts that, during these events, waves should also propagate through the extra spatial dimensions and that the standard waves and the hidden ones (the ones travelling through other dimensions other than the 3 known dimensions) should interact in a subtle way. (Rickles, D., 2016.)

This discovery is incredibly important as Einstein's general theory of relativity does not anticipate this; which suggests that we need to update our interpretation of how gravity acts. String theory is one choice, but other competing theories also exist. The lack of interaction would help exclude or limit a glimpse into some of these hypotheses. Others remain unconvinced that the requested experimental evidence would be provided by such observations. "The question is that string theory states nothing in the context of these extra dimensions, they could be anything from indefinitely large to exponentially small, so there are not clear assumptions.", said Peter Woit, Columbia University, New York's theoretical physicist and an old sceptical of string theory. There is no reason to believe that these have anything to do with string theory if we ever see extra dimensions. (de Lacroix et al.2017)

Why Gravitational Waves May Hold The Key To Experimental Verification Of String Theory?

In 2015, LIGO made the first observation of gravitational waves, the compression and expansion of space which takes place when an object having mass moves through the spacetime. The extreme collision of a pair of black holes about a billion years ago had sent out a ripple through the spacetime as gravitational waves which LIGO's sensors had detected. Now, these gravitational waves are peculiar, as we've only seen their wavelike component,

never the part concerning their particle aspect. It is a wave and that wave is discovered to be consistent with General Relativity's predictions. They are somewhat different from their other wave counterparts we are used to, they are not scalar waves, like water waves, or even vector waves like light, with electric and magnetic fields wobbling in phase. Alternatively, these are tensor waves that trigger space to contract and expand as the wave passes through that region in a perpendicular direction. The weight of this proposed graviton particle is less than $(1.6 \times ⟦10⟧^{(-22)}$ eV$)/c^2$, and $\sim ⟦10⟧^{28}$ times lighter than the electron. (de Rham et al. 2017)

Yet, we won't be able to conclude whether the "particle" component of the wave-particle duality of gravitons until we find a way to check quantum gravity using gravitational waves.

An essential element of string theory–a possible candidate for a quantum gravity concept–are extra measurements that are concealed because they are very small. Quantum physics, incorporating quantum mechanics and general relativity was sought to understand what occurs inside a black hole or during the Big Bang at both microscopic and macroscopic level. Gravitational waves can tear through every dimension at a characteristic frequency comparable to how organ pipes of different lengths produce notes of different tone. So the difference in wavelength due to the occurrence of extra dimensions would vary depending on the energy of the collision, etc. If the extra wavelength length is believed to be very small, a sequence of higher frequency gravity waves would be expected, probably at a frequency more than a billion times higher than what LIGO now can sense. We have a few opportunities, but LIGO likely will not work in any of them. When two singularities unite, the quantum effects— which should be distinct from General Relativity— should happen just before or shortly after the fusion. Apparently, we can't use micro-to-millisecond timescales to test picosecond timescales, but that may not be unlikely. We developed laser pulses that work in

the femtosecond or attosecond (〖10〗 ^(-15) s to 10^(-18) s) so that we can be sensitive to minor deviations. Yet, theoretically it is not difficult. It is only technologically demanding! Nevertheless, it is impossible to be detected because the current terrestrial gravitational-wave sensors at high frequencies are insufficiently active, but one day a potential detector can see this.

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A Brief Sketch of the Modern Universe

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As long as we can remember, mankind has always been extremely curious about everything. And this curiosity has played a key role in our development. Our ancestors, being curious of their surroundings, learnt to stand on 2 limbs, which increased their limit to the observable surroundings. Similarly, with the advancement of optics, mankind started to try and glimpse at "The Unknown", which lies behind the blue curtain enveloping the Earth. Since then, we have not looked back. And now, we are also able to tell what happens at the "End of the Universe". But, even with so much knowledge of the Universe, we can still say that we know nothing of it.

The Universe has no end. It is of infinite volume. According to Quora, the Universe cannot be considered as a "Bubble". It exists everywhere and is approximately the same everywhere. Also, recent scientific development states, that the Universe is expanding. And not just expanding, it is expanding at an accelerated rate! But it should not be thought that the Universe is a balloon, and you blow more air into it. This just means that the distance between 2 points in the universe increases with time. The distance between Earth and the Sun, other stars, planets, etc. is increasing, with time. Quora also provides another analogy to understand this phenomenon. Consider the number line, having all the integers. It consists of the numbers

$$\ldots \quad -4 \quad -3 \quad -2 \quad -1 \quad 0 \quad 1 \quad 2 \quad 3 \quad 4 \quad \ldots$$

extending up to infinity on either side. Now consider another number line, but this one contains only the even numbers. Then we have the numbers

$$\ldots \quad -8 \quad -6 \quad -4 \quad -2 \quad 0 \quad 2 \quad 4 \quad 6 \quad 8 \quad \ldots$$

We can now say each element of the previous number line is half of each element in the second line. And also, they represent the same number line. Only the spacing changes. Similarly, in the Universe, only the distance between the objects in the Universe changes, but that does not mean that the total volume of the Universe changes (if it has one). But obviously, there are exceptions. We can say that the distance between our fingers, hands and feet do not change. Also, the Milky Way does not expand. But that does not account for much in this huge universe when we look into it quantitatively.
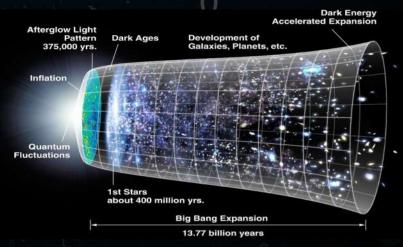

Energy conservation

$$E_T = 0 = (+E) + (-E) = \sum +m_c c^2 + \sum -m_- c^2 + \sum +K_{+m} + \sum -K_{-m} + \sum U = 0$$

Nothing   Pair Creation   Positive mass   Negative mass   Kinetic Energy   Potential Energy
   Something   Something

Fig: The concept of a zero-energy Universe

The most accepted theory regarding "The Birth of The Universe" is the Big Bang Theory, which states that the Universe was born from nothing, and a major explosion led to the Universe. This also led to the formation of the hypothesis of "Zero-Energy Universe". It may sound astonishing at first, but it is true that due to the law on energy conservation, the total energy of the universe before the Big Bang, must be equal to the total energy after it. And since there is nothing before the Big Bang (i.e. E=0), the total energy after the Big Bang must also be zero. Hence the total energy of the Universe is taken to be zero. We can say that the

Universe is made of positive matter-energy and negative gravitational energy, which are equal in magnitude but opposite in sign. However, it is also true that the concept of time started after the Big Bang, i.e. the Big Bang occurred at t=0. Now it is to be noted that, in an explosion, there is always a kind of repulsive force which pushes the matter (and energy) outward. Similarly, the Big Bang started pushing the energy (and hence, matter, according to Einstein's famous equation, E=mc2) outward and still does so today. Also, another important question must be answered:

"Many stars and other heavenly bodies emit energy in the form of light, heat, etc. This energy must travel up to infinity, until and unless it hits a surface of another star, planet, or is sucked into a black hole since energy cannot be destroyed. Where does this energy go?"

Afterglow Light Pattern 375,000 yrs.

Dark Ages

Development of Galaxies, Planets, etc.

Dark Energy Accelerated Expansion

Inflation

Quantum Fluctuations

1st Stars about 400 million yrs.

Big Bang Expansion

13.77 billion years

Well, this question must be answered within our observable universe. And for that, we must understand that light did not exist from the time the universe was born from the Big Bang. We might imagine that a blinding explosion happened at t=0, but it is not so. Though it is true that a lot of energy was indeed generated, but not light energy. Everything was dark

about 384,000 years. The first light to come into existence was when the Universe became transparent, about 384,000 years after the Big Bang. Another assumption might be taken. The Universe can be taken to be of a constant density of heavenly bodies within it. And the stars, emitting light energy, hit other non-luminous objects. Since the Universe extends up to infinity, most of this energy will be absorbed by them, just like Earth absorbs Sun's energy. The concept of a 4-dimensional space must also be understood here. To do this, let us start from the concepts of 0- dimensional analysis, and steadily move on to the 4-dimensional one.
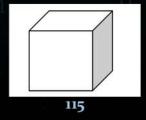
1. The definition of 0-dimension, a point (.)

2. The definition of 1-dimension, a straight line(an infinite collection of points)

3. The definition of 2-dimension, a plane(an infinite collection of straight lines)

4. The definition of 3-dimension, a volume(an infinite collection of planes)

5. The definition of 4-dimension, an infinite volume.

Thus, the Universe can be considered as a 4-dimensional volume. And we also know that light energy, when it hits a surface, produces a certain radiation pressure in it. Hence, the force exerted on that surface is the pressure times area, and this force is supposed to provide acceleration. Hence we can say that all the light energy that hits a surface of the planet is accelerating it. As the light travels from inside the Universe, the planets and other heavenly bodies, which have light striking their surface, get displaced due to the force acting on them, and since these celestial objects are accelerating with respect to one another, we arrive at the concept of an expanding Universe. However this mechanistic approach has many contradictions, hence physicists altered this theory a little bit saying that in a 4-dimensional space, an accelerating universe exists due to radiation pressure due to "Dark energy". And what is this Dark Energy? Something which we know nothing about (If there was no dark energy, everything in the Universe would collapse at one point due to gravitational attraction).

Fig: Model of Dark energy causing Universe expansion

Although the mechanistic approach here is not plausible, Einstein did mention that just as "Radiation Force" exists, there is also something called "Radiation Friction", i.e. opposition to the radiation force. This becomes extremely obvious because if nothing called radiation friction (resistance to radiation force) existed, our Earth would be displaced from its orbit

(millions of years ago, moving farther away from the Sun), and then we wouldn't be here to talk about it.

The reason why the mechanistic approach is not possible in space because the concept of force (which is the base of mechanics) is invalid in space (but it must be acknowledged that they do quite well for us inside Earth). In space, everything must be explained in terms of space-time curvature due to gravitational waves. According to Wikipedia, "Gravitational waves are disturbances in the curvature of space-time, generated by accelerated masses that propagate as waves outward from their source at the speed of light." Gravitational waves are an important consequence of Einstein's general theory of relativity. Even Euclidian geometry is invalid in space. Geometrical calculations regarding the Universe requires extensively complex mathematics for their solution.
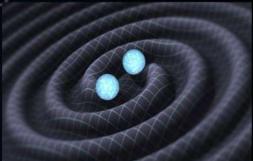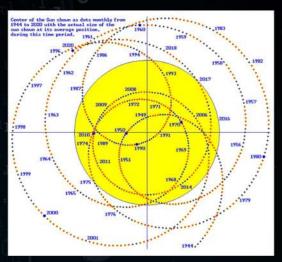

Fig: Space-Time Curvature

Fig: Gravitational waves

Let us look at another aspect of space that does very well go with Newtonian mechanics (specifically Newton's law of gravitation). We know that there is a mutually attractive gravitational force between the Sun and Earth that balances the centrifugal force of Earth. Here we consider the Sun to be practically stationary with respect to the frame of the Solar system, since $M_{Sun} >>>> M_{Earth}$ But we fail to notice here that even though the displace-

ment of the Sun is quite small compared to the distance between the Earth and the Sun, it is enough to create a "wobble" in the Sun. And the effect of this "wobble" gets more and more pronounced as we consider more and more planets into our system (which till now only consisted of the Earth and the Sun). In the adjacent image uploaded to ResearchGate by V.T.-Toth, where the centre of the Sun is mapped from 1944 to 2020, the Solar wobble can be well understood.

Center of the Sun shown as dots monthly from 1944 to 2020 with the actual size of the sun shown at its average position, during this time period.

An important point to be noted here is that when the entire solar system with all its planets is considered, the main cause for the wobble is due to Jupiter and Saturn (since they are the 2 planets with the largest mass, and gravitational force on the Sun is directly proportional to the mass of the planet). Hence from this, we can say, "Earth does not exactly revolve round the Sun" (nor does any other planet in the Solar System) since the Sun is not exactly stationary.

Now, just as this wobble affects our Solar System, the same physical consequences apply to any other system, where planets orbit a star. Also, this must be well understood that whatev-

er observations we take about the Universe, most of it depends on the light energy reaching us. And this light energy generally comes from a star. It would be inappropriate to assume that we can see faraway planets and other satellites directly, even with the most advanced telescopes available today. Then how do astronomers predict the existence of planets? A simple answer would be to check for any black spots on the image of the star we receive (which is just the planet blocking the starlight reaching us), which is almost equivalent to a solar eclipse.

Fig: A solar eclipse and another similar example

But for a faraway star, the search would only be worthwhile when the distance between the planet and the observer is quite small compared to the distance between the observer and the star to get a visible spot in the image (which is absurd) or the planet is quite comparable in size (and hence mass) to the star (which is impossible, since then the mutual gravitational attraction between them would make the star and planet collide with each other). Hence, the astronomers depend on the wobbling effect of the light coming from a star to predict the existence of planets. An important application of this process comes when the question of life in other planets arises.

CONCLUSION

So we see that our understanding of the Universe has changed a lot since the beginning of mankind's quest for knowledge. It was first believed that the Earth was stationary, the Sun moved around it. Later it became that the Earth moves around the Sun in a circular orbit, then the orbit changed into an elliptical one with the Sun at one of the 2 foci of the ellipse, and now we know that the Earth doesn't even exactly orbit the Sun. Similarly, the geometry of the Earth changed from flat to spherical, and then we added a slight bulge to it. Recent developments have rejected Newtonian mechanics in outer space. We see that, as time progresses, the Universe demands more complex and higher-end knowledge from its observers. But even after knowing so much, we know so little. The irony here lies in the fact that we know so little of the Universe, it would be nothing more than a mere assumption to predict how much we truly know about the Universe. But science does not see this as a drawback but as a challenge. And even though mankind may not be there to witness the demise of the Universe (or will it?), scientists have started to predict the changes in the Universe that will happen over the next trillions of years, until the very end of it.

One thing can be said without a doubt:

"The Universe has Only just begun."

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Russell's Paradox

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Let us begin with a story. Consider a town, where the entire population consists of males. In this town, there is just one barber (who of course is male). Given that the barber shaves only those who don't shave and an absurd law over the town which specifies that every citizen must be shaved,

A question arises...

Does the barber shave himself?

Well, if "YES", then that is a contradiction because that means THE BARBER IS SHAVING SOMEONE WHO SHAVES HIMSELF.

And if one answers "NO", that too, is a contradiction because that means someone in town is unshaved, which is against the laws of the town.

This story is a simple way to understand the paradox in question. Before I come to it, let me describe the history behind the groundbreaking counterexample paradox.

Gottlob Frega was a mathematician who throughout his life, described, defined and discovered various fundamental concepts of Mathematics. One such concept was the definition of numbers. Plato had defined numbers to be objects in the universe; I.e. he believed numbers to be 'objective truths'. Aristotle, on the contrary, defined the term 'number' to be the characteristics of various real objects in the real universe. Then there was Emmanuel Kant who believed that to understand the concept of numbers or any concept behind mathematics, we

need some kind of INTUITION.

This is where Gottlob Frege arrives. Frege disagreed with Aristotle's views of numbers being the characteristics of objects. So did he, for the concept of intuition by Kant. He said, if numbers are properties of objects, then only 'ONE NUMBER SHOULD BELONG TO ANY OBJECT AND DEFINITELY IT SHOULD NOT BE INFLUENCED BY ANY MATTER OF OPINION'.

Take a second and imagine a swarm of 80 bees. Should we call it 'A' swarm of bees? Or should we call them '80 ' bees? When we change our viewpoint, the number corresponding to the object essentially changes.

By this Frege proved that the concept of OPINION or INTUITION should be ripped off. So, he asserted that Numbers don't belong to objects; they rather belong to 'concepts'. His idea was to show that the foundation of Numbers in Mathematics is derived from logic. He called this idea LOGICISM. Frege started his quest of Logicism by trying to give a concrete definition of what a number was. It is difficult for you and me to define Numbers without using the word 'number' or a word attached to the word 'number'.

Frega defined Number by introducing the idea of 'concept' and 'extension'. A concept is any sort of idea. An extension is the set of all things that fall under that concept. For example, given the concept of the colour GREEN, its extension would be the set of all green objects. For the concept of WOOD, the extension would be the set of all wooden objects and so on. If the concept is 'rectangular squares', the extension would be an empty set. Frege said that numbers are actually 'extensions of objects'. Like the concept of extension of the NUMBER 4 would be "ALL THINGS MADE OF **** many objects"; the conception of the extension of the number 8 would be "ALL THINGS MADE OF ******** many objects".

He gave his axiom that all concepts, we can build, would have a corresponding extension. So,

the number of concepts would be equal to the number of extensions. He named this, THE GENERAL COMPREHENSION PRINCIPLE. The principle sounds reasonable. If not, can you possibly think of a concept that doesn't have a corresponding extension to it? I couldn't. This is where Bertrand Russel appears. In June 1901, when Frege was close to publishing his theory, he received a letter from Russel which shattered all his dreams and led to him being hospitalized. The letter simply read: What about the concept of the set of all sets that don't contain themselves? Does it contain itself? To explain the dilemma, let's begin by noting that we can assume all sets. Sets are the distinct collection of objects, such as the set of all frogs or the set of all computers. Most sets don't contain themselves. For example, the set of all teapots is not a teapot. So, it cannot contain itself. But considering the set of all sets that are not teapots? We ask: Does it contain itself? If it is not a teapot, it must be containing itself. Now returning to the set of all sets that do not contain themselves, does it contain itself? If it does, then it contradicts the definition of the set, i.e, NOT CONTAINING ITSELF. Hence, it must be that it does not contain itself, but then by it, the set must contain itself. Here the contradiction arises again as the set must be that it doesn't contain itself. Similarly, if the barber shaves himself, it is a contradiction; but if he doesn't shave, it is a contradiction as well. This is what Russel's paradox is all about. Since one counterexample is enough to disprove a statement, this one small counterexample by Russell was enough to shatter Frege's theory of one-to-one correspondence of concepts and extensions. Thus Frege seemed to have gradually lost his interest in various theories regarding concepts and logic of mathematics. There have been various other theories regarding the foundation of mathematics. The most popular being the Zermelo-Fraenkel set theory which puts to use a lot of Frege's actual ideas. The Russel's paradox, however, is considered to be one of the most groundbreaking paradoxes, ever, to date.

The bizarre behaviour of rotating bodies: 'Dzhanibekov effect or the Tennis racket theorem'

Sidhartha Chatterjee
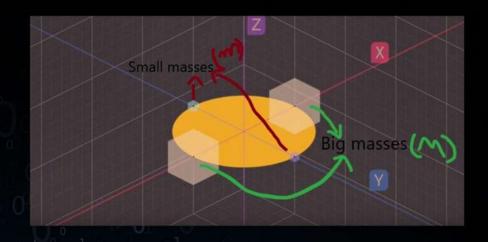
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Named after Russian cosmonaut Vladimir Dzhanibekov, who had noticed one of the theorem's logical consequences while in space in 1985, the Tennis racket theorem states that in a body with three different moments of inertia, rotation about the intermediate axis is unstable while about the other axes is stable.

This effect is fascinating because a body always rotates in the direction of rotation, but when it rotates about its intermediate axis, it sometimes turns a 180°while facing the other side forward. According to Richard Feynman, there is no intuitive way to understand the Dzhanibekov effect, only mathematical expression can explain it. But mathematician Terry Tao proved Feynman wrong. He proposed a way, rather than some mathematical derivation, but with visualization.

The theorem is important as the effect is valid for all the bodies which have three different principle moments of inertia, like our 'Earth'. So does the earth flip after certain time period? Well, this would pose a big problem for our scientific community to tackle.
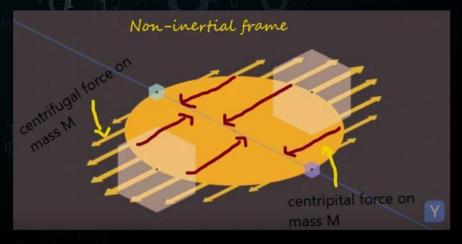
Analysing the Tennis racket theorem

In this picture, we consider a disk with two small masses lying on the Y axis, two big masses lying on the X axis and the Z axis passes through the centre of the body.
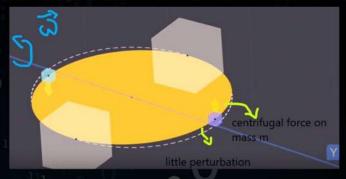
This body has three different principle moments of inertia. One is when the body rotates about Z axis (this is the largest moment of inertia as all the masses are contributing), second is when it rotates about the X axis (this is the smallest moment of inertia as only the small masses contribute) and the third is when it rotates about the Y axis (only the big masses contribute in this case).The third moment of inertia is the intermediate one.

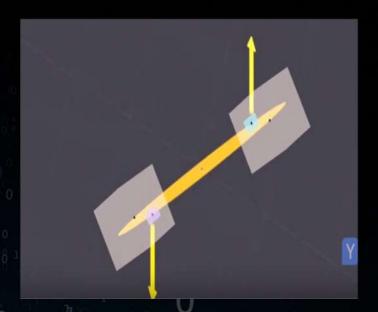So we will discuss about the intermediate axis as it causes some bizarre effect.

While rotating about the Y axis, the bigger masses experience centripetal force which accelerates them towards the centre, and they rotate in a uniform circular motion. But if we consider the non-inertial frame of reference, these masses experience the centrifugal force, which is proportional to the distance of Y axis. These two forces balance each other.

Now the two small masses experience centrifugal force proportional to the length of Y axis for a little perturbation. The tension force between the big and the small masses restrict the motion of smaller masses in the X-Y plane. Centrifugal force acting on the smaller masses, causes them to flip and their distance from Y-axis begins to increase. Maximum force is experienced when they are parallel to Z axis. As the masses move towards Y axis again the distance decreases and the force tends to zero. In this condition, the masses align on Y axis and become stable. This motion is repeated periodically.

This effect was first published in 2012 on 'ROSCOSMOS' website by the Russian space agency. A hypothesis was proposed that our planet, in the course of its orbital motion could execute the same overturn.

Worry not! The angular momentum of Earth is conserved but its energy is not, therefore, some internal energy dissipates over time. So it moves around its highest moment of inertia axis and hence we will not be in any danger.

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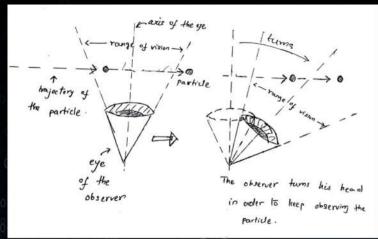
The observer-machine

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The following discussion is basically an analysis of a thought experiment. The experiment is quite simple, involving a number of observers and a moving particle. The purpose of this experiment is to understand the role of observers in physics, and finally in realising the origin of coriolis force.
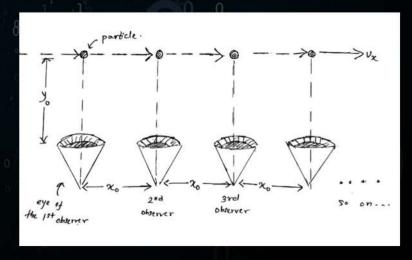
Understanding the 'observer-machine':

Consider the following statement: "An inertial observer is observing a particle, and concludes that it is moving with constant velocity". An inertial observer is, say a man with undiminished eyesight who is not accelerating. Now if the particle is either approaching or moving away from the observer, then there is nothing more to the aforesaid statement. But if the observer's line of sight is perpendicular to the particle's trajectory then a little more brainstorming reveals that a single observer cannot serve as an inertial observer. Human eyes can cover a certain range beyond which it cannot see. So, a single observer will be able to observe the particle as long as the particle is within the range. As soon as that particle moves out of this range, the observer must turn his head in order to see it. But if the observer turns his head then he is no longer an inertial observer, since rotation is not uniform motion (even if the observer turns his head with constant angular velocity, his line of sight changes direction at every instant). We must then reformulate our notion of inertial observer in the

present scenario.

The observer turns his head in order to keep observing the particle.

Let us consider an array of observers in the following manner: They are all of the same height with equally strong eyesight. All of them stand in a straight line facing the line of motion of the particle, with equal spacing say x_0 in between them (see the figure below).
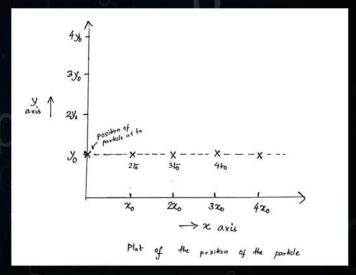
The first observer finds the particle at a distance of y_0 directly in front of him (the particle is at the same height as his eyes from the ground). He looks at his wrist watch and finds the time to be say, t_0. Now, before we proceed further, let's talk about the wrist watches first. It is assumed here that every observer has with him an identical wrist watch and that they all tick together, i.e. they are all synchronised. In other words, when the wrist watch of the first observer read t_0, so did the watches of each and every other observer.

 The next observer finds the particle to be in front of him at the same distance y_0 at an instant $2t_0$. The third observer finds the particle directly in front of him at the distance y_0 at an instant $3t_0$ and so on. These data so collected by the observers are now sent to a single person who analyses the data. This person, the collector and analyser of data is the inertial observer. Let's take a moment to understand this. It's clear that a single observer cannot be an inertial observer because of the reason mentioned above. But a linear collection of observers, now that's different. In this case, a single observer observes the position and the time and leaves it at that. Since there are a number of such observers, each one has a set of data, and no one needs to turn his head to follow the particle. We can keep track of the particle for as long as we want by increasing the number of such observers.
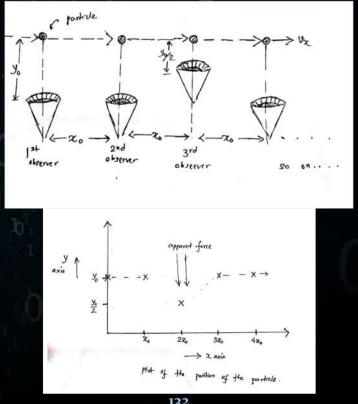
Let's call the collector and analyser of data the Observer (with a capitalized 'o'; it's kind of dramatic, that' why). He knows that the separation between each observer was x_0, and the data provided to him tells that the particle has covered equal distances (x_0) in equal intervals of time (t_0), so the speed of the particle was constant. Moreover, since every observer had found the particle to be at a constant distance (y_0) in front of them, it implies that the particle's trajectory was a straight line parallel to the linear collection of the observers. Thus it turns out that $v_x = x_0/t_0$, and $v_y = 0$. Our Observer then concludes that the particle's velocity was constant; however he is not wholly satisfied. It is so because in between two suc-

cessive observers, there was no one to keep track of the particle. One can say that the particle became invisible while moving from one observer to the next. How can one be sure that it had not changed course in that region? After all the data provided to the Observer are only discrete positions of the particle, not its continuous trajectory. Some error is bound to come into play. So, the Observer decides to decrease the separation between individual observers and increase their number. The error is somewhat reduced. In theory he can continue to do so until he gets an almost continuous array of such observers with infinitesimally small separation in between them. In reality though, if all the observers are of same width, then if they are made to stand shoulder to shoulder, the smallest separation and thus the measure of error is their body width. The error cannot be reduced further.
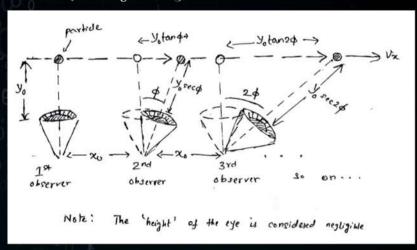

Plot of the position of the particle

The arrangement thus mentioned above is what I prefer to call an 'observer-machine'. Each individual observer works independently of each other and the data collected is sent to the Observer, it's analysed and the behaviour of the system or particle under observation is deduced. The observer-machine can be arranged in a number of ways, the simplest one being

the linear format as discussed above and the only arrangement that serves as an inertial one. Any other arrangement would be non-inertial. Here's an example to help understand this. Consider the same linear arrangement as before, but with one observer shifted towards the line of trajectory of the moving particle. If every other observer had found the particle to be at a distance of y_o in front of him, then let's say this one would find the particle at a distance of $y\_o/2$ in front of him. Thus while analysing the data, the Observer would be under an impression that a sudden force had acted on the particle at that point, displacing it momentarily. But there was no real force present and the existence of a force to the Observer is only due to the arrangement of the observers, making the observer-machine a non-inertial one.

Plot of the position of the particle.

The observer-machine as a rotating frame:

We now wish to arrange the observer-machine in such a way that it represents a rotating frame. Let's consider the following arrangement. The observers are arranged in a single file as was done previously with a separation of x0 between them. But here the second observer's head is tilted at an angle φ with respect to the head of the first observer who's looking straight ahead. The third observer's head is tilted at an angle of 2φ with respect to the first observer and so on (see the figure below).

Note: The 'height' of the eye is considered negligible

It's interesting what happens next. The first observer finds the particle at a distance y_o in front of him at an instant t_o just like the arrangement of the inertial observer-machine. But the next observer doesn't find the particle at the same distance in front of him. Since his head is tilted, he finds the particle at a distance of y_o secφ in front of him, which is obviously greater than 〔y〕_o. Also, the instant at which the second observer sees the particle is not 〔2t〕_o but something greater than that, precisely it is t_o (2+y_o/x_o tanφ). To understand how this comes about, one must realise that the particle has travelled a distance of x_o+y_o tanφ before it is seen by the second observer. Since the actual speed of the particle

(i.e. with respect to the inertial observer-machine) is x_0/t_0 so the time taken by the particle to reach from the first to the second observer is $t_0 (1+y_0/x_0 \tan\varphi)$. Since the first observer's watch had read t_0 when he had seen the particle so the next observer's watch must read $t_0+t_0 (1+y_0/x_0 \tan\varphi)=t_0 (2+y_0/x_0 \tan\varphi)$. Similarly the third observer finds the particle at a distance $y_0 \sec 2\varphi$ in front of him at an instant $t_0 (3+y_0/x_0 \tan 2\varphi)$ and so on; all these data so collected is then delivered to the Observer.
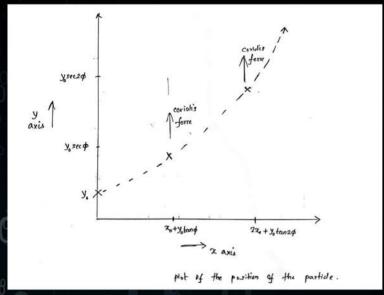
Our Observer makes the following deductions: since the particle was found at a distance of y_0 in front of the first observer but at a distance greater than 〖y〗$_0$ in front of the second observer so he readily concludes that $v_y \neq 0$, in other words the trajectory of the particle is in no way parallel to the linear collection of the observers. When the particle was in front of the second observer, the value of 〖v〗$_y=(y_0 \sec\varphi-y_0)/(t_0 (1+y_0/x_0 \tan\varphi))$.

But when the particle was observed by the third observer, 〖v〗$_y=(y_0 (\sec 2\varphi-\sec \varphi))/(t_0 (1+y_0/x_0 (\tan 2\varphi-\tan\varphi)))$, a close inspection reveals that the value of v_y had actually increased as the particle had moved from the second to the third observer. A force must have then acted on the particle along the line of sight of the observer. Further calculations reveal that the value of v_y increases continuously as the particle moves; however v_x remains constant. From the perspective of the Observer, the only explanation amounts to the existence of a force field that acts on the particle along the line of sight of the observers. This force field is known as the coriolis force field and it depends on the velocity of the particle as measured by the observer-machine and the angular velocity of the frame (i.e. the angular velocity that our observer-machine mimics). This is given by the well known relation,

$$F=-2m\omega \times V\_rot$$

Where m is the mass of the particle, ω ⊠ is the angular velocity and (V_rot) ⊠ is the velocity of the particle as measured in the rotating frame. $V\_rot=\sqrt{(v_x^2+v_y^2)}$, since v_y

changes so does ∇V_{rot} and as coriolis force depends on ∇V_{rot} so the force on the particle also changes. Thus the coriolis force field is a time dependent variable field. Also, the coriolis force changes due to the change in the angular velocity of the frame, which is the case in this scenario. Generally ω is considered constant. But with the given arrangement of the observer-machine, ω is indeed variable. We must realise that as such there is no angular velocity involved with our arrangement, the observers don't turn their heads continuously, their heads are only tilted at certain angles and they are static. But, as the particle moves from the first to the second observer, the angle of tilt increases from 0 to φ, and the time in which this happens is the time the particle takes to be seen by the second observer, i.e. $t_0 (1+y_0/x_0 \tan\varphi)$. Therefore, $\omega = \varphi/(t_0 (1+y_0/x_0 \tan\varphi))$. But this value changes when the particle is seen by the third observer, because the time taken by the particle to move from the second to the third observer is $t_0 (1+y_0/x_0 (\tan 2\varphi - \tan\varphi))$ but the numerator of ω is still equal to $2\varphi - \varphi = \varphi$.

From the vector relation of coriolis force, one can easily find the direction of the coriolis force on the particle using the right-handed rule of vector product (ω is taken to be directed into the plane of the paper since its sense is clockwise) and the reader must verify that the direction so obtained tallies with the direction of force inferred from our experiment. However, a total match of the result obtained from this experiment with the vector relation is difficult because of the fact that the observer-machine can only provide and deal with discrete data, not continuous ones. In other words, the velocity of the particle is actually an average velocity, but the vector equation requires it to be instantaneous. Thus, this experiment involving the observer-machine aims at understanding coriolis force qualitatively, rather than quantitatively. The coriolis force wouldn't have existed had the Observer known that the observers heads were tilted. But this piece of information was withheld from him and the only way he

could have reasoned out the observations was to introduce the existence of a force (although we write the expressions of time and position as functions of φ, the Observer is not aware that they are functions of φ, to him they are just numerical data supplied by the observers).

Plot of the position of the particle.

There is another point worth mentioning. It is the following: the observer-machine can observe the particle as long as the tilts of the observers' heads are less than $[90]^\circ$. As soon as $n\varphi = [90]^\circ$ (for some $[n+1]^\text{th}$ observer), that observer's line of sight becomes parallel to the actual trajectory of the particle, thus he can no longer see it; to the Observer, it appears as if the particle has accelerated to infinity.

Acknowledgements:

in writing this article. I hope the reader finds it interesting to read and ponder over.

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An introduction to Mechanics, by Kleppner and Kolenkow, pg: 359 (the vector relation of coriolis force)

Self-Driven Cars: The future of Transportation

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"Success in creating AI would be the biggest event in human history. Unfortunately, it might also be the last, unless we learn how to avoid the risks."

- Stephen Hawking

Before stepping into the broader topic, I would first like to introduce you all to what Artificial Intelligence actually is. It is James McCarthy, who coined the term, in 1956. Artificial Intelligence can be considered as an aspect of Learning or a feature of Intelligence through which machines are trained in a way to solve problems just like the human brain. Or in other words, through the implementation of AI, we can make intelligent machines mimic the functions of the human brain.

Many multinational corps have made great progress to develop AI. Organizations moving in great pace for the development of AI includes big names starting from Google, Apple, Microsoft to Elon Musk's SpaceX and Tesla and even Facebook.

"AI is one of the most important things humanity is working on. It is more profound than, I don't know, electricity or fire." Says Google CEO Sundar Pichai.

As Artificial Intelligence is related to machines, it is getting profound importance in fields like robotics, medical treatments like surgeries, and also in the automobile industry.

I would like to throw light on one such field: How Artificial Intelligence is being used in auto-

mobile industry to produce Self-Driven Cars.

Have you ever thought of a car without a driver? Well most of us instead of completely reject-
ing the fact that this idea is not at all possible, will be thinking there can be a possibility of a
technology which will allow us to make such cars in the future, which will drive on its own.
What if I told you that we have that technology and we have such cars? What if I told you that
the future is already here?

Yes. Answer to all these questions is Artificial Intelligence.

• Tesla's Model X consists of an autopilot technology.

• Peugeot's E-Legend consists of autonomous driving.

• BMW is currently developing its new model i-NEXT.

• Yandex, a Russian tech-company has developed a self-driving taxi. Being a taxi, it already
has predetermined routes and drop-off points set.

• Waymo began as the Google self-driving car project in 2009.

Peugeot's E-Legend:

It is predicted that 90% of the traffic fatalities would be reduced by the introduction of these next generation cars. Tech giants are pouring millions of dollars to develop this technology. Researchers even claim that self-driving cars are statistically much safer than traditional vehicles. Various self-driving softwares have been developed my tech companies which have been embedded in these cars. These cars consists of a variety of sensors like Uber's self-driving car consists of 64 lasers beams. Google's prototype uses other wide ranges of sensors like laser beams, sonars, radars and high power cameras to build an internal map of the surrounding. After collecting these data, its gets analysed by a central computer system and the car then decides to act accordingly, which artificial intelligence is all about. These decisions include accelerating, breaking and steering.

Obstacle avoiding algorithms help the cars to maintain the traffic rules while driving and machine learning softwares help in distinguishing between the objects/obstacles. Fully autonomous vehicles may not even have a steering wheel as introduced by General Motors.

Benefits:

• The car analyses almost everything: the road conditions, the traffic lights, the pedestrians, the turns, the other cars, speed changes, etc. Keeping in mind all these factors, it is nearly impossible for an intelligent machine to make any fatal mistake. Thus it can easily choose which path to take and which path to not. As a result, the no. of accidents will be reduced greatly if these cars are introduced.

• Peugeot's E-Legend provides an interactive driving experience with a 49 inch screen and heavy embedded speakers to watch a movie while the car drives itself. As they say, boredom is clearly not part of the Peugeot Brand's DNA.

• Tesla focuses on features like navigation on autopilot, automatically retrieving the car, auto parking facility and auto changing of lanes. Eight cameras and 12 ultrasonic sensors detect lane lines and surrounding objects—providing 360 degrees of visibility, at all times. Model X keeps you within a lane while matching speed to traffic conditions, without any driver input. Forward facing radars provide a long range view of distant objects. Ultrasonic sensors detect nearby cars, prevent potential collisions and assist while parking. The sonar fitted in the wheels senses the curbs and other obstacles.

• In Waymo, the Software developed by Google predicts the movements of everything around based on their speed and trajectory thus reducing chances of collision.

• Once introduced, they can cut a lot of transportation cost (over 50%) for some of the companies. They will also reduce the need for parking space. Smart parking features will also allow the cars to use minimal space and less time for parking.

• Autonomous cars merely execute instructions. They don't need to take breaks. We may be less conscious or may be distracted while driving but the autonomous cars are intelligent machines. They may be the perfect solution to all our problems.

Drawbacks:

• During adverse weather conditions like when its snowing and all the sensors are jammed because of cold and ice, or its raining heavily, it could be a problem to drive. So the manufacturers are trying to overcome these series of redundancies and system fails.

• People will lose jobs. We will be throwing our lives in the hands of the machines.

• Cost of these cars are going to be extremely high because of the millions of dollars of investments made by the companies.

• Critics have pointed out the fact that though it will reduce parking space, cruising across the streets will clog the streets and waste fuel.

Deshla hits the road

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While the pollution rate in India is increasing at an alarming rate, a group of students from IIT Kharagpur (KGP) has come up with the indigenous electric auto. Vikrant Racherla, an Associate Professor in the Department of Mechanical Engineering at IIT KGP, was the pioneer behind this project. While originally mentoring some students to develop electric racing cars, he directed his focus to developing an e-rickshaw. After three years of research and development, out came the Deshla from the teamwork of a twenty-member contingent (Electric Vehicle Group) headed by Racherla. It is a great step on the part of the institution towards the Make In India initiative.

With its powerful motor, lithium ion battery that can last up to 6-7 years, high load carrying capacity, sturdy frame and yet easy maneuverability, Deshla is a better option than diesel-guzzling, polluting autos and even the flimsy and high-maintenance Totos. It is not only clean and green, but it also steals a march on both when it comes to the issues of safety, reliability, performance, and comfort.

It uses lithium-iron-phosphate batteries that last for 6-7 years. Deshla's batteries are more expensive but given their long life, it gains in the cost-benefit analysis. Besides, they provide a uniform power delivery unlike lead-acid batteries, giving a uniform performance. In lithium batteries, a 10-degree Celsius drop in operating temperature can increase battery life by

about three years- a huge value addition for the end user. Customers will have to charge their batteries for 4 hours at home.

Deshla's battery can provide a higher amperage and easily powers the 3.5 kW motor, which in turn provides more torque, and therefore, higher speed. Deshla can travel at a peak speed of 50 km/hr, which is higher than the e-rickshaws which we already have.

Deshla has a steering wheel that works on gear mechanism with high mechanical advantage. This was a conscious decision of the team to make it impossible for the vehicle to make very sharp turns which autos are infamous for. The gear mechanism allows for only one-way motion. So bad roads will not automatically turn the steering wheel of Deshla. Hydraulic braking instead of mechanical braking is used for more effective braking. Deshla's back wheels have independent suspension, making Deshla far more stable and jerk free on bad roads.

Deshla is completely an indigenous device. The EVG team of IIT Kharagpur has created the embedded and power electronics subsystems like BMS (battery management system), Motor Controller, Battery Charger, GPS and 3G Cellular connectivity modules in-house. This means the Deshla will be more reliable, easy to service/repair, and customizable.

As Prof. Vikranth Racherla, Professor of Mechanical Engineering and PI of the project, put it, "Instead of retro-fitting an existing vehicle, we thought we would build one up from scratch, especially because the design is so important for an electric vehicle. It was also important for the students to learn to do things from scratch... Each design has been conceived, analysed, prototyped and the cycle repeated many times before the actual product came out."

Around 50 students from various backgrounds have been associated with this project since its inception three years back. Two students who graduated in 2018 have even stayed back

on campus to steer the project together with Prof. Racherla. The project has also attracted interns from various engineering schools across the country.

Prof. Partha Pratim Chakrabarti, former Director, IIT Kharagpur mentioned in his social media post that the ride was excellent. He also said, "... going from here to a start-up is the way to go ... we must develop technology which is very good and spawn as many start-ups as possible."

Thus far, the team has conducted successful user trials, and developed the embedded and power electronics subsystems such as motor controller, battery charger, 3G cellular connectivity modules, GPS and a battery management system.

Prof. Racherla, Shyama Agrawal, and Manuj Agrawal (leaders of team EVG) have already floated a start-up for commercialization of the vehicle. They are planning to raise a seed of 3 crores. It seems that it is only a matter of time that this Indian Deshla hits the road with a bang.

Reference: http://www.kgpchronicle.iitkgp.ac.in/deshla-hits-the-road/

Post-Quantum Cryptography

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Cybercrime is the largest threat in the world and one that is still growing rapidly. With the ever-changing dynamics in the field, it becomes harder to catch these criminals. In such times when we get the news that there is a new kind of computer already in the market that can break most of our encryption systems, we are put into a frenzy.

A quantum computer is an electronic device that uses principles of quantum mechanics to carry out tasks that even the most powerful of supercomputers can't.

So, we all know that a regular computer translates all the data input into it into long sequences of 1's and 0's and these "bits" tell the computer what to do. Quantum computers perform calculations based on the probability of an object's state before it is measured- instead of 0's and 1's-which means they have the potential to process exponentially more data compared to classical computers. This is possible due to the phenomenon called superposition. To understand superposition, here's a way to look at it.

When we toss a coin, there are only two outcomes possible, heads or tails. That is how a regular computer works, with 1's and 0's. Now imagine that you are spinning the coin. At the exact moment when the coin is spinning, we can't tell if it is heads or tails. While it is spinning, it is both heads and tails or as in a quantum computer, both 1 and 0. This is called superposition. This phenomenon was first noticed by Werner Heisenberg. He said that for

sub-atomic particles, it is impossible to determine the velocity and position of that particle at the same time. This phenomenon is actually applicable to all objects in the universe but for objects like an automobile, the uncertainty quotient is so small that it is negligible. Now what a quantum computer does is that it controls the environment such that subatomic particles like electrons and photons are in a quantum state or in a state where they are both 1 and 0 at the same time.

With this phenomenon, it becomes fairly easy to do any task where we have multiple options and we need to figure out exactly the right combination to get optimal results. The problem with our current encryption technique is that it is based on one of the following hard mathematical problems: the integer factorization problem, the discrete logarithm problem or the elliptic curve discrete logarithm problem. We use these problems to encrypt our messages. These schemes are used by most of our day-to-day higher-level security applications including Wickr, SSh, TLS, HTTPS, Bitcoin, PGP and VPNs. All of these problems can be solved easily on a sufficiently powerful quantum computer running Shor's algorithm.

Every number theoretical mathematical problem that we have been using over the last 40 years as a foundation of our security can we solved using a powerful quantum computer and some variant of Grover's Search algorithm.

What we need is a new crop of mathematical problems and matching cryptographic schemes which are hard to solve (and thus secure) even in the face of quantum computing.

Millions of dollars have been put into finding and testing new algorithms that cannot be broken by the quantum computer. One of them is Lattice based cryptography.

This is the most popular form of post-quantum encryption. Crypto schemes in this area come equipped with security proofs that relate their security to hard math problems around lattices. A lattice can basically be thought of as any regularly spaced grid of points stretching

out to infinity. To understand how this works let's look at an example. Suppose we take a 2-dimensional lattice, like the plane of a paper with points made on it.

First, we choose two points that don't happen to lie on a single line that goes through the origin.

For example, we could choose (2,0) and (0,2). Here are how these points can be used to generate a third point:

- First, we choose two whole numbers; say, 3 and -1.
- We multiply the coordinates of the first point by 3 to get the point (6,0) and the coordinates of the second point by -1 to get (0, -2).
- Now we add the results together to get our new point (6, -2).

Using this method, we can use (2,0) and (0,2) to generate an entire grid of evenly spaced points, namely all those with coordinates (x,y) such that both x and y are even numbers where we also count 0 as an even number. In other words, the basis (a small collection of points that can be used to reproduce any point in grid that forms the lattice) consisting of vectors (2,0) and (0,2) generates the lattice points with even coordinates. This lattice acts as the encryption for the original 2 points (2,0) and (0,2). This seems like an easy encryption to break when we think in terms of 2 dimensions but when it comes to cryptography, we're really talking about lattices in much higher dimensions (e.g. 10,000). That means that our points actually have 10,000 coordinates, not 2 coordinates. So, finding a combination of the points that simultaneously make all 10,000 generated coordinates turns out to be quite hard, so much so that we don't know how to solve the problem quickly even with a quantum computer, let alone a conventional one.

There is still a lot of mathematical proof that needs to be derive but then again, a quantum computer that has the potential to hack into current computers is still at least a decade away.

The chances of our data being unprotected at the advent of quantum computers is negligible.

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Interrogating Authenticity

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The term 'authentic' is used either in the compelling sense of being "of irrefutable origin or initiation", or in a feeble sense of being "faithful to an original" or a "reliable, adequate representation". When you define a term that is controversial in itself, it comes with the risks of opposing it while defining it. Authenticity is a subjective constituent in the spectrum of human psychoanalysis. It characterizes an anomaly such that what might be genuine to one might not be to another. But to what extent are these notions intersubjective?

Even though the science of authenticity has surged in recent years, the more that authenticity is scrutinized under the microscope the more blurry the definitions become. Prevalent notions about authenticity are being revoked and renewed, so what seemed like a transparent analysis has now become an obscure hypothesis.

"Given the complexity of people's personalities, two seemingly incompatible actions might both be highly self-congruent. People are simply too complex, multifaceted and often conflicted for the concept of a unitary true self to be a useful standard for assessing authenticity, either in oneself or in others."

- Katrina Jongman-Sereno and Mark Leary (The Enigma of Being Yourself)

The term "social media" coined in the Internet era specifically refers to the web-enabled interactive media. The two features dominating today's social media are immediacy and lack of real-time control. With a ceaseless and regenerating feed of information every minute of every day, it isn't shocking when our thought processes are manipulated to compile in the same wired format. However, we know that authenticity is a fundamental question to human existence, regardless of any technology or media.

"An authentic self is a norm, a rule, a form of living-in a place, a form of living through instruments, and a form of living-with instrumental ties. Social media is a relatively new method or way of living: in a virtual place, through technology, and with virtual social ties. They are merely the new tools for living in this widely connected technical modern world, either authentically, or not."

In this age of social media, it is difficult to recognize what could be authentic. Everyone attempts to distinguish the 'fake' from the 'real' without grasping the concept of what 'real' really is.

The immediacy and pervasiveness of social media with its heightened interactions between self and others, serves as a platform for the in-betweenness, and thus the more frequent evaluation of the gap between inauthentic decisions. If technology is constructed in an authentic context and is restructured systematically, it allows for reflection on self and others. It serves as a mediator between the supposed authenticity and the use of technology (such as social media).

"A frequently stated fret with the ideal of authenticity is that the attention to one's inner feelings and attitudes may result in a self-centered engrossment with oneself that is anti-social and destructive of compassion toward others."

On closer introspection, what people refer to as their "true self" really is just the aspects of themselves that make them feel the best about themselves. Intentions, desires and commitments are postulates that engulf the core idea of authenticity that often outweighs the restrictions of radical contemplation. The principal nature of these intentions are crucial for the coherence of one's absolute recognition such that overshadowing them would result in the degeneration of the very self that is the prime moral agent.

With the basic idea behind authenticity and the basic need to interrogate it, a discussion of its segment of 'scientific authenticity' seems inevitable. In a writing by Philip Kanarev, a practicing physicist, who is concerned with the demise of scientific thinking and teaching, he says:

"A conjunction of scientific results in the 21st century has reached a level that provides an opportunity to find and to systematize the scientific authenticity criteria of precise knowledge already gained by mankind."

The idea of autonomy—the view that each individual must decide based on his or her own rational deliberations about the best course of action—has in many ways paved the way for the idea of authenticity. It offers us grounds for elimination of the authority of any former, present and future scientist from any scientific authenticity criteria and thus, makes it possible to establish an estimation of the results of scientific investigations. A certain level of knowledge being accumulated over time allows us to solve a problem in the first approximation.

Euclid, a Greek mathematician who established scientific knowledge in the 3rd century BC, is a founder of the formation of authenticity criteria for scientific results. He was the first to pay heed to the necessity of giving a precise definition of scientific knowledge, because it is impossible for all other scientists or investigators to have a similar understanding of the essence of a phenomenon or a process under analysis.

However, neither Euclid, nor Newton gave precise definitions of the notions revolving an axiom, a postulate and a hypothesis. Consequently, Newton referred to his laws as axioms, contradicting the Euclidean ideas concerning the very essence of axioms. To abolish these confutations, it was essential to give a definition not only to the concept of the axiom and postulate, but also of hypothesis. This necessity is governed by the fact that any scientific research begins with an assumption regarding the reason causing a phenomenon or process being studied. A formulation of this assumption is a scientific hypothesis. Thus, the axioms and postulates are the main criteria of authenticity of any scientific result.

An axiom is an obvious statement. It requires no experimental check and has no exceptions. Absolute authenticity of an axiom appears from this definition. It protects it by a vivid connection with reality. As used in modern logic, an axiom is a conjecture or starting point for reasoning.

A postulate is a non-obvious statement, its reliability being proven by experiments or a set of theoretic results originating from the experiments. Postulates are the basic structure from which theorems are derived including the whole of Euclidean geometry, which is based on five postulates known as Euclid's postulates.

Time appeared in space only after matter. Yet, we do not know of a source that produces elementary particles – building blocks of the material world. That's why we have no reason to consider that matter is absolute. However, it does not prevent us from observing an interconnection of the primary elements of the universe: space, matter and time. They exist only simultaneously and irrespective of each other. This lucid fact is why we consider a permanent existence of space, matter and time as an axiomatic one.

Science has a rather concrete list of criteria with respect to estimating and evaluating the authenticity of scientific investigative results. It requires fidelity to axioms and postulates de-

scribing natural realities, insisting that hypotheses be validated by experimental results. For testing scientific authenticity, axioms occupy the first place, followed by the postulates. If a new theory is in conflict with at least one axiom, it will be rejected immediately by the scientific community without discussion.

Coherently, we can say that the science of authenticity behind one's true self has become an implicitly critical concept, often calling into question the existing social order and public opinion. Even without the explicit existence of the 'real self ', a link with one's mindfulness reliability of spirit serves as a strong predictor of the many measures of well-being.

Healthy authenticity is full acceptance of all conflicting and complex charades. It underlines the dismissal of the negative facets and encapsulates the positive nuances. It is pivotal to discover solitary ways to advance in the direction of who an individual truly wants to be.

Perhaps, to actually attain and understand every aspect of authenticity one needs to first decipher what inauthenticity is. In the midst of contemporary thinking, authenticity is perceived as a term referring to a way of an individual's consciousness which builds an entity that is worthy in itself.

"The curious paradox is that when I accept myself just as I am, then I can change."

- Carl Rogers.

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Quantum Computing – Larger than Life, Trapped in Hype and Hope

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We humans, with our relatively limited access to the universe, can see far beyond our horizons just by using our imagination and ingenuity. And the universe rewards us by showing us how incredibly interesting and surprising it is. The future is fundamentally uncertain and that's what makes it certainly exciting. Quantum Physics describes the behavior of atoms and fundamental particles like electrons and protons. A quantum computer operates by controlling the behavior of these fundamental particles in a way that is completely different from our regular computers. The classical computer is made of circuit chips having basic modules made of logic gates composed of transistors. As transistors are shrinking to the size of only a few atoms, electrons face quantum tunneling and hence we might reach a physical barrier to technological process.

Where's the trick?

Quantum Physics in Action!

A quantum bit has a fluid non-binary identity. It can exist in a combination or superposition of 0 and 1 with some probability of being 0 and some probability of being 1. Its identity is it is a spectrum. The possibilities are endless. An orbit can be any 2-level quantum system such as spin in a magnetic field or a single photon. 0 & 1 are the system possible states like the photons horizontal or vertical polarization which we call 'superposition'. But in its final state by sending the photon through a filter, the quantum computer can unmix the 0,1 - the resul-

ant can be either vertically or horizontally polarized .i.e. it collapses into one of the definite steps but as long as it is unobserved, the orbit is in a superposition of probabilities for 0 & 1 . We cannot predict which it'll be. It's this uncertainly that brings out the magic. Four classical bits can have one of 24 configurations at a time but 4 qubits in superposition can be in all of those 16 combinations at once. This number grows exponentially with each extra orbit. Twenty of them can store a million values at once. The amount of equivalent classical information contained by N qubits is 2n classical bits.

Another really weird and unintuitive property qubits can have, is entanglement- a close connection that makes each of the qubits to react to a change in the other's state instantaneously no matter how far they are. This means that while measuring just one entangled qubit, one can directly deduce properties of its partners.

Qubit Manipulation:-

A normal logic gate gets a simple set of inputs and produces one definite output.

A Quantum gate manipulates an input of superpositions, rotates probabilities and produces another superposition as its output. By proper exploitation of superposition & entanglement, we can get an entire set of calculations that are possible at the same time and this can exponentially be more efficient than would ever be possible on a normal computer.

Field of Renaissance: -

• Quantum Encryption: Quantum uncertainty can be used to create private key for encrypting messages sent from one location to another so that hackers cannot secretly copy the key perfectly.

• Diagnosis & Pharmacy: Design and analysis of Drug development is a challenging prob-

lem today because exactly describing and calculating all the quantum properties of all the atoms in the molecule is a computationally difficult task even for our supercomputers but not for a quantum computer because it operates in the same quantum properties that the molecule is trying to simulate. Future large-scale quantum simulations for drug development could treat diseases that affect thousands of lives.

- Quantum Internet: – Simulating a quantum network on a quantum computer Teleportation of Information from one location to another without physically transmitting the information because the fluid identity of the quantum particles can get entangled across space and time in such a way that if we change something about one particle, it can impact the other and that creates a channel for teleportation.
- Database Searching: A normal computer may have to test each and the entries but quantum computers need only square root of the time.

What are we waiting For? Superconductivity can be used to create a qubit and maintain a quantum state. To work with these superconducting qubits for extended periods of time, they must be kept at temperature close to Absolute Zero. A way to combat quantum decoherence (to stop superposition and obtain a definite state as a result) is supercooling but that is impractical for commercialization. Also, there are methods like quantum error correction to combat decoherence. This works on paper but not to the level of precision which is required to get a quantum computer. It will be a challenge to scale up to a size that is useful. Thus, computer is wrapped between hype and hope.

Potential sole superpower??!

A quantum computer is not just a more powerful version of a current computer just like an

electric bulb is not a more powerful candle. It is a different technology based on deeper scientific understanding.

It is not universally faster; it is helpful only when we have all the quantum superpositions available at the same time for some kind of computational parallelism. If you want to watch a video in high definition or browse the internet or write a document, they would not give any classical algorithm to get the results; but it is a computer where the number of operations required to arrive at the result is exponentially small. So, the improvement is not in the speed of individual operations but in the total number of operations we need to arrive at the result.

As explorers in the quantum wonderland, we need to tread carefully and responsibly towards our quantum future. Let's see quantum computers as a way to probe the mysteries of nature and reveal more about the hidden world outside of our experience.

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Environmental Benefits To Economic Prosperity

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"It's not just the effect of technology on the environment, on religion, on the economic structure, on society, on politics, etc., it's that everything now exists in technology to the point where technology is the new and comprehensive host of nature of life."

Godfrey Reggio

Since the inception of mankind, human beings have aimed at growth and development for which they have used technology as a helping tool. But have we ever considered the social and environmental costs of using those infrastructures? The answer is probably no. But it's high time to take into account the costs and benefits of using technology because we should remember that we are the ones who must control technology, not the reverse.

Technology And Economic Growth:

To summarize the role of technology in the economy, we can say that technological develop-

ment increases the profit and market share of a firm at the micro level and as a whole accelerates the growth rate of the economy at the macro level.

According to the classical growth theory, technological improvement induces the productivity of workers thus increasing the growth rate. Similarly, the neoclassical theory also points out that technological transformation increases the income of an individual per capita and motivates savings and investments thus resulting in an increase in real GDP. Thus, it is clear that scientific technological change ensures economic growth and development.

Technology And Environment :

Technology certainly boosts the economy but we often ignore the social and environmental costs of infrastructural changes. We forget that human beings are mere guests on this earth; we've ignored being a part of it as a whole.

Primarily, technological advancements in the 1880s caused the Second Industrial Revolution but it proved to be detrimental to climate change by increasing carbon emissions. Nobody is ready to sacrifice their quality of life expecting that everybody else is already doing that, be it an individual or a firm. This selfish approach towards the environment increases the magnitude of the problem. Most of the activities that cause global warming are done in the name of economic growth. We do not use alternative technologies to fossil fuels as it may decrease the output, boosting unemployment and causing huge losses for the firms.

Economy And Environment :

There's often a trade-off between environmental protection and economic development. For example, if a factory is forced to shut down due to higher emission of pollutants, then it affects its workers. But if the matter of employment gets prioritized then Mother Nature is

harmed.

It has been shown in a survey that the pollution level in developing countries is higher than that of the developed countries. This may be because not only have developed countries exported their largest polluters to the developing countries but the developing countries have also failed to regulate power plant and auto emissions.

Hence, the economy and the environment seem to share a dynamic yet a very perplexing relationship between themselves.

Remedy And Policy-Costs And Benefits :

In the present era, protecting the environment for the sake of our future is undoubtedly one of the major priorities of the government and policymakers. For this purpose, countries and various health and environmental organizations are defining and listing various regulations with their cost and benefit analysis.

We need to identify the economic activities which can create value from some of the opportunities that global warming brings about. We cannot deny the necessity of economic growth, what we can do is change and adapt the ideas and procedures behind it by replacing with the technologies that contribute to the problem to a lesser extent. But the shocking fact is that some of the entrepreneurs treat global warming as an important opportunity to generate income in exchange for a net environmental improvement.

However, the government may play an efficient role in tackling this trade-off. By imposing rules and laws and enforcing standards, pollution can be reduced while at the same time the workers can be compensated and offered alternative means of employment. However, government regulations requiring pollution control are generally technology based. As a result, a marginal company with a low budget will not last in the long run. But an investment in en-

vironmental cleanup stimulates other upgrades that make the businesses more competent in the global market. Regulations are on various issues viz. on climate policies, waste management, clean water, on the use of resources efficiently and many more. Now the question that arises is, how many comply with the regulations and how many do justice to them, what are the costs and benefits of such regulations.

World Health Organization (WHO) has created guidelines for public health policymakers and for the general public which are often followed as baselines. Other than that, different countries have enacted various laws for such regulations. The Clean Air Act and the Clean Water Act have been implemented by the USA which set the standards for the reduction of pollutants.

The developed industrialized nations form different organizations but they often fail to meet various standards set by the world organizations. The industrialists and capitalists try to form a consensus that different norms if followed will cause irreparable damages. But it's not always true. Many studies have shown that the norms if followed may lead to near-zero costs in the long run. For example, carbon taxing leads to coverage of the total social costs which should be done. In economic theories, it is known as internalizing negative externalities. It is often recommended to use higher graded materials to lessen the emission of harmful substances. Again, in the less developed nations with a lesser amount of capital and modern technologies it becomes difficult to comply with the health and environmental standards. Moreover, due to lack of awareness and education, the citizens do not pay much attention to maintaining environmental standards.

Certain stringent laws indeed add to the producers' costs reducing their profits and making them reluctant to comply with the laws. But if the government imposes such laws, it won't bring any close down production. In the modern world, people with rising incomes are ready

to pay for better commodities. Also, in the long run, it will not affect the costs much. Such measures bring sustainable business. When a company follows such regulations it forms goodwill of its own and its products are considered to be much better than others. Producers allocate scarce resources more efficiently while complying with the regulations. This leads to sustainable development. These are major benefits that corporate houses enjoy. Overall, people would lead better lives, have better health and have better human capital which would increase the productivity of the economy.

While moving towards a green economy for the market, green technologies are also created which if produced domestically can benefit the country much more. This can create more jobs and make people more aware. That is to say, if by the laws we can create more consumer demand for such products then it will promote more economic activity.

Alongside this, we should consider the costs of such environmental regulations. It is not always possible for a growing, less developed country to comply with certain rules. Also for small businesses, it is quite difficult to finance advanced technologies and capital requirements to maintain the norms. Not only are the capital costs are huge but in some cases, the opportunity cost is also quite huge for small firms with limited labor and capital resources. The time spent on doing the necessary paperwork among other things is not considered beneficial. This makes many firms disregard most of the norms. So, we should create more innovative and inexpensive methods for the prevention of pollution and maintenance of sustainable development.

It should be noted here that most of the organizations, even the EPA, should sometimes consider private costs and not social costs. Occasionally, these social costs exceed private costs. In fact, environmental regulations are more dynamic in the process. The inter-temporal costs should also be considered in the process; without which the concerned authorities

think that they have made sustainable rules but in reality, the producers and consumers suffer from them. This leads to further disappointment at the ground level. Thus, the authorities must have such rules and regulations which can actually be followed by the firms and producers without creating much disagreement among them.

 Some environmental plans may not even work to their full potential. So it should be well analyzed before implementing the program. Finally, such regulations should be made that can be easily realized because we all want a better future, in which our successors can live peacefully and happily.

Dice Model :

In this context, William Nordhaus' work is worth mentioning. Using Dynamic Integrated Climate Economy (DICE) model, he tried to estimate the economic cost of climate change by not only calculating the social cost of carbon but also examining the 'feedback loop between human activity and climate'. Thus, he developed a method of analyzing the effect of environmental degradation on economic growth which became a tool to measure the damage caused by climate change and hence designing climate policy as a remedy. We cannot deny the fact that environment and economic growth put some inexplicable negative externalities in front of each other but we need to learn how they can be evolved together under different future assumptions and this model sheds light on that ocean of thought.

Crux :

So now we are summing up our discussion so far. As a solution for the global village, two things are necessary-

i.   Building and innovating technology which will lead to higher output generation, but

remain eco-friendly as well. Thus, we need technology that will keep the growth rate of the economy at a good pace and won't affect the environment adversely. Now such technology demands heavy public spending on educational and research facilities of a country. Higher government spending on education along with the better formation of human capital is necessary for such innovation of technology. Petty issues and profit-maximizing motive of private investors should not affect the economic policies in this regard.

ii.   Role of public policy to strengthen the need for making a greener economy. The government has to keep a vigil notice on how the economic agents are working and if they are following all the norms. Apart from that, the government needs to do a continuous evaluation of the methods being developed and followed in pursuit of getting a better and greener economy. In fact, such investment spending will also provide the necessary stimulus for the growth of the economy. Besides, such public investment which leads to the betterment of the economy may lead to crowding in private investment in the long run.

Conclusion :

The primary focus of this article was to link the environmental benefits to economic prosperity. Standing in the 21st century we cannot think of a life without technology nor can we deny the importance of economic growth and development. But at the same time, a sustainable environment is also necessary to accelerate and strengthen that development. Different eco-friendly economic policies have already been adopted in this regard. Sustainable consumption and production (SCP) is targeted in the production pattern. Investments have been ensured to promote income and jobs in the green economy. The government is also playing a significant role but the most important thing that can maintain the equilibrium threshold is individual awareness and the desire to maintain sustainable development. Then

only we will be able to leave a planet for our future generations which is both economically and environmentally rich.

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The Brief History of the Nobel Prize

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We have all heard of the famous chemist and inventor Alfred Nobel most famously known for the invention of dynamite and thus starting the first transition into weapons and explosives manufacture through the invention of several chemical explosives of which Nobel had patented a mind-boggling 355. Through all his inventions and the subsequent rise in demand of armaments for the tumultuous war spread times of the late 19th century where countries and republics were developing their defense sector, Nobel had earned a huge fortune of money through the manufacture and sales of all his chemical explosives.

In the year 1888, a certain French newspaper had published the obituary of Alfred Nobel where the headline stated: "The Merchant of Death is dead". However, it was Nobel's brother, Ludvig, who had died and thus the obituary for Alfred Nobel was premature. Nobel was shocked when he had read this and pondered about the legacy that he was going to leave behind and left him extremely concerned. He was filled with extreme remorse about what he had done and how his inventions had become the medium that brought on the death of people. This inspired him to change his will. Nobel penned his last will a year before his death on 10th December 1896. The will he penned was signed to a Swedish Norwegian club in Paris in 1895. To the widespread astonishment of the people, Nobel had instructed that 94% of his fortune, which amounted to $186 million, for the creation of a series of prizes. He instructed that these awards be given to the people who bestow the "Greatest benefit on

mankind". The will was not approved at first owing to the skepticism surrounding the will. The executors of the will, Ragnar Sohlmann, and Rudolf Lilljequist had therefore formed the Nobel Foundation to manage the fortunes and to organize the awards. Nobel had given a certain emphasis on the Peace prize as an act of retribution his invention which had brought on a lot of suffering for people.

The Nobel Prize Foundation was founded as a private organization on 29 June 1900. The first awards were presented in the year 1901 where each recipient of the prize received 9 million Swedish Kronor amounting US$ 986,000. The prize money is shared in the case of multiple recipients of the award. The Nobel Prize in Physics, Chemistry, and Economic Sciences are presented by the Royal Swedish Academy Of Sciences, the prize in Medicine given by the Karolinska Institute, the prize in Literature by the Swedish Academy and the Peace Prize given by the Norwegian Nobel Committee as specifically mentioned by Nobel in his will for the Peace Prize. Later on, in 1968, Sveriges Riksbank, the central bank of Sweden established the Sveriges Riksbank Prize in Economic Sciences in honor of Alfred Nobel. The prize for Economics happens to be the only one which has been awarded all the years after its establishment while the other prizes were not awarded in several years as the Nobel Foundation had a condition that "If none of the works under consideration is found to be of importance, the money shall be reserved until the following year. If even then the prize can't be awarded, it should be added to the restricted funds of the Foundation". Other conditions like the World Wars have also prevented the awarding of the prizes. Since the establishment of the prize, a total of 590 prizes to 935 laureates.

Malala Yousafzai in 2014 was awarded the Nobel Peace Prize and thus became the youngest to ever do so beating out Physics Nobel laureate Ernest Lawrence for the youngest. On the other hand, John B Goodenough is the oldest to have ever won a Nobel Prize when he

won the Chemistry award in 2019 at the age of 97 years.

The International Committee of the Red Cross has won the most Nobel prizes with 3 Peace prizes awarded to it. The first Nobel Peace Prize was awarded to the founder of the Red Cross, Henry Dunant. Four Individuals have been awarded the Nobel Prize twice. The first person to have won it twice was Marie Curie for Physics in 1903 and Chemistry in 1911. Linus Pauling had won the Chemistry and Peace awards in 1954 and 1962 respectively. John Bardeen won the Physics award in 1956 and 1972 for transistors and the BCS theory. Frederick Sanger won the Chemistry prizes in 1958 and 1980 for his work in Protein Structure and Insulin and the latter for his work on recombinant DNA.

Though Alfred Nobel had started the trend of weapons manufacture and may have laid down the materials for mass destruction, later on, he had realized about the legacy that he was going to leave behind and thus felt remorse. To atone for this, he had set up the Nobel Prizes that we have today which serve to encourage people to do work for the benefit of mankind and improve the world we live in. Hence it can be safely said that Nobel's legacy will live on.

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Breakthrough

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(This is a personalized account of the life of James Allison as heard while attending a seminar of one of his Ph.D students Dr. Dipankar Nandi, Dept. of Biochemistry, IISc Bangalore.)

The Nobel Prize in Physiology or Medicine 2018 was jointly awarded to James P. Allison and Tasuku Honjo "for their discovery of cancer therapy by inhibition of negative immune regulation."

To begin with what led to this magnificent discovery, several years of consistent effort, hard work and sheer intellectual brilliance of numerous people cannot and should not be undermined. For context, over decades, scientists have been striving to answer one of the most important and difficult questions of biology till date: How to cure cancer?

This question has been attempted by several generations of scientists and it is safe to say that forms of the cure have been outlined at present.

The common cancer therapies proposed till date are:

1. Surgery

2. Radiation

3. Chemotherapy

4. Hormone Therapy

5. Immunotherapy

Out of all the suggested therapies, immunotherapy had been considered as a "scientific

red-light district... and a landscape littered with hulks of abandoned hypotheses and charred reputations."

However, it is to be understood that many cancers protect themselves from the immune system by inhibiting the T cell signaling.

Jim had stated while working on Immunotherapy:

"People were skeptical of immunology and immunotherapy. They would say, 'Oh, anybody can treat cancer in mice.' Sometimes they'd say, 'You think you can treat cancer by just removing this negative signal on a T-cell?' "

Quite surprisingly, that came out to be true!

Jim had recounted as a then biochemistry student at the University of Texas, Austin,

"The professor that taught me immunology in undergrad wasn't even sure that there was such a thing as T cells, much less whether they had a specific receptor that could recognize things."

So, one day, he decided to attend a talk by Irv Weissman, following which he developed an idea of how to identify a T-cell antigen receptor and started working on his idea leaving aside everything else.

 Jim was the sort of person who had either straight A's or D's on his transcript, nothing in between. This was because he never did anything half-heartedly, and put significant effort into things he loved doing. He had a strong respect for the individual drive of a person and believed that the phone was the best instrument for a scientist!! (He was referring to telephonic exchange of information with scientists all over the world.)

He had initially enrolled in college as a premed major, but watching his father as a doctor, he opted out of it.

"..I realized that doctors have to be correct all the time. They have to diagnose what's going

on, pull out an algorithm they've memorized, and apply it to the patients.

In science, you don't have to be right. You have a hypothesis, and you test it, and you only have to be right some of the time. I thought that being wrong a lot was more fun."

With his quirkiness and level of intellect, he also played the harmonica, was a member of their college band and worshipped Willie Nelson.
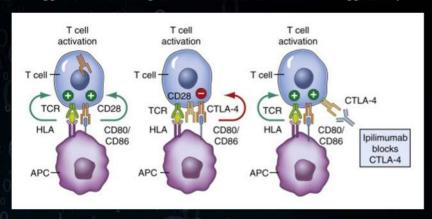
Soon after, he published his paper as an assistant professor on the diagonal analysis of labelled cell surface antigens which the community realized to be the first sight of the elusive T-cell receptor! Almost immediately, he was offered a job at the University of California, Berkeley. Jim joined Berkeley in 1984 and started on his research at full pace. This research was quite personal to him, as his mother had died of lymphoma, and his brother had been diagnosed with prostate cancer after which he died too. He was determined to find a cure for this, and this is the only road he knew he had to take.

He was the first person to introduce the concept of co-stimulation in T cells. But why co-stimulation? When a T-Cell interacts with an antigen presenting cell (APC), there are certain signals that upregulate or downregulate their interaction. This was of particular interest to Allison and he set out to find a response in the T-Cells that would potentially enhance the anti-tumor responses so that cancer can, in no way, evade the immune system of the body. He found out that CD28 (Cluster of Differentiation 28) was expressed by both resting and activated T-Cells whereas CTLA-4 (cytotoxic T-lymphocyte-associated protein 4) was expressed only by activated cells.

Therefore, CD28 was the accelerator whereas CTLA4 was expressed later during T cell activation and acted as the brake, i.e. reduced activation. This was the basic concept in anti-CTLA4 or anti-PD1 working as check point inhibitors to increase anti-tumor T cell responses.

In 1998, a small company Medarex, bought the patent from UC Berkeley and made human

antibodies to CTLA4, using mice with human Immunoglobulin genes. Thus, started the initiation of clinical trials with humanized anti-CTLA-4 and MDX-010 known as Ipilimumab. In 2004, Bristol-Myers Squibb made a partnership with Medarex. A subsequent trial showed very little impact after twelve weeks. Many of the tumors got bigger, and in some patients new lesions appeared. Concluding that it was a failure, the trial was stopped early.

Months after the end of the Bristol-Myers Squibb study, several of the clinicians involved realized that the tumors had either stopped growing or begun to shrink. A new clinical trial was initiated involving a longer time period. Inclusion of over-all survival rates of patients over several years clearly showed efficacy of anti-CTLA4 in increasing the survival of patients over a longer period (as opposed to first 12 weeks post treatment). Perhaps, Ipilimumab takes time to generate enough T cells to show efficacy. One day, Bristol-Myers Squibb received a call from the radiology department, and they said, "What have you guys done? All the cancer's gone!"

In 2011, FDA approved Ipilimumab for treatment of metastatic melanoma. In 2014, a retrospective study of about 5,000 patients treated with Ipilimumab showed that 22% were still alive after 10 years compared to the median survival of 11 months. This was a huge ratio for

longevity of life of cancer patients in general. With that, it finally seemed like a mystery had been resolved, a path could be seen.

Indeed, the human body is so fascinating that it ended up protecting itself via its own immune responses from one of the deadliest diseases known to mankind: Cancer.

The Nobel Prize @NobelPrize — Follow

Just in! Nobel Laureate Tasuku Honjo, surrounded by his team at Kyoto University, immediately after hearing the news that he had been awarded the 2018 #NobelPrize in Physiology or Medicine.

2:46 AM - 1 Oct 2018

The Nobel Prize @NobelPrize — Follow

Cheers! Friends and family celebrate James P. Allison's #NobelPrize with champagne in a New York hotel after hearing the public announcement.

5:19 AM - 1 Oct 2018

Reference :

The 2018 Nobel Prize in Medicine : A Personal Perspective, presented by Dr. Dipankar Nandi, Professor, Department of Biochemistry, Indian Institute of Science, Bangalore (September 26, 2019)

Decoding Dreams

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"For in dreams, we enter a world that is entirely our own. Let them swim in the deepest ocean and glide over the highest cloud."

— Albus Dumbledore

(Harry Potter and the Prisoner of Azkaban, J.K. Rowling)

A dream is generally defined as a succession of images, ideas and emotions that the mind expresses in certain stages of sleep. Dreams typically involve elements from waking lives—known people or familiar locations—but often take on a fantastical feel. Dreams are frequently interesting, and can allow people to act out certain scenarios that would never be possible in real life. However, dreams are not expressed in a linear fashion. Instead, they are non-linear and chaotic, and do not always make much sense. Humans typically have multiple dreams per night that grow longer as sleep draws to a close.

A number of hypotheses have been suggested in order to explain the neurobiological ratio-nale behind the appearance of certain scenes in our dreams. One of them is the Activation Synthesis Model put forward by Hobson and McCarley, which believes that dreams do not essentially have any implications or meanings. Instead, they are thought of as mere electrical impulses, caused by the random misfiring of neurons that pull random images from our memory.

Another such theory is the Continual Activation Theory. It proposes that dreams occur as a result of continuous neural activation in the brain. This hypothesis believes that the primary function of sleep is the encoding and conversion of short term memories into long term memories by a process called consolidation. This theory is based on an underlying assump-tion that during REM Sleep (discussed later), the unconscious part of the brain processes the procedural memory (implicit and long term memory, related to motor skills, frequently re-siding below the level of conscious awareness.) As the sensory inputs do not reach the brain, at this time, the activation in the conscious part of the brain decreases manifold, triggering a 'continual activation' mechanism generating a data stream that flows from the memory stores to the conscious part of the brain.

On the psychological front, Sigmund Freud, postulated that our dreams are a manifestation of our innermost desires or conflicts. He compartmentalized the content of our dreams into two parts, the manifest content which comprises the actual images and visuals seen in the dream, while the latent content represents the hidden psychological interpretation of the manifest content.

It is often said that while the conscious mind sleeps, the unconscious mind dreams. The re-search of the day serves to disprove any possible biological function of dreams, along with the possibility of dreams occurring as a result of random misfiring. Instead, dreams are

simply assumed to be a result of 'sleep thinking', wherein the organized neural network within the brain functions to think, similar to the way it does when we are awake.

Our sleep cycle can be distinctly divided into two major parts; Rapid Eye Movement (REM) Sleep and Non Rapid Eye Movement (NREM) Sleep. The dreams that are usually recalled, on waking up, are usually associated with the REM stage of sleep. This is also indicated by an Electroencephalogram taken during REM sleep, which shows that brainwaves pattern during this time, are most similar to those obtained in the wakeful state of the person.

When a person begins to fall asleep, the serotonin levels in the body increase, resulting in the triggering of NREM sleep. There is a subsequent release of acetylcholine by the pons, which then travels towards the forebrain, causing cholinergic activation there, resulting in the synthesis of the apparently meaningless visual clips that appear in our dreams and thus resulting in the generation of REM sleep. During REM Sleep, the two most active regions of the brain are the hippocampus and the amygdala, which are both parts of the limbic system. Interestingly, dreamers are not aware of the fact that they are dreaming, while doing so and tend to become uncritical during dreams, accepting impossible events as though they are real. This can be attributed to the decreased activity of the prefrontal cortex (the region of the brain responsible for planning and logical reasoning) while dreaming. The cortex is responsible for the content of dreams.

On the other hand, NREM sleep is associated with more static dreams and this stage of sleep is generated by neurons present in the preoptic region of the hypothalamus and the basal forebrain. The sharp contrast in the neurochemical patterns during REM and NREM sleep suggest that the representation of the dreaming self can be established as a function of the sleeping state. Dream data suggests the presence of at least two representative selves; the

Aggressive self, characteristic of REM sleep and the Friendly self characteristic of NREM sleep. However, the reason behind the dreaming mind creating two diametrically opposite selves, using contradictory behavioural strategies to combat a hostile situation, continues to leave researchers baffled.
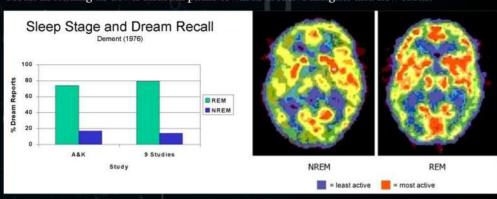
It is said that every person dreams but not all of them can remember it the next day. It varies from person to person. Few remember the entire dream, some remember parts of it while others don't remember dreaming at all. Norepinephrine, which aids in remembering is present in low levels during dreaming and so is the electrical activity in the prefrontal cortex which is associated with long-term memory. We have a better chance of remembering a dream if we wake straight out of it. A recent study showed that people who have more theta brain-wave activity in their prefrontal cortex after waking from REM sleep have a better chance of recalling a dream. It is also believed that alpha waves represent a wakeful period during sleep and has some role in consolidating dreams. A new study has discovered that heightened blood flow activity within certain regions of the brain could help explain why some people remember dreams better than others. In general, recalling a dream is thought to require intermittent wakefulness during the night for the vision to be incorporated in longer-term memory. But what causes some people to wake up more than others is not known yet.

Dreams involving emotions and organized storyline are remembered more frequently. Nightmares and other vivid, emotional dreams are most likely to be retained and result in a greater arousal of brain and body and are therefore more likely to wake us up.

In addition to throwing light on the functions of hippocampal and neocortical circuits in the consolidation of episodic memory, and to the content of dreams, research also points towards intriguing possibilities about creativity and the generation of novel thoughts. One

stage of consolidation possibly involves the integration of information with pre-existing knowledge and associating these with known realms. We dream when we become aware of these activated memories, which are usually discontinuous images and sounds coupled with motor activity.

Although accurate recall is mostly adaptive, there may be a positive side to a process that produces fragmentation—both in the wakeful state and during sleep. All new ideas are based upon previously acquired information. These patches of knowledge, are used to recall information about personal experience. If these bonds are weakened, this information may be recombined, either in the form of dreams or that of misremembered episodes and may even result in leading us down unusual paths towards creative insights and new ideas.

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Biorthogonal Chemistry, A New Age Tool For Tracking Biomolecules: It's Aplication In Pathogen-Host Interaction

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Tracking of biomolecules in complicated biological reactions and their visualization is a major problem in understanding complex biological processes within the cell. Traditional methods using antibodies as protein trafficking probes, for high resolution microscopes (TEM, SEM, Cryo-EM) even could not fulfil the aspirations of biological researchers to visualize the complete dynamics of biomolecules say from the site of metabolic labelling of cellular biosynthetic pathway to final destination, e.g. subcellular localization.

Discovery of Green fluorescent protein (GFP) revolutionised the protein research, and have been profoundly used in visualizing genetically tagged protein molecules involved in biological processes. GFP can be genetically tagged to the N terminus or C terminus of the target proteins and using live cell imaging by fluorescence microscope their changes in cellular localization can be studied during certain processes. While this approach along with techniques like FRET helped in studying protein interactions, localizations etc., which helped to decipher several bio processes, there still remains a major drawback. This GFP mediated ap-

roach can't be applied to non-genetically tagged biomolecules like glycans, lipids, nucleic acids and for post-translational modification reactions in biological cells. This is where bioorthogonal chemistry comes in play.
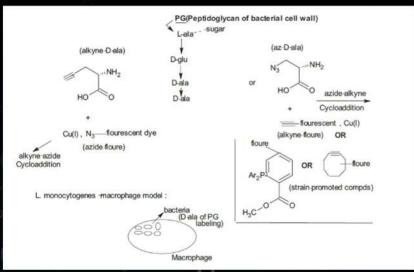
Bioorthogonal chemistry or reactions developed from some basic chemical reactions (Staudinger ligation, Diels Alder reactions/Inverse Diels-Alder reaction, tetrazine ligation) and these reactions can occur inside the cell environment without hampering the native processes going on within the live cell. Bioorthogonal chemistry is a more general platform to tag all kind of biomolecules. It involves the use of bioorthogonal functional groups like azide and other chemical reporters to modify the cellular substrate (biomolecules, proteins, nucleic acids and glycans). For bioorthogonal reactions, first the analogues of biomolecules (azide-tagged) introduced into the cell, then a secondary probe containing a complementary functional group like strained or non-strained alkene or alkyne-tagged with fluorephore is introduced in the cell to label the substrate through azide-alkyne cycloaddition reaction. Thus bioorthogonal reactions removes the barrier in studying and visualization only a restricted group of biomolecules in live cells without using stains. Small molecules like azide, which are used as reporters provides excellent biocompatibility, stability, efficiency, specificity and bioorthogonality in biological environment. Azide group is extremely small, which eases its permeability through cell membrane, and it is essentially absent from biological system that avoids metabolic cross talk and maintains stability. This makes Azide-alkyne cycloaddition reaction and tetrazine ligations the most versatile and powerful method that satisfies bioorthogonal criteria. Hence, these reactions are widely applied in biology including host-microbe interaction, nucleic acid dynamics, protein trafficking, drug targeting and even in plant cell-wall biosynthesis or plant biology.

Host- pathogen interactions involves the cell surface ligand of the pathogen and the cognate

receptors on the host cell surface. In vitro experiments provides us wealth of information about the surface molecules of microbes (peptidoglycan, PG, lipophosphoglycan, LPG, lipopolysaccharides, LPS, lipoarabinomannan, LAM, glycoprotein, GP etc.) like their synthesis, maturation etc. However, these informations in host environment are still in shade. In a recent model, bioorthogonal chemistry has been used to study bacteria (Listeria monocytogenes) -macrophage interaction. As we know, PG is the major constituent of bacterial cell-wall, and PG built of 1-4 linked glycan strands cross linked by D-amino acids containing peptides(as shown in the following fig.) . It gives the cell its shape, size and resistance to lysis, and is essential for bacterial viability; hence, it serves as a good antibiotic target. However, the informations on PG synthesis and degradation for intracellular bacteria still lacking due to insufficient study. In bioorthogonal chemistry approach, analogs of D-alanine (the amino acid present in the PG cross linking peptide) azides or alkynes D-ala, can be incorporated into the nascent PG of bacterial species (as shown in the following figure). For in vitro labelling, unnatural D-alanine can be added to the medium of bacterial growth. Live or fixed bacterial cells are then stained with complementary fluorescent dye using strain-promoted cycloaddition or copper-catalyzed azide-alkyne cycloaddition (CuAAC) respectively. These unnatural D-alanine can be taken up in vivo during macrophage infection by the pathogen cells (Listeria monocytogenes), and once stained with cyclooctynes the PG labelling for intracellular bacteria and their further analysis will help to calculate PG turnover. As host cells (eukaryotic macrophages) naturally lack D-ala, the labelled D-ala within the host would certainly come from pathogen PG.

Chemistry of the reaction : Azide-D-ala or Alkyne-D-ala metabolic incorporation to D-ala of PG of bacteria + complementary probe, Alkyne or azide-fluorephore then click or strain promoted reaction gives rise to cycloaddition reaction and forms a cyclic compound tagged with

fluorephore as follows:

In future, this method can be applied to diverse bacterial species, protozoan parasites and even for globally emerging pathogen like Ebola and Zika virus exploiting different surface molecule of pathogens. Further research using this tool urgently needed to unveil novel routes of survival mechanism of intracellular pathogens.

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Chimera: From Fiction To Reality

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In Greek mythology, one finds the mentions of several creatures. Some bring solace to those in need, while others wreak havoc. Needless to say, a good majority of us are intrigued by these creatures and want them (in part) to be 'real'. Maybe they can be?

One of these magnificent beasts chronicled in Greek mythology is the Chimera. According to Homer's Iliad, Chimera was a goddess who was not a human but an amalgamation of several different animals. She had a lion's head, a goat's body and a serpent's tail. On the other hand, in Hesiod's Theogony, Echidna gave birth to a chimera. In this case, the chimera was a three-headed monster resembling a powerful dragon, a goat and a ghastly-looking lion. The chimera was known to ravage cities by spouting ferocious fires and instilling terror in people until it was killed by the valiant Bellerophon and Pegasus.

Today, as the scientific world is developing at an unprecedented rate, chimeras are no longer a work of fiction but a reality. Unlike Greek mythology, in science, a chimera is an organism originating from two genetically different organisms. Known to exist both in kingdom Animalia and Plantae, they are also observed among some viruses.

CHIMERISM IN BOTANY

It would come as a surprise to many but we have all encountered chimeras in our daily lives

The apples and citrus fruits we consume are actually products of chimeric trees. These trees are propagated by grafting, a well-known example of chimerism. Grafting is an ancient horticultural technique in which tissues from two different plants, in the form of a stock and a scion, are combined to form the desired plant cultivar. In 1907, German botanist Hans Winkler became the first person to meticulously study this type of chimerism by grafting Solanum nigrum (Black Nightshade) onto Solanum lycopersicum (Tomato). Winkler observed that most of the buds represented one parent or the other. However, there was a single bud that grew at the junction of the two plants and in part represented both the parents. It had not been formed by a fusion of cells but was a conglomeration of cells from both parents as a result retained their respective identities. This bud was denoted as a chimera.

CHIMERISM IN VIRUSES

The centre for veterinary biologics defines chimera virus as a hybrid microorganism formed by joining nucleic acid fragments from two or more different microorganisms. The only requirement to generating a chimeric virus is that the fragments should contain genes necessary for replication. These chimeric viruses are increasingly being used in research to cure diseases such as cancer. Recently, researchers from Instituto de Medicina Molecular (IMM) Lisboa (Portugal) in collaboration with people from Harvard Medical School developed a chimeric virus that allows them to study unique approaches to treat cancer caused by human herpes virus infection in mice. Unfortunately, these chimeric viruses are formed by combining two or more pathogenic strains of viruses and are potential bioweapons as they are often more lethal than the parental viruses.

CHIMERISM IN ANIMALS

In animals, chimerism dates back to the early 1960s when the first chimeric mouse was developed. Ever since, several chimeric animals have been developed including human-sheep, human-pig, lion-tiger etc. have been created. In 2012, the first primate chimera was created in Oregon National Primate Research Centre. Of the three chimeras that were born, one singleton was christened Chimero whereas the other two were a set of twins, Roku and Hex. Chimero was created by combining three rhesus monkey embryos while the twins were created by combining six rhesus monkey embryos. Interestingly, all three monkeys were phenotypically males but Roku contained cells from both sexes and hence was considered as a sexual chimera. According to a report recently published in a Spanish newspaper El País, a team of scientists from the Salk Institute in the US have also successfully created a monkey-human chimera.

Nevertheless, Chimerism is now considered to be a mine of gold. Scientists from around the world are trying to gain a comprehensive understanding of this phenomenon in the hopes to exploit it for several downstream applications. In medicine, chimerism can help meet the ever-increasing demand of human organs for transplants. Chimeras can also serve as a valuable tool to study different diseases and help improve existing treatment regimes. In agriculture, chimeras might provide a solution to crop loss due to adverse weather conditions. It might also help meet the growing demand for crops and fodder. The possibilities are endless! However, researches involving chimeras are raising ethical concerns worldwide and not just amongst the scientific community. If exploited for wrong reasons, chimeric organisms can potentially cause mass-destruction. So, the question that needs to be asked is: Will these experiments lead to the advancement of the society or will result in annihilation?

Guess we will just have to wait and see!

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"Orphan" Genes - How evolution gives rise to genes de novo

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In the story of organic evolution, genes are the protagonists. They instruct our body on how to make proteins. But our body does not need to make all proteins all the time. Hence some genes also regulate the activity of other genes and specify which protein to make and when. In a nutshell, our genes are an encyclopaedia about who we are-how we look, how our body controls metabolism, how much protein our body makes and so on. Thus understanding the genetic code is essential.

Throughout the course of evolution, genes have modified themselves time and again to "best fit" to a particular environment due to a process called natural selection. This selectivity is the central theme of the famous law-"Survival of the fittest".

It was previously thought that new genes are formed when evolution tampers with old ones. But a recent study conducted by evolutionary biologist Helle Tessand Baalsrud and her team at the University of Oslo has brought to life a puzzle that might change the way we look at evolution.

In the cold Northern Hemisphere waters, survival is tough, except for one inhabitant-the Arctic cod fish. Baalsrud wanted to see how special antifreeze proteins arose in certain lineages of Arctic cod. In a study conducted by her team, it has been shown, that in certain groups of codfish (Gadidae,) which are prone to colder and harsher environment, more

numbers of the antifreeze glycoproteins (afgps) were found. In fact, a particular lineage of Arctic codfish, which inhabits warmer waters show no trace of this gene. Believing that this gene originated from an extant gene, Baalsrud and her team searched the genomes of the Arctic cod and its closest relatives to obtain a similar gene. But it turns out that AFGP gene in code are orphans suggesting that under necessary conditions, selection can give birth to a gene.

Although this is not the first time such a study has been conducted, but this is the first time it has garnered such widespread attention. In fact in the last few years researchers found numerous such signs of de novo gene synthesis. But initially there was a lot of skepticism. When evolutionary geneticist David Begun at the University of California, Davis, in 2007 found de novo genes in testes and seminal fluid of the fruit fly Drosophila melanogaster (the first study of its kind) and reasoned that a powerful evolutionary force meditated the process, the scientific world was not ready. But with numerous such results coming up in a short time, the theory of de novo gene synthesis is slowly being accepted and active research is being taken up to see why this is happening.

Genetic "plasticity" as the researchers call this, is a relatively new area of study. The fact that genes can be "orphans" is something that the scientific community still finds hard to believe. But this also raises another important question-what then, is a gene?

Well, to explain simply, it is that part of our genome that codes for a protein. Proteins are essential for every major molecular activity our body performs. Hence the genetic code makes up humans. But if genes can be synthesized de novo, it would change our whole understanding of what a gene is.

But, having stated that, not all genes code for proteins. In fact about 99% of our DNA is "junk DNA"(non protein coding).They also perform various functions (like coding for RNA that

control gene regulation).But molecular biologists have now found out that some part of this non-coding DNA can change to coding DNA, thus giving birth to a gene. Gene-in-waiting or proto-gene as they have been called by scientists are essentially more "gene-like" than others and have " longer sequences and more instructions necessary for turning the DNA into proteins".

So, how do you tell that a gene has been formed from scratch? There needs to be a comprehensive database of the genetic constitution of the organism and its close relatives. If after sequential analysis, it is found that the gene or it's "cousins" are not found in closely related species, then there is a high possibility that it has been formed de novo. In such a study conducted on rice plants (Oryza sativa japonica) it has been found that around 175 of its genes have been created de novo.

A few of the functions performed by "orphan" genes include starch production in the thale cress plant (Arabidopsis thaliana) and in Caenorhabditis elegans, they are involved in signalling transduction pathway and metabolism process.

Artificial de novo gene synthesis has been performed by manipulations in the laboratory but the validity and safety of such experiments remain an ethical question.

Scientists have now asked the most fundamental question regarding this matter-why are genes being built from scratch? Why have organisms and plants derived a complicated way to synthesize genes de novo when they could have easily formed new genes by natural selection? This remains an ongoing field of research and is part philosophy, part genetics.

With the newly found data and ongoing experiments, the world of genetics gains yet another dynamic question to answer.

Blood-Hunting

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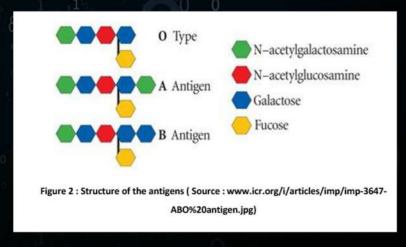
The ABO blood group system, discovered by Karl Landsteiner, identifies four different blood groups- A, B, AB and O. These are classified based on the type of antigen present on the surface of the red blood cells. Of these, blood group O is famed to be the universal donor, whereas type AB is the universal recipient.

		ABO Blood Groups		
	Antigen A	Antigen B	Antigens A + B	Neither A or B
Antigen (on RBC)				
	Anti-B Antibody	Anti-A Antibody	Neither Antibody	Both Antibodies
Antibody (in plasma)				
Blood Type	**Type A** Cannot have B or AB blood / Can have A or O blood	**Type B** Cannot have A or AB blood / Can have B or O blood	**Type AB** Can have any type of blood / Is the universal recipient	**Type O** Can only have O blood / Is the universal donor

Figure 1 : ABO Blood Groups (Source: www.vec.bioninja.com.au
/_Media/abo_blood_groups_med.jpeg)

The human ABO blood groups illustrate the effects of biocatalysts or enzymes, called glycosyltransferases, that add natural glycosidic linkages. Carbohydrates are attached to glycoproteins and glycolipids on the surface of red blood cells. The A, B and O blood groups have in common an oligosaccharide foundation called the O or H antigen. The A and B antigens differ from the O antigen by the addition of one extra monosaccharide, either N-acetylgalactosamine (for A) or galactose (for B) through an α-1,3 linkage to a galactose moiety of the O antigen. Specific glycosyltransferases add the extra monosaccharide to the O antigen. An individual, by inheritance, possesses only one type of glycosyltransferase- the type A transferase specifically adds N-acetylgalactosamine while type B adds galactose. The most striking fact remains that these two types of enzymes differs only in 4 of 354 positions, as has been discovered by protein sequencing. The O phenotype is, in fact, the result of a mutation that causes premature termination of translation of the concerned mRNA, and hence, to the production of no active glycosyltransferase.

Figure 2 : Structure of the antigens (Source : www.icr.org/i/articles/imp/imp-3647-ABO%20antigen.jpg)
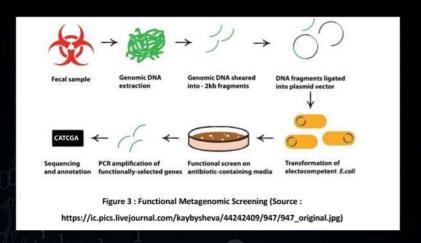
Now, if an antigen not normally present in a person, is introduced in him or her, during blood transfusion, the immune system recognizes it as foreign and initiates intravascular de-

struction of the incompatible red blood cells - a phenomenon also called isoagglutination, which is common when a person is transfused with a blood group different from his own. However, in times of medical emergencies where the patient's blood group is not known, O-type blood is often universally administered as it does not have any antigen on its surface, thereby decreasing chances of agglutination.

Thus, the easiest hack to combat both the shortage of blood during transfusion, and the probable incompatibility, is to design an enzyme that cleaves off cell surface antigens from type A, B (and AB) blood cells, to get type O cells, which is the universal donor.

Previously, in the 1980s, using an enzyme isolated from green coffee beans, researchers snipped B antigens off red blood cells, effectively creating type O blood that could be transfused into human patients. However, the major drawback of the method was the inefficiency of the enzyme – a substantially huge amount of enzyme was required at a high temperature, for a relatively meagre volume of type O cell turnover.

In an attempt to find a new and efficient enzyme, researchers opted for a quicker technique called metagenomics, which allows the sampling of the genes of millions of microorganisms without the need for individual cultures, whereby, a community of microbes were pooled. Next, Escherichia coli was used to select for DNA that codes for enzymes that cleave the sugar residues. The search for such an enzyme began with the gut microbes. Our gut flora consists of microorganisms.

that can be called "professionals", without exaggerating, at breaking down sugars. Glycosylated proteins called mucins line the walls of the small intestine, which simultaneously act as anchorage sites as well as nutrition for the gut microbes. Now, some of these mucins contain sugar entities that resemble the A and B antigens of the RBCs and these microorganisms have shown to possess the ability to cleave the sugars off.

Figure 3 : Functional Metagenomic Screening (Source : https://ic.pics.livejournal.com/kaybysheva/44242409/947/947_original.jpg)

The team tested for different fragments of DNA against sugar proxies mimicking A and B antigens, to finally find a low maintenance worker, performing at a variety of temperatures and salt concentrations - the family 98 glycoside hydrolase from strain SP3-BS71 of Streptococcus pneumoniae (Sp3GH98). It cleaves the entire terminal trisaccharide antigenic determinants of both A- and B-antigens from the RBC surface. Using directed evolutionary techniques like selection and screening and ensuring heredity, mutant strains were tested for 5 generations, till the team produced an enzyme that was 30 times more effective than the previous version of the inefficient enzyme.

On testing the new enzyme against type A human blood (keeping in mind that the enzyme is removed before the newly synthesized blood is transfused), it was found that only a small quantity of the enzyme was required to cleave the antigenic determinant sugar, thereby justifying itself as a true biocatalyst.

The next obvious question that comes up is whether the same method is applicable to the Rh antigen, which determines whether an individual has "positive" or "negative" blood type. This is a pertinent question in pregnant women with negative blood groups, carrying babies

with positive blood group, as the babies are then at a risk of fatal diseases like erythroblastosis foetalis, hydrops foetalis etc. Although preventive measures for these diseases are available, getting rid of the Rh antigen could seem as an easier prevention. However, the major difference between the Rh antigens and the RBC surface antigens determining blood groups is that the Rh antigen is actually a protein, more precisely, a membrane protein, which makes it harder to remove, and also non-reactive to sugar hydrolases.

Hence, the concern that comes up is that there are still chances of mismatch if the type O blood is synthesized from an Rh positive individual and transfused to an Rh negative individual. Thereby, a different set of enzymes needs to be explored to create the actual universal blood group – O negative.

Modifying natural enzymes has always been a tricky task and scientists have already started on yet another quest for a more efficient enzyme that addresses both the issues at the same time or at least in cascade steps. Currently only the tip of the iceberg has been reached and there are miles to go before another revolutionary revelation is unveiled.

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Sherlock: A Gift Of Nature

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Nature has presented to us a world full of surprises and undiscovered truths that needs to be unveiled in the due course of time. Man, in order to quench the thirst for the unknown have embarked upon the untrodden paths of Nature and thus in their course of evolution, have utilised those gifts of Nature for the well being of the civilisation. We, especially the young ones are very well versed with the term 'SHERLOCK' and the only thing that comes into our mind is that of Arthur Conan Doyle's creation; a detective to whom no mystery seems to be unsolvable. But, recently, a group of researchers from the Broad Institute of MIT and the Massachusetts Institute of Technology have named a detection tool as 'SHERLOCK' that harnesses CRISPR-enzyme systems for uses beyond gene editing. Unbelievable, isn't it!!

Latest research work provided shocking results in which the team of researchers used SHERLOCK to detect cell-free tumor DNA in blood samples from lung cancer patients, detection of Dengue, Zika, the dangerous Ebola virus and any other types of viral diseases.

Now, the obvious question is: What is SHERLOCK??

- SHERLOCK (Specific High-sensitivity Enzymatic Reporter unlocking) is a diagnostic tool associated with an enzyme Cas13 and some specific guide RNAs that provides an inexpensive, easy-to-use, and highly sensitive diagnostic method for detecting nucleic acid material – that can mean a virus, tumor DNA, and many other targets.

The method of detection is a very novel and cheap one including a thin strip of paper having some coloured indications. Just like a pregnancy test, this paper strip is able to display test result for a single genetic signature and is highly specific. After dipping the paper strip into a processed sample, a line appears, indicating whether the target molecule was detected or not. Now, obviously it is not such a easy process from the molecular point of view. For understanding it's molecular phenomenon, we need to get acquainted with some terms like 'CRISPR' and 'Cas13 complex'. Let us know about it.
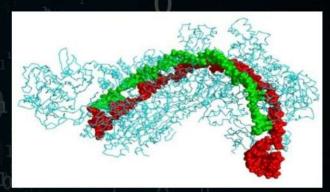
Fig. CRISPR protein complex

CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) is a family of DNA sequences found within the genomes of prokaryotic organisms such as Bacteria and Archae. Then, why are they so special??

Actually they are derived from DNA fragments from the viruses that have previously infected the prokaryote and are used to detect and destroy DNA from similar viruses during subse-

quent infections. Hence, these sequences play an important role in the antiviral defense system of prokaryotes.

These conserved sequences are sometimes in association with a group of enzymes called as Cas (CRISPR-associated) complex. The CRISPR-Cas system is a prokaryotic immune system that confers resistance to foreign genetic elements such as those present within plasmids and phages that provides a form of acquired immunity. RNA harbouring the spacer sequence helps Cas (CRISPR-associated) proteins recognize and cut foreign pathogenic DNA. Other RNA-guided Cas proteins cuts foreign RNA as well.
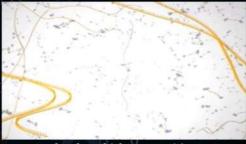
A few years ago, a group of scientists working on the Archaeal community residing in the hyperthermophilic lakes (in South America) found out a special Cas protein and named them as Cas13 complex. Now, this CRISPR-Cas13 nuclease complex have been modified genetically to edit genomes. By delivering the Cas13 complexed with some guide RNA molecules into a cell, the cell's genome can be cut at a desired location, allowing existing genes to be removed and/or new ones to be added. Cas13's target can be any genetic sequence, including viral genomes, genes that confer antibiotic resistance to bacteria, or mutations that can cause cancer. The beauty of Cas13 is that it has such a high power of sensitivity that it can even detect a single molecule of nucleic acid or even a single base substitution in a single DNA/RNA.

⊠ **The process by which this entire SHERLOCK detection system works --**

1. Researchers take as sample from a patient with a possible viral infection like, lets say, influenza.

2. Then they amplify the levels of RNA in the sample to suitable quantity.

3. After that, certain reporter molecules which are sensitive to Cas 13 are added to it which will help in the detection process.
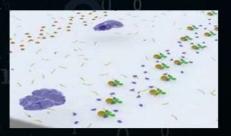
4. An engineered (genome editing) CRISPR-Cas13 is added to the sample. This Cas13 complex is programmed with a guide RNA that is designed to find only viral RNA and bind to it, that is become double-standred.

RNA that is designed to find only virus RNA and bind to it.

5. Then only the CRISPR-Cas13 complex become activated and it starts off to cleave any RNA that it comes in contact with by a process termed as collateral cleavage, including that of the reporter.

6. Then, the entire sample is allowed to run through a commercial flow detection system.
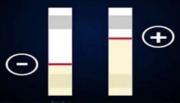
7. And so by the process, the Cas13 starts to cleave off any RNA it encounters with and so, the reporter molecules (as it also contains RNA) also gets spliced into parts. Now, the reporter molecule has differently labelled molecules in the two ends and for that reason, Cas13 cleavage creates a signature molecule.

8. If the sample is negative for influenza, then the reporter molecules will remain intact and hence, will collect at the first detection line.

Lateral Flow Strips

9. But, if the sample is positive for influenza, then the cleaved-off reporter molecules will go to a different location and thus will be detected.

This SHERLOCK detection system indeed gives us some added advantages which are to be mentioned:-

• Before SHERLOCK, field samples had to be carefully shipped and refrigerated in lab conditions. But in this unique system, we can simply use the detection tool immediately and need no refrigeration or anything. It does not even require expensive gene sequencing tech-

niques to detect diseases unlike the earlier days.

• SHERLOCK can be adapted to detect any genetic signature, specially cancer in virtually, any location.

• It has increased the crop enhancement programme due to powerful gene editing mechanisms which have conferred upon the plants, resistance to virus particles.

So, what do you think?? Is it really that complex??

I guess no. And even it is a very inexpensive one and highly sensitive to detect any trace of a disease in our body. And, indeed for that reason, SHERLOCK detection system is thought to be as a big deal for the future world. Scientists of McGovern Institute, Broad Institute and Harvard University are carrying on vigorous research on this new emerging field. Guess, how many more such surprises are waiting to be discovered in the upcoming future??

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Genetic Control Of Coat Colour In Labrador Retriever And The Dudley Labrador

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INTRODUCTION

As we know every aspect of an organism is predetermined in the form of the genetic code located in the DNA within the nucleus. Specific nucleotide sequences of the DNA code for a mRNA strand which then codes for a specific polypeptide. These sequences are known as genes. Alternative forms of a gene which give rise to different phenotypes (externally observable characteristics) are known as allelomorphs or alleles. The various external and internal characteristics of an organism are dictated by allelic (interaction between the alleles of the same gene) and non-allelic (interaction between alleles of different genes). In this article we wish to explore the effect of the genes on pigmentation in dogs while giving special emphasis on the Dudley Labrador. Sewall Wright in 1918 published one of the first articles about the genetic effect of pigmentation in dogs. Where he studied the various spotting patterns in dogs. He determined the piebald pattern to be dominant. Many genes responsible for pigmentation have subsequently been discovered. Kaelin and Barsh in 2013 introduced a nomenclature for gene names and symbols and identified 12 coat colour loci in dogs.

DISCUSSION

In order to fully understand the cause and implications of being a Dudley Labrador it is imperative that we study the mechanism of gene action in detail.

During embryogenesis, melanoblasts, which are melanocyte precursor cells are derived from the neural crest and migrate to the epidermis and the hair follicles.

Labrador retrievers have three different coat colours. These colours arise due to non-allelic interaction at two gene loci, these are as follows:

- B locus (alleles: B, b)
- E locus (alleles: E, e)

B locus:

This locus affects the colour of eumelanin which is the dark pigment. Variation in this locus leads to a lightening or a "dilution" of eumelanin from its original black colour to a brown colour. This gene codes for the protein TYRP1. TYRP1 or tyrosine related protein 1 is an enzyme located in the melanosomes. These are organelles which produce and store the pigment. TYRP1 is responsible for the oxidation of eumelanin precursors. Three mutations of this gene have been identified in dogs. Of these three, one includes the truncation of the protein while the other two involve an amino acid deletion or a single amino acid substitution. This led to a recessive allele "b". As the TYRP1 encoding gene is dominant so a dog with a genotype "BB" and "Bb" both give a black phenotype. While the dog with a "bb" genotype has a brown coloured coat.
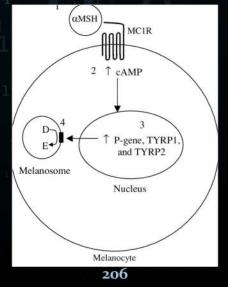
E locus:

This second locus known as the E or Extension locus encodes a protein known as melanocortin 1 receptor (MC1R). This is a receptor protein which in response to melanocortin signals the pigment producing cells which results in the deposition of eumelanin in the hair. One

such corticotropin is the Alpha Melanocyte Stimulating Hormone (α-MSH) stimulates melanogenesis resulting in hair and skin pigmentation in mammals. It is also responsible for the transcription of the TYRP1 gene and other related genes.
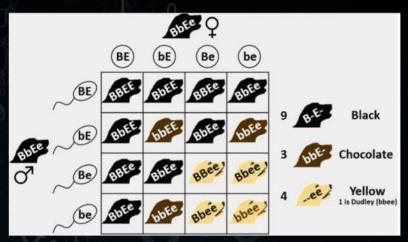
A recessive mutation in the E gene ("ee") leads to truncation in the protein which in turn acts as a non-functioning receptor. This prevents the deposition of eumelanin in the fur under any circumstance. So, even if the dog has a genotype "BB", the eumelanin is produced, but is deposited on the skin only and not on the fur. Even if a single copy of the gene encoding a fully functional protein is present ("EE" or "Ee"), deposition of eumelanin in the fur is observed. This leads to the dog having a yellow coloured coat. But if the dog has a "BB" or "Bb" genotype eumelanin will still be deposited in the skin and so will be visible on the nose, eye-rims, lips and foot pads.

 Thus, the "ee" genotype masks the effects of the genotype of the B locus. This sort of genic interaction is known as epistasis. In this case, as the epistatic gene is recessive, the phenomenon is known as recessive epistasis.

Binding of αMSH to MC1R (1) leads to elevated levels of cAMP (2) leading to a signal transduction cascade leading to the expression of eumelanin promoting enzymes (like TYRP1) (3). These are then directed to the melanosome membrane forming a macromolecular complex (black rectangle) (4) catalysing dopaquinone (D) to eumelanin (E) conversion.

What is a Dudley Labrador?

The adjoining figure depicts a cross between two black Labradors heterozygous at both the B and E loci.

The resultant phenotype is as follows:

9- Black coat colour

3- Chocolate coat colour

4- Yellow coat colour

In the above phenotypic ratio, among the 4-yellow coat-coloured, 1 is a Dudley Labrador.

A Dudley Labrador is one which lacks pigmentation in their nose, eye-rims and feet. They appear pink throughout their lives. This is not to be confused with the natural changing of

the nose colour in winters (a phenomenon known as 'snow nose'). This is because a Dudley Labrador has a genotype of "bbee" that is a double recessive genotype.

As a result of this genotype ("bb"), a Dudley Labrador lacks pigmentation in these regions. This implies that there is a lack of functioning TYRP1 which leads to problems is the eumelanin synthesis. Thus, there is no deposition of pigment in the skin. This leads to a pink colouration.

However, there is a disagreement as to where exactly term "Dudley Labrador" ends. Some people believe that even Chocolate Labradors with brown noses (also known as 'livers') are also Dudley's, while others feel that only yellow Labradors (that is the ones with "bbee" genotype) can be Dudleys.

CONCLUSION

As we have studied the reason for the lack of pigment in the Dudley Labrador, we can state that it is not a genetic defect, nor does it have any adverse effects on the health of the dog. A lack of pigment however can be tied to an increased risk of sunburn and skin cancer.

An interesting fact which presents itself when studying the phenotypes of the filial generation is that even though chocolate Labradors also have a "bb" gene they have noses of darker colours (brown) than yellow Labradors with the "bb" gene (pink). This indicates that the gene MC1R might have a role to play in the pigment deposition in the skin as well. Possibly due to its role in the expression of melanin promoting enzymes. Thus, its absence in addition to a "bb" genotype in the B locus leads to a pink colour. This supports the fact that only yellow Labradors can be "true Dudleys".

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Going With The Flow

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Flow Cytometry is a process which may be utilized to study cell size, granularity, metabolism and other both physical and chemical parameters of a cell.

It can be defined as the technology which empowers scientists to discriminate, quantify and sort distinct populations of cells/organelles based on their expression of specific markers with rapid pace is flow cytometry.

In terms more relevant to a physicist, it is a technology that simultaneously measures, and then analyses multiple physical characteristics of single particles, usually cells, as they flow in a fluid stream through a beam of light, usually a laser.

The Basic components of a flow Cytometer are:

1. A source of light

2. A chamber called the Flow Cell

3. An Optical System

4. Photo Detectors

5. Computer
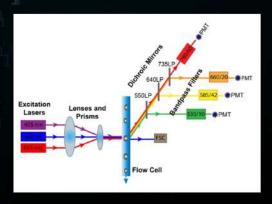
These can be broadly classified as Fluidics, Optics and Electronics sections of a Flow Cytometer. It is essential to remember that Flow cytometry is an application of an instrument called a Flow Cytometer. The instrument's only work is to analyse the substance flowing through it and produce any relevant data.

It cannot by itself differentiate what the sample is. A scientist skilled in Flow Cytometry can only do that while reviewing the data produced by the Flow Cytometer.
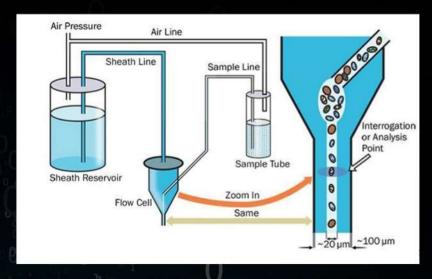
It is essential to differentiate between FACS (Fluorescence Activated Cell sorting) and Flow cytometry. It is a common phenomenon to denote both of these processes as one. However FACS is an application of the principle of Flow Cytometry, aiding in the differential collection of cell populations. Flow cytometry does not 'sort' cells, but only analyses them. Thus a Flow cytometer is often called an analyser whereas a FACS machine is called a sorter. In this article we will discuss only Flow Cytometry.

HOW DOES THE FLOW CYTOMETER WORK?

The Fluidics of the Flow Cytometer ensure that the cells in suspension flow through the machine in line, one by one. A source of light interrogates the cell at the Flow Cell. The emitted light is scattered. This light is filtered by the optics and detected by the photo detectors. If a Fluorochrome is involved, Fluorescence is detected accordingly. The detectors produce an analogue signal in the form of a voltage pulse which is processed through the electronics, to be displayed through a relevant software in a computer.
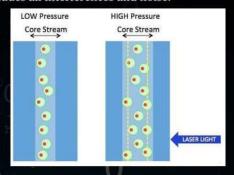
The most important aspect of a Flow Cytometer is to ensure that the cells move in line, one by one and that they move quickly obtaining 'Rapid Pace'. If there is an overlap of cells at the point of interrogation, it will lead to spurious data. This is maintained through the principle of Hydrodynamic Focusing.

Cells in suspension is added to the sample tube. In another reservoir, a special fluid called sheath fluid is kept, which can be any relevant buffer. A pressure difference is created between the two reservoirs. The sample is kept at a pressure higher than the sheath fluid. The sheath fluid is released into the flow cell and the sample inserted at it's centre. Due to the differential pressure, both streams move at different speeds and the sheath fluid forms a wall around the sample core, acting as a sheath. As a result, a small sample stream can be created, down to the micrometre magnitude. This aligns the cell in the sample core, allowing them to flow through the interrogation point in a single file.

The rate at which the sample flows is an important factor. A Slow Flow Rate (10⊠l/min) pro-

duces a better data resolution and ensures that the cells flow through one by one. A higher flow rate (med: 30μl/min, High: 60μl/min) will ensure a faster processing with lower data resolution, and multiple cells at the point of interrogation.
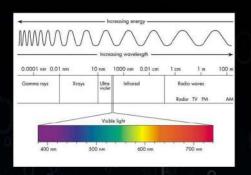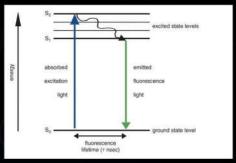
The number of signals detected by the detector is called the event rate. It may not always denote cell count. It includes all interferences and noise.

OPTICS

One of the basic principles on which a Flow cytometer works is that of Fluorescence. When a particular molecule absorbs a certain wavelength of light, it absorbs energy and it's electrons are excited to higher orbitals. However, the electron is not stable and loses an equal amount of energy and comes back to the ground state. This loss of energy takes place in two steps. First, there is some energy lost through heat or otherwise, followed by a loss of energy through a phenomenon called fluorescence. In fluorescence, the energy is released in the form of light. The wavelength of light is decided by Planck's equation($E=h\upsilon$). As Energy is inversely proportional to wavelength, the wavelength of emitted light is greater than that of light used to excite the molecule
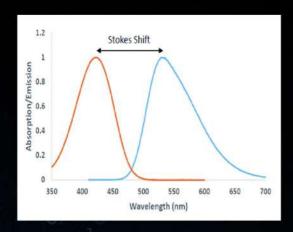
The wavelength of light corresponding to the Energy at which the molecule is excited is called the excitation maxima. The wavelength of light emitted is the emission maxima. The difference, in nanometres between the peak excitation and the peak emission wavelengths is called Stokes Shift. Each Fluorophore has a characteristic Stokes Shift. Greater the Shift, better can the signal be detected.

Each Cytometer has some laser inside it, and the number of lasers can also vary. Each laser that is utilised produced light where all photons emitted are in phase and have a particular wavelength at which it operates. The fluorophore which is being used in an experiment must be chosen wisely, so that the excitation maxima of the fluorophore matches the wavelength of the laser installed in the machine.

A laser is converted into a beam through lenses, which are part of the Excitation Optics. A laser beam has a circular, radially symmetrical cross-sectional profile with a diameter of approximately 1±2 mm. A direct dose of it can cause damage to the cells, so an obscuration bar is used to reduce the intensity of the laser.
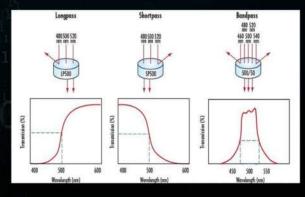
Emission Optics is responsible for the collection of the light emitted from the particle-beam interaction. It comprises a system of optical mirrors and filters to route specific wavelengths of collected light to designated photodetectors.

The Filters are of three kinds:

1. Long Pass- These only allow wavelengths of light above certain wavelengths to pass. Eg: LP500- Long Pass 500 allows wavelengths of light above 500 to pass through.

2. Short Pass- These allow only wavelengths of light below certain wavelengths to pass through. EG SP550- Short Pass 550 allows wavelengths of light below 550 to pass through.

3. Band Pass- These only allow wavelengths between two values of wavelengths to pass through. Eg- BP 550/20- Band Pass filter allowing wavelengths between 540 and 560 to pass through.

DETECTORS

The principle of the detectors is derived from the idea of semiconductor devices, running on the Principle of the Photoelectric Effect. Incidence of light generates electrons and thus current, producing a voltage Pulse. The primary devices used as detectors are:

1. Photodiodes- to detect Forward Scatter.

2. Photomultiplier Tubes- To detect Side Scatter and Fluorescence.
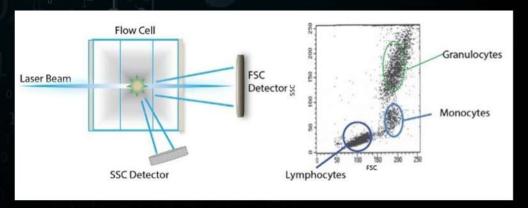
Light is scattered in all directions. The light which is scattered in the forward direction is detected by FSC detector (Forward Scatter Detector). Those which are scattered perpendicular to it are detected through SSC detectors (Side Scatter Detectors).

FSC is proportional to cell size; the bigger the cell, the more light is scattered, the higher the detected signal.

SSC is proportional to the granularity or inner complexity of the cells.

A FSC versus SSC plot is the most common data representation in Flow Cytometry.

Eg: it allows us to differentiate small lymphocytes from bigger monocytes, and monocytes from similarly sized granulocytes but with more complexity.
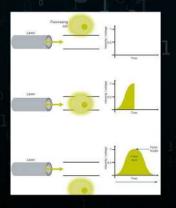
SIGNAL GENERATION:

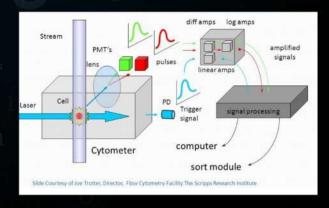The photo detectors sense the signal and give out a voltage pulse shaped as a gaussian curve. The signal is generated as the cell enters the laser beam, peaks when the entire cell is within the laser beam and dies out as the cell leaves the laser beam. A particular wave has the following characteristics:

1. Peak/Height- Provides the intensity of the signal which is proportional to the size of the cell.

2. Width- represents the time of flight or time taken by the cell to cross the laser beam.

3. Area/Integral- it is area under the curve of the voltage pulse.

These pulses need to be amplified, and this is done through Voltage and Gain settings. An increased Voltage is directly applied to the PMT to increase its sensitivity to light. This causes the signals to move further apart, to higher channel numbers. The fold of amplification is called the Gain.

This signal is fed into the ADC (Analogue to Digital Converted to convert the signal into the computer binary language.

DATA DISPLAY

The most common and which is always produced on analysing the data provided by the cytometer, is a bivariate plot or a dot plot. SSC is taken as the Y axis, FSC as the X axis. The scale can be Linear or Log. The difference between the two powers of 10 in Log scale is called a decade. Each row and column is called a channel. The voltage pulse data is displayed as a dot, with a particular FSC and SSC value. This is a scatter plot of the cell sample under study. The most well derived plot and by far the one which should be used during data analysis is Contour Plot.

SOFTWARE MANIPULATION

When we get data from any instrument, it needs to be refined to suit our purpose. In a Cytometer, this is done through the processes of setting a threshold to remove noise, and any cellular debris from the readings, gating to select populations of interest, compensation to correct the spillover effect in case of fluorescence tags, Doublet Discrimination to remove aggregate cell data from the machine. These processes, in theory, do not vary from system to system, but they do in execution.

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Could things get any Stranger?

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One of the worst scenarios the world faced was from 1939 to 1945, i.e, the Second World War. The Nazis were notorious enough to use weapons with enigmatic and arcane technologies. The US also conducted its fair share of tests through their heinous weaponry and war tactics. A few of the most brilliant minds, including those of Nikolas Tesla and Albert Einstein were employed to execute the military's labyrinthine wills.

One of the most bizarre and eccentric attempts was the one made by the US navy to make an entire ship invisible to the radar. But these resulted in some unintended conclusions which led to the entire experiment being shut down and to date, continues to mystify scientists.

Most of us are familiar with the Netflix original series "Stranger Things"(2017-). Ever wondered if these stories could have some validity to them?

In 1955, Morris K. Jessup, the author of the published book "The Case with the UFO" was researching vigorously and was trying to establish a connection with the outer world, perhaps aliens? It was during this time that he received a letter from a man named Carl M. Allen, who criticized Jessup for his naïve understanding of the UNIFIED FIELD THEORY (UFT) which Allen claimed to have been taught by Albert Einstein himself. The UFT (which has never been proven to date) aimed to unite gravitational and electromagnetic forces just as the electromagnetic effect which is a combination of electric and magnetic forces. To prove that UFT

existed, Allen claimed that he was witness to a secret naval experiment that took place on the 28th of October 1943 conducted by the US navy, on the ship named USS ELDRIDGE at the Philadelphia Naval Shipyard by using Einstein's revelations. What he explained as the secret experiment not only baffled scientists but also fuelled decades of speculations. There was an eerie blue-green halo of light surrounding the hull of the ship for a few seconds and suddenly, it disappeared! Not only invisible to the radar but completely gone-VANISHED! Witnesses even mentioned that Eldridge was spotted near a port at New Virginia and further rematerialized at the Philadelphia Shipyard with most of its crewmen dead, some entirely 'run into bananas' while others were fused to the steel hull of the ship. He even mentioned that the ship was teleported to a fourth dimension during this period, where it met aliens, travelled through time and reappeared at the shipyard, ultimately lacking time of ten minutes.

Jessup discarded the entire concept considering Allen as a psychiatric patient. Unfortunately, he had to commit suicide due to his constant failures while Allen lived for a long time, narrating his experience about the Philadelphia Experiment to anyone interested in listening to his fantastical tales.

Most people did not believe the story until a man named Al Bailek came forward, after the release of the film "The Philadelphia Experiment" in 1984 and claimed to be a part of that horrific experiment.

Despite the dire account of both these men, no one could provide the scientific basis to such an experiment because then, with not much advancement in the field of science, teleportation seemed to be IMPOSSIBLE!

What had actually happened that led to such widespread speculations that are still believed in, even in the 21st century?

The journal of Jacques Valle titled "Anatomy of Hoax: The Philadelphia Experiment Fifty Years Later" could shed some light on the real happenings of the Philadelphia Experiment and open up a new vista in front of our eyes. Valle while writing about the Philadelphia Experiment asked his readers to contact him if they knew anything about the experiment. Valle was contacted by Edward Dudgeon, an electrician, who served the US Navy from 1942-1945. He mentioned that it was often attempted to make ships invisible to the radar (no successful attempts were made) by degaussing them or removing the unwanted magnetism. The ships were wrapped in magnetic cables and fitted with high voltage charges. That didn't make the ships invisible to the radar but it did, to the U-boat's torpedo. He further mentioned that the greenish halo was due to an electrical storm.

Again in 1999, it was reported in the Philadelphia Inquirer that USS Eldridge was not docked at Philadelphia Shipyard but was instead present in Brooklyn on its supposed date of disappearance. The ship's log had confirmed this.

Despite the differing accounts, both Dudgeon and ship's crewmen confirmed that nothing out worldly occurred on the ship.

Valle mentions that powerful imagery is the key to a long-lived hoax. In the 1980s, the movie "The Philadelphia Experiment"- based solely upon the narrative of Carl M. Allen was hardly an Oscar contender but the special effects easily captured the movie-goers' minds. The images of a ship vanishing all of a sudden and mangled crewmen along with the banner of the movie mentioning "based upon true incidents" had a long-lasting impact on the audience. Though the crewmen and the US navy mentioned that there was no experiment conducted on invisibility, people still believe that this is a cover-up by the government. Despite the emergence of shreds of evidence regarding the true identity of Carl M. Allen as a mental patient, the Philadelphia Experiment hoax refuses to die.

Will the Philadelphia Experiment mystery live for another century? Or will it live for a millennium? Who knows. Why should we try to bring scientific explanations to such burning issues? Let the hoax live! Let the people debate! Let the fantastic fables of teleportation be passed on! Who knows maybe researching on such topics may open up new chapters in science which will justify UFT and allow teleportation?!

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The World Within A World

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"On the earth, even in the darkest night, the light never wholly abandons its rule. It is diffused and subtle, but little as may remain, the retina of the eye is sensible of it."

Jules Verne

The tantalizing concept of the 'world within a world' advocated by tempting science-fictions and fantasies so far has only existed in the realms of imagination. But nature has its way of vicariously delighting in breaking our well-ordered ideas of the physical world. While Earth was evolving prodigiously with primates descending from trees and advancing to Homo sapiens, the inmates of the cave, even without sunlight were busy becoming uniquely distinct. In the southeast Romania, close to the Black Sea, sealed off for 5.5 million years, a new world was forming. Movile Cave with its existing chemosynthetic world has become a treasure trove. The desolate field is unremarkable and so, in 1986, workers in communist Romania while working to find a suitable spot for building a power plant were taken aback when they stumbled upon the Movile Cave. The first man to make the adventurous descent into the unknown depths of the cave was the famous Romanian scientist, Cristian Lascu. Ever since then approximately only 100 people have been allowed entry into the cave.

What makes the Movile Cave so interesting is the fact that it's laden with life. But it is ex-

tremely difficult to enter the cave. One must first be lowered into a narrow shaft and then climb down through even narrower limestone tunnels coated with ochre clay, in pitch darkness and temperatures close to 250C. Ultimately one will reach into a central cavern containing a lake. In 2010, microbiologist Rich Boden of University of Warwick, Coventry, UK, (now in the University of Plymouth, UK) the 29th person to see the cave remarked, "It's pretty warm, and very humid so it feels warmer than it is, and of course with a boiler suit and helmet on that doesn't help."

The lake room with its heavy atmosphere stinks of rotten eggs and burning rubber, which could give you a bad headache and if someone's been down there for more than 5-6 hours, he or she may very well die of kidney failure. To explore the rest of the cave, one has to dive into the acid pool, navigate through passages all the while squeezing through tiny gaps called air bells. Surprisingly, even at such hostile conditions life thrives. So far 48 species of creatures have been found, with 33 of them found only in the Movile. There exist unique scorpions, spiders, woodlice, and centipedes who owe their lives to a floating mat of bacteria in the acid lake. Moreover, the worse the air, the more variety of creatures that crawl and wriggle in the cave. The autotrophic and methanotrophic bacteria provide food for the dwellers. But there's nothing special about these bacteria which are found everywhere else on the earth. Amazingly, most of the animals dwelling inside do not have eyes. They have antennae-like long appendages for movement. These creatures lack pigments and are translucent. It is funny how even though there are no flies around, spiders still spin webs and instead catch insects called 'springtails'. Water scorpions, shrimps, leeches, etc are some fascinating creatures that abound the cave.

The origin of life inside this strange ecosystem has become a heated debate topic among the scientific world. One such theory speculates that when the climate of the Northern Hemi-

sphere changed about 5.5 million years ago, the Atlantic Ocean dried up while Africa moved to the north. The freezing temperatures forced the animals to seek shelter in the undergrounds of caves like Movile. But somehow, the cave got sealed off due to some calamity and has remained such for all these years.

Studying the inhabitants of the cave could lead to a better understanding of primordial earth and the course of evolution. The bacteria's ability to oxidise methane and carbon dioxide, both important components of greenhouse gases could help in developing ways to fight global warming. Even though it's been almost 33 years since the cave was discovered, Movile still remains a dark and dangerous mystery.

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Knowing What Is Unknowable, But Not What the Unknowable Actually Is

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Some truths are unknown – they are not known or fully explicable to us within the present limits of our knowledge. But we can reasonably expect that they would somehow (with or without the help of science) be revealed in future. Again, truths that we would never be able to know and would always remain as unanswerable questions are called "unknowable truths". These are of two types:

(i)   Practically Unknowable Truths: A part of the truth is beyond the scope of our knowledge, as exemplified in chaos theory and quantum mechanics.

(ii) Intrinsically Unknowable Truths: Some truths can logically explain the occurrence of many other natural phenomena. But we can never explain why those truths are the way they are, at least within the purview of the existing system. Examples include mathematical axioms and the laws of nature.

Some examples from science are discussed below:

(i)   Chaos Theory:

Chaotic systems are complex, non-linear and infinitely sensitive – small perturbations in any parameter can make huge differences in their behaviour. So, even if an experiment is repeated with extraordinary accuracy, the outcomes may agree with each other over a short range but long-term concurrence can never be achieved. In the range over which the outcomes do not concur, even if they differ within estimable boundaries, their pattern of differ-

erence is unfathomable. (That is why short-term predictions work for weather, a chaotic phenomenon, but long-term predictions fail to tally with the results.)

(ii) Quantum Mechanics:

Contrary to Newtonian physics which is deterministic, predictable, intuitive, and conforms to our daily physical activities, quantum mechanics is indeterminate and sometimes counterintuitive. Here, the state of a quantum particle is described by the wave function $\psi(x,t)$, derivable from Schrödinger's wave equation, which only provides the probability of attaining a state value but does not state with absolute certainty which state a randomly chosen quantum particle will be in.

One interesting concept is the state of superposition. Let a quantum particle exist in a state Q which has two measurable values q_1 and q_2 associated with the corresponding wave functions ψ_1 and ψ_2. Then the particle will be at a "suspended" state, i.e., the state value is neither q_1 nor q_2 but a collection of two potentialities q_1 and q_2. Any one of them can be realised and the wave function ψ associated with the particle at that state is a linear superposition of ψ_1 and ψ_2:

$$\Psi = \alpha_1.\psi_1 + \alpha_2.\psi_2$$

where

probability of measuring $q_1 = |\alpha_1|^2$,

probability of measuring $q_2 = |\alpha_2|^2$,

and $|\alpha_1|^2 + |\alpha_2|^2 = 1$.

Measurement yields a definite value of Q (either q_1 or q_2) associated with a probability. The transition from a linear superposition (which has some uncertainty associated with itself) to any one of the wave functions is explained by two contradictory theories:

During this transition, there is a "collapse" of the wave function associated with the state

of superposition to the wave function associated with the outcome we have obtained.

There is no "collapse"; instead, every time such a transition takes place, reality splits into multiple universes in each of which one of the possible outcomes is realised. We can measure the outcome associated with the universe we live in and have no idea what is occurring in the remaining universes.

(iii)   Heisenberg's Uncertainty Principle:

We can never measure the position and momentum of a quantum particle simultaneously. The dispersions ΔP and ΔX of momentum and position, respectively, in the corresponding probability distributions for a quantum particle are not independent. They are related as

$$\Delta P.\Delta X \geq h/4\pi \quad \text{where h is Planck's constant.}$$

Let us imagine that a quantum particle is confined in a very narrow space. Such a particle will have a finite ΔX. But the corresponding dispersion ΔP in the probability distribution curve of p(P) versus P will tend to infinity and would thus be indiscernible.

(iv)   String Theory:

String theory states that the universe is made up of nine, not three, dimensions. It has been hypothesised that, originally, the universe was in a miniscule form with all the dimensions less than Planck's length (10-35 m). But, after the Big Bang, it inflated by about 10^{50} times during which the three measurable dimensions expanded while the remaining six remained as they were. Now, Big Bang is just a theory and nobody knows exactly how the universe originated. Also, quantum mechanics has set Planck's length as a hard limit – anything smaller than that is immeasurable. Hence, the remaining six dimensions will always remain unknowable to mankind.

(v) Cosmology:

A black hole comes into existence when a star collapses. As a star starts shrinking, its mass density gradually increases while the escape velocity from the star's gravitational attraction starts increasing. The point at which the escape velocity becomes equal to the speed of light is known as 'event horizon', the point of origin of the black hole, when the radius of the star is denoted by Rc (Schwarzschild radius). We do not have any information about the region of a shrinking star having a radius less than Rc, i.e., what goes on inside a black hole is a practically unknowable truth.

(vi) Mathematics:

In 1931, Kurt Gödel suggested two theorems of mathematical logic, aiming at the fact that mathematics is incomplete. They implied that in mathematics, there are always propositions which we can neither prove nor disprove within a given system, known as unknowable or un-decidable propositions. But we can prove or disprove them if we step out of that domain and step into a meta-domain, which again has its own set of undecidable propositions. E.g., the string, "NNNPNQN",is absolutely meaningless in terms of the English alphabet. But if we map it into the number system using the following index:

P stands for +

Q stands for >

N stands for 1

NN stands for 2

NNN stands for 3

then we get the statement:

3 + 1 > 1

which is a true statement. Thus, a proposition undecidable by the English alphabet can be proven or disproven in the number system, which has its own undecidable propositions, when mapped suitably.

Intelligence, curiosity, rationality and skepticism have guided man to reflect upon and search for the unknown, something that has always lured one to discover new truths, thus broadening one's mind and expanding one's purview of knowledge. With each discovery, mankind moves one step ahead towards achieving the much sought spiritual awakening.

Acknowledgement:

The Human-Tiger Conflict In Sunderbans: Social And Environmental Repercussions
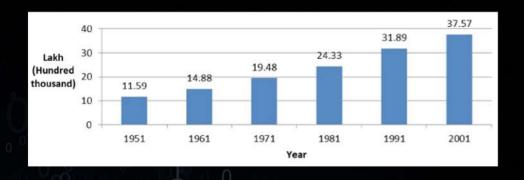
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Can we think of a place where being at the mercy of tigers is our only way of survival? Even in the 21st century? The Sundarbans- the mangrove forests of India and Bangladesh is such a place. But why? What forces men into such a hapless situation? For that, let's go back in time. To 1973, when Sundarbans underwent a radical change in governance.

Prodded by tiger enthusiasts, the first tiger census conducted in India in 1972 produced a shocking result- the total number of tigers in 1972 had dwindled to 1872 from an estimated 40000 in 1900. The alarming threat to the species and a dire need for conservation policies were realized and Project Tiger, India's blueprint for tiger conservation emerged. While this gave enormous powers to the state to protect its flora and fauna both inside and outside forest areas through the Wildlife Protection Act, the fishers of Sundarbans were suddenly denied access to the creeks and canals they always knew as home. The Act also overlooked the rights of indigenous communities living in the outskirts of forests for generations and heavily dependent on forest resources. Regions of the Sundarbans were made into tiger reserves where any kind of forestry were prohibited. Now let's take a look at the demography of Sundarbans in the next fifty years.

The population of the Sundarbans more than trebled in the last fifty years creating tremendous pressure in the Sundarbans ecoregion. A look at the proportion of core area and sanctuary area(fishing prohibited) and the buffer area(fishing permitted) reveals that while the actual number of fishers has increased, the fishing area has radically shrunk.

This gives rise to a very sensitive situation, a conflict between fishermen and forest guards. Due to insufficient catches, a fisherman almost always enters the prohibited area and then desperately hides in a creek to avoid a forest patrol boat because if caught, he suffers fine, physical abuse and humiliation. It is then that he becomes most vulnerable to tiger attacks. The other prime occupation is honey collecting which also involves crossing a tiger's territory, deep in the forest. Why can't there be alternative means of income for this impoverished people? Well, agriculture is productive due to high water salinity and fragmentation of landholding through generations. Rampant construction of lodges and diesel fuelled boats are already harming the vulnerable ecology, so ruthless promotion of tourism is not an option either.

But tiger attacks during fishing or honey collecting is just one side of the problem.

Tigers in the Sundarban mangrove are widely known for frequently straying into the surrounding reclaimed areas. In most cases, tigers resort to cattle lifting and poultry feeding. In

8.9% of cases, human beings were attacked. But human beings are not always the prey.

Incidents of killing these tigers by angry villagers are often reported. Right now, even one tiger being beaten to death is a huge loss. But why do tigers increasingly stray into villages? It is here that the man tiger conflict becomes a global issue. Global warming comes to the picture. Sea level rise due to global warming causes salinity intrusion in the freshwater rivers and canals. This affects the growth of trees like Sundori, Byne, Keora, consequently affecting the deer population. The fall in deer population leads to a shortage of food for tigers which then increasingly stray into villages.

On one hand, the human-tiger conflict (HTC) causes loss of life and livestock, making their poverty unbearable. However, what is overlooked often, is the immense suffering the "tiger widows" go through. They are ostracized by the society, considered ill-fated and treated as outcasts. These extremely poor widows easily fall prey to trafficking. No wonder 24 parganas witness highest number of women trafficking in West Bengal. It is also a fatal blow to conservation - the conflict between villagers and forest officials often results in dead or injured tigers.

Even at the expense of so much, why are we so keen on conserving the Royal Bengal Tiger? Because of its royal looks and lustre? Or because Sundarbans is a unique biodiversity rich region, the only mangrove forest with a tiger population? Or our ethics to honour the integrity of every lifeform on earth?

The Royal Bengal tiger plays a pivotal role in the health and diversity of an ecosystem and is a keystone species. It is a top predator at the apex of the food chain and keeps the population of wild herbivores in check, thereby maintaining the balance between prey herbivores and the vegetation upon which they feed. The extinction of this top predator will lead to destruction of the Sundarbans. And what will that do to us? The entire eastern coast of India might

be submerged under water! Besides ecological services like clean air, water, pollination, temperature regulation that Sundarbans provides like any other forest, it acts as a protective biological shield against cyclones and tsunamis originating from the Bay of Bengal. Without this protective shield, the eastern coast shall become very vulnerable to cyclones and tsunamis. So what is the way out?

Population outflow observed in recent years is healthy because it reduces the tremendous pressure on forest resources. Government incentives or relocation of human settlement programmes are a good option as well. But for the substantial population that still remains there, the killing of 'problem tiger' has been proved to be unjust and not implementable. Whereas preying on human beings is extremely rare among tigers generally, the Sundarban tigers are infamous man-eaters and the reason is still clouded in mystery. Therefore, killing those tigers who stray into villages is a deathblow to the species. Preventive measures such as nylon net fencing, creation of task forces and response teams are already existing and have been successful at times too, but could not stop tiger attacks completely. The tiger compensation programme is an important measure because monetary compensation often helps appease the villagers and prevent killing of tigers out of anger. The failure of Joint Forest Management in Sundarbans is a testimony to the fact that sustainable use of tiger reserves by local communities is not feasible, especially for their man-eating traits. However despite the tremendous loss, many villagers in the Sundarbans are not against the idea of conservation. It is but the repeated attacks and livestock loss that become unbearable for these extremely poor people after a certain time.

Thus, perhaps the time has come to accept the fact that not every ecology is meant for human interference and exploitation. The tiger is already threatened by habitat fragmentation, poaching and biodiversity loss. Let us not interfere in its last stronghold. Let us consider ef-

fective implementation of relocation of human settlement programmes and allow the Royal Bengal Tiger to not be a fearsome destructive animal, but the greatest asset in conserving biodiversity in Sundarbans.

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Harnessing Energy from the Dark

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The earth is on the brink of a mass-extinction event, and the use of renewable and sustainable sources to meet our energy requirements has become imminent. Non-renewable sources of energy such as coal, gasoline, and petroleum produces a lot of toxic gases and by-products, and therefore, are not preferred in this age of rising global temperatures. Solar panels are regarded as an innovative approach towards energy-harvesting; however, they too have their disadvantages. Solar panels are extremely costly and occupy a lot of space. Their efficiency is hindered by the presence of clouds. These factors reduce the feasibility of solar panels for public usage.

Solar panels generate electricity from solar energy primarily by two processes: one of them utilizes a physical process known as the photovoltaic effect, in which certain materials such as silicon block crystals produce electricity when exposed to light energy. The second kind of solar panels uses a thermal process, in which the difference in temperature between the sun and the earth is used to generate electricity. The latter served as an inspiration for a team of scientists at Stanford University to design an inverted version of the solar panels that can harness energy from darkness, and are hence, advantageous over solar panels. 'Anti-solar panels', as they are called, make use of the temperature difference between the earth's atmosphere which is on a relatively cooler side as compared to the earth, which is on a hotter side. The paper has been published in 'Joule', Stanford's scientific journal.

The temperature of the earth stays more or less constant because the amount of energy coming from the sun is approximately equal to the amount of energy being radiated by the earth. Anti-solar panels bridge the gap left by solar energy, as it accumulates energy from the night sky. The researchers have used a process called 'radiative sky cooling'. It is a passive cooling mechanism used to keep the temperature of a thermoelectric generator several degrees below ambient. This process was employed 6000 years ago in the Middle-East where enormous bee-hive structures called 'yakhchāls' were used to store ice in the desert.

The sky-facing side of the generator is attached to an aluminium plate and shielded with a transparent cover and insulation to keep the heat out. Meanwhile, the bottom of the generator is attached to an exposed aluminium plate that is continually warmed by ambient air. The resulting temperature difference pushes electrons from one side of the electrically conductive material to the other, generating an electric current.

Figure: Anti-solar panel

The researchers have tested this system on an 8-inch aluminium disc painted black and connected to commercial thermoelectric generators. It was successful in generating enough energy to light up a small LED bulb- a small achievement with tremendous implications. Improved insulation around the top plate significantly increases energy production.

Unlike solar panels, anti-solar panels require less space and are not significantly disturbed by the presence of clouds. These devices consist of polystyrene enclosures covered in aluminised mylar: cheap basic components (less than $30) that can efficiently reduce the cost of production. Thus, they are much cheaper than solar panels. If designed on a large scale, these anti-solar panels could be used to charge phones, light rooms and power electronics in remote areas that lack electricity at night when solar panels do not function. Moreover, due to the rapid and extensive depletion of non-renewable sources of energy like fossil fuels, human beings would soon face a dead end when they try to generate energy for various purposes. Devices like anti-solar panels promise to resolve this problem. Anti-solar panels could also be used for emergency back-up power, or by people who live far off from solar grids. These devices could also power remote power stations or environmental sensors. If some low power load needs to be powered through three months of darkness, this is the only option.

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CROSSWORDS

1.

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1.

ACROSS :-

1. The behaviour which benefits other organisms at its own cost. (8)

2. A facial feature in humans which is indistinct in Fetal Alcohol Syndrome affected babies. (8)

3. A literature database(6)

4. An imino acid found in proteins(7).

5. buffer used to elute His tagged proteins(9)

6. non-protein enzyme(8)

7. First cell of male gametophyte(6)

8. anticoagulant secreted by leaches(7)

DOWN :-

1. type of T-cells, due to lack of costimulatory signals, become nonresponsive and hence, never proliferate. (7)

8. For detecting gene linkage, radiation hybrids are selected on this medium. (3)

9. functional group found in the constant regions of antibodies.(8)

10. microscope that creates high magnification images of the internal structure of samples(3)

11. catadromous fish that lacks pelvic fins(3)

12. second messenger needed for angiotensin II action(3)

13. lowest concentration of an antimicrobial drug that will inhibit the visible growth of a micro-organism(3)

14. organic matter fraction of varied origin in aquatic systems(3)

2.

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2.

Horizontal

2. Layer just beneath the epidermis of our skin, derived from mesoderm, also called corium.

5. –log [H+], also called Sorenson scale.

6. Electron carrier with flavin nucleotide as prosthetic group.

7. _____ acid is the coenzyme of E2 in Pyruvate Dehydrogenase Complex of the TCA Cycle.

9. 3 and 6 are classes of this type of fatty acids.

11. Costly metal, often used as catalyst, used in jewellery.

12. Uncontrolled cell proliferation, most dreaded disease.

14. Best conductor of electricity.

16. Chemical symbol of Niobium.

18. Aromatic amino acid with indole group in its side chain.

22. Z=18, inert Gas.

23. Isoelectric Point.

24. Used as a gelatinous agent, obtained from red algae.

26. Heavy metal. Maggi was banned in 2015 in India due to excessive presence of this metal.

27. Short form of one of the main structural constituents of the extracellular matrix of animals.

28. One characteristic feature of mammals is the presence of hairy_____.

31. 3-lettered code for the amino acid from which thyroid hormones are derived.

33. Splicing of m RNA removes the _____.

34. _____ currents are associated with power loss in transformers.

36. _____ Gardens is the Cricket stadium in Kolkata.

38. Portion of the eye which is completely avascular and can be transplanted easily.
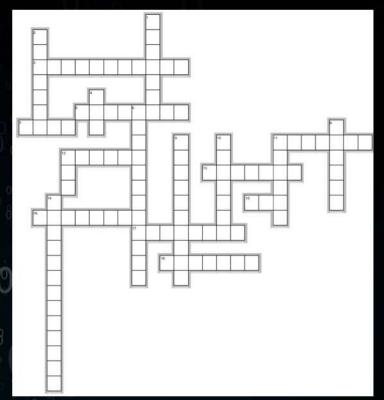
41. Emulsifies fat, produced in the liver.

2.

42. Malleus, Incus and Stapes are the three _____ ossicles.

44. Equational division of cells.

45. Hydrogenation of fat is done in the presence of this metal catalyst.

46. Www stands for World Wide _____.

47. CFLs are being replaced by these nowadays as they have better efficiency.

48. 3-lettered code for the smallest amino acid that can be found anywhere in the Ramachadran plot.

Vertical

1. Short form of Restriction Fragment Length Polymorphism.

2. Insecticide which shows the phenomenon of biomagnification.

3. Reciprocal of ohm, a former unit of electrical conductance.

4. Vitamin precursor of NAD.

5. Short form of the only Cu containing electron carrier in light reaction of photosynthesis.

8. Be developing an infectious disease before symptoms appear.

10. This metal is a cofactor (metal activator) in many metabolic reactions, other than Mg.

13. Genetic material of viroids.

14. Chemical symbol of the lesser known, radioactive member of the Halogen family.

15. Packaging of proteins to be secreted from a eukaryotic cell takes place in this organelle.

17. Chemical symbol for the reddish-brown gas of the halogen family.

18. One of the five cofactors of Pyruvate Dehydrogenase Complex, derived from Thiamine.

19. Protein factory of the cell.

20. Short form of the compound used in somatic hybridization to induce fusion of protoplasts.

21. In parasitism, the parasite draws nutrition from the _____ , but does not kill it.

2.

24. Earthworm is an _____, (related to phylum).

25. _____ constant, appears in formula for wave numbers of lines in atomic spectra.

29. _____'s Cycle is the other name of TCA Cycle.

30. Starch gives a bluish-black color with this compound.

32. The engineered DNA in Recombinant DNA Technology is called _____ .

35. Short form of a compound, used in explosives, a derivative of toluene.

37. Chemical symbol for the inert gas in the 2nd period of The Periodic Table.

39. The _____ cage protects our heart and lungs.

40. 3-lettered code for Aspartic Acid.

43. A _____ of light. A collection of _____s is called a beam of light.

3.

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3.

Across:

3. Ovoviviparous reptile. (11)

5. Every herd is a matriarchy ruled by an alpha female. They are the largest animals on land. (8)

7. This animal lives in a pride. (4)

11. Crepuscular mammals hopping about in Australia. A group of them called a 'mob'. (7)

12. This crustaceans have their hearts in their heads. (6)

13. Large, fierce bears. (7)

15. Australia's national bird. (3)

16. Animal with the largest cranial capacity. (8)

17. Insect eating mammal. (8)

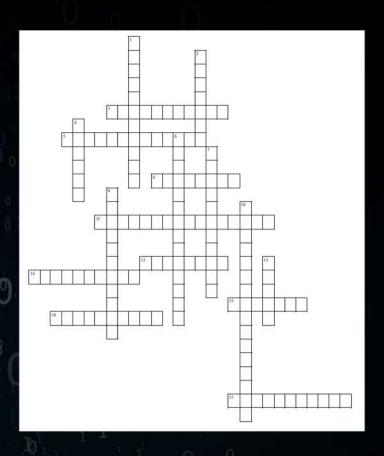18. Flightless birds that swallow pebbles to grind their food. (7)

Down:

1. South American freshwater residents, known for their sharp teeth, and voracious appetites. (7)

2. This tribe hails from Indonesia and still practice cannibalism. (7)

4. Large North American deer. (3)

6. Females are called cows; these African natives can't swim and are one of the most aggressive animals on Earth. (12)

8. They have survived unchanged for 100 million years. In spite of being ambush predators, they are a source of food for Jaguars. (6)

9. Their migration is considered one of the greatest wildlife spectacles on earth. (10)

10. One of the most iconic creatures, having an exceptionally strong heart, weighing about 25 pounds. They are vulnerable and are hunted for their tails. (7)

3.

11. Tooth walking sea-horse. (6)

12. A female pig. (3)

14. A natural dye that causes pink coloration in Flamingos. (13)

4.

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4.

Across

3. A substance that can both accept and donate a proton or H+

5. A region of space surrounding an astronomical object in which charged particles are manipu-lated or affected by that object's magnetic field 8. The study of viruses and virus-like agents

11. Scientific method of dating tree rings (also called growth rings) to the exact year they were formed 12. Second period of the Mesozoic Era

14. A region of the Solar System that exists beyond the eight major planets, extending from the orbit of Neptune (at 30 AU) to approximately 50 AU from the Sun 15. A quantity that characteris-es lack of order or predictability

16. The ratio of the speed of a body to the speed of sound in the surrounding medium 17. A severe allergic reaction that is rapid in onset and can cause death

Down

1. A type of anxiety disorder in which you fear and avoid places or situations that might cause you to panic and make you feel trapped,helpless or embarrassed

2. A straight-sided clear container for holding liquid samples in a spectrophotometer or other in-strument 4. A bright region on the surface of the sun, linked to the subsequent appearance of sunspots in the same area

6. Excessive richness of nutrients in a lake or other body of water,frequently due to run-off from the land, which causes a dense growth of plant life

7. The ratio of the speed of a body to the speed of sound in the surrounding medium 9. Chemi-cal element with atomic number 111

10. A laboratory method used to detect specific RNA molecules among a mixture of RNA 13. A type of elementary particle and a fundamental constituent of matter
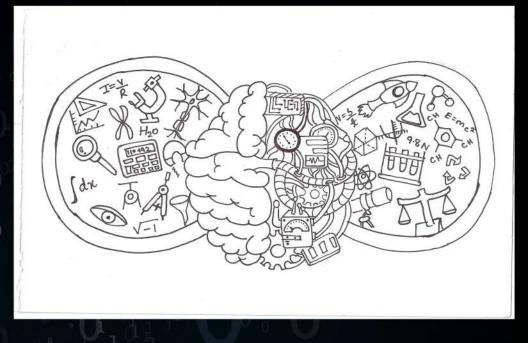
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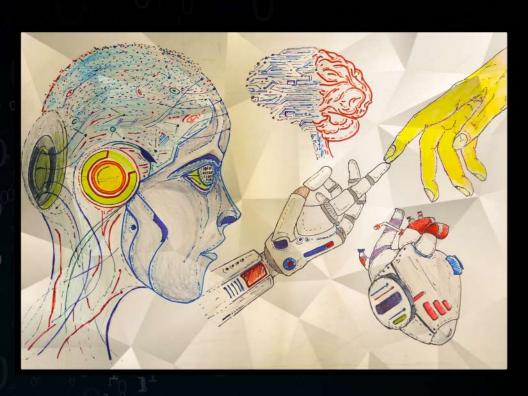Future Institute of Engineering and Management

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SCIENCE FACTS

AND

CURRENT TECHNOLOGIES

"Nature uses only the longest threads to weave her patterns, so that each small piece of her fabric reveals the organization of the entire tapestry."

- Richard Feynman

Every one of us has, at some time, been bothered by how, when and why. The impulse to explore & enquire still chases us all. Getting to know the unknown fills us with unadulterated delight!

The universe is ever dynamic. Something interesting is happening all around. From the water we drink to the time that is passing by, amazing little things occur every picosecond!

Great inventions and discoveries have simplified our lives and most of all, they have made us realise that the most fundamental desire all of us share is the indomitable will to know more about the surroundings. These inventions and discoveries have revolutionized our lives and totally changed the way we see the Universe.

"Looking behind the Glory of Inventions and Discoveries"

By Uttirno Nath

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SCIENCE FACTS

DOES GOD PLAY DICE WITH THE UNIVERSE?

One of the fundamental principles of quantum mechanics is quantum superposition, in which a particle exists in two or more states simultaneously. Recently an international team of physicists from the University of Vienna, The Austrian Academy of Science, University of Queensland (AUS) and The Stevens Institute of Technology (US) has revealed the quantum properties of time according to which the flow of time doesn't follow a straight path forward but a path where cause and effect can coexist in both forward and backward direction. As a result of this, elements of two big contradictory theories were brought together- General Relativity and Quantum Mechanics. Flow of time has different characters in both the theories. Quantum mechanics regards the flow of time as universal and absolute whereas Relativity regards the flow of time as malleable and relative.

THE LONE SURVIVOR

Have you ever thought that a tree can be lonely as well?

Well, in the midst of the Nigerian Sahara desert there was a lonely tree, an Acacia famously known as "Tree of Tenere", which was almost 300 years old. It was the only tree for over 250 miles. It grew on sand which was a wonder, and how it strived to live in that place for so

many days. Unfortunately the tree was knocked down by a drunk driver as he was driving his truck and now a metal sculpture remains at the place where it stood.

Now as Tree of Tenere is down, we have a tree which is the world's loneliest tree in New Zealand which is nothing but a result of anthropogenic activities. A Stika spruce, planted on the turn of the 20th century, has its neighbour tree almost 170 miles away from it. Also, the Campbell island where it is located, was exploited by humans while doing whaling and farming. But still the Stika spruce is striving such human atrocities and inclement climate of the island to become the living loneliest tree of the world.

THE PLANET THAT SPINS CLOCKWISE!

Venus defiantly spins in the complete opposite direction to that in which Earth and other planets rotate. Scientists are still puzzled by Venus's retrograde, or backward rotation.

Current theory holds that Venus initially spun in the same direction as most other planets and, in a way, still does: it simply flipped its axis 180 degrees at some point. Some scientists argued that the rotation of Venus didn't flip at all. They propose instead that its rotation slowed to a standstill and then reversed direction. Taking into account the factors mentioned above, scientists concluded that Venus's axis could have shifted to a variety of positions throughout the planet's evolution.

Venus

CAN HELIUM GAS CLIMB?

At a temperature of 21.7K, called "lambda point", a remarkable transition occurs in liquid Helium- part of it becomes a super fluid, a zero viscosity fluid which rapidly moves upward/downward through any pore in an apparatus. Thus, helium 'climbs'!

JELLYFISH ARE AMAZING CREATURES

Jellyfish have been in the world's oceans for more than 700 million years, which is nearly 3 times the age of the earliest dinosaurs!
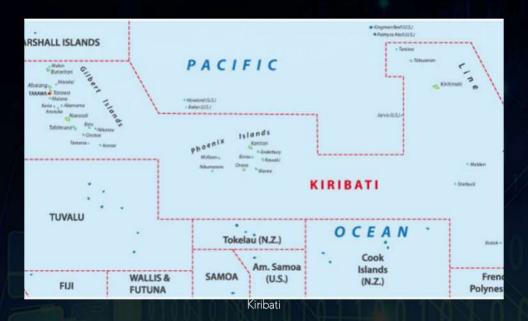
Despite the name, they aren't actually fishes but gelatinous zooplankton with body comprising of 98% water. Most importantly, they don't have a brain or heart. High water content in them can make them evaporate within hours if they are washed ashore.

They are the one of the deadliest creatures and some are so venomous that they can kill a human adult within minutes by only a single sting! One unique species of them, *Turritopsis nuticula*, are immortal.

Jellyfish

THE COUNTRY IN ALL THE HEMISPHERES!

There is a country with only 110,000 population named Kiribati which is spread across all the four hemispheres. For Kiribati, unlike Russia or USA, the reason for such unusual spread is its large number of small islands and its position in Micronesia. Both the Equator and the Prime Meridian passes through it with Gilbert Island, a group of islands having 16 atolls, lying in both Northern and Southern hemispheres and Phoenix Island having 8 atolls lying entirely in the south. Due to its unique position, Kiribati is the most distant nation from Greenwich Meantime and also the first nation (partly) to experience the New Year.

Kiribati

MATHE-MAGIC

Mathematics, even though a subject which generates fear in most minds, is actually filled with amazement! Well, "Forty" is the only number that is spelt with letters arranged in alphabetical order. Conversely, "one" is the only number that is spelt with letters arranged in descending order. "Four" is the only number in the English language that is spelt with the same number of letters as the number itself. However, every odd number has an "e" in it. Also, there are 13 letters in both "eleven plus two" and "twelve plus one", which also sum up to 13! The word hundred is derived from the word "hundrath", which actually means 120 and not 100. Surprisingly, letters a,b,c,d don't appear anywhere in the spelling of 1 to 99.

CAN WATER BOIL AND FREEZE AT THE SAME TIME?

Baffling as it sounds, under particular physical conditions called the triple point, when the temperature and pressure is right, water vapor, water and ice coexist in thermodynamic equilibrium.
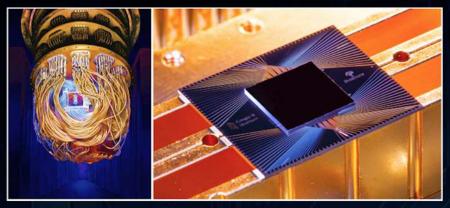
CURRENT TECHNOLOGIES

5G NETWORK

5G is the fifth generation of cellular mobile communications succeeding 4G, 3G and 2G systems. Use of 5G network system will greatly enhance the speed, coverage and responsiveness of wireless networks.

5G network is not just about speed. One of the key benefits is low latency. Latency is the response time between when we click on a link or start streaming a video on a device, which sends the request up to the network, and when the network responds, delivering us the website or playing the video. This lag time can last almost 20 milliseconds with current networks. This doesn't seem like much, but with 5G, that latency gets reduced to as little as 1 millisecond.

GOOGLE'S QUANTUM SUPREMACY

In October 2019, Google announced that they have achieved "Quantum Supremacy". According to Google, their 54-qubit Sycamore processor was able to perform a calculation in 200 seconds that would have taken the world's most powerful supercomputer 10,000 years, which means the calculation, which involved generated random numbers, is practically impossible on a traditional, non-quantum computer.

Left: Artist's rendition of the Sycamore processor mounted in the cryostat.

Right: Photograph of the Sycamore processor.

NEURALINK

Elon Musk, founder of SpaceX and co-founder of Tesla, started an Intelligence startup, 'Neuralink'. Neuralink was supposed to create devices that can be implanted in human brains to help them keep up with machines.

In July 2019, Elon Musk unveiled Nauralink's flexible threads designed to be inserted in human brains to link them directly to computers. Musk said Neuralink's main motive in the long term is to "achieve a sort of symbiosis with Artificial Intelligence". "We hope to have this in a human patient by the end of next year," Musk added.

WAVE COMPUTING

Classical computers consume massive amounts of electricity and data storage, and generate a lot of wasted heat. In search of efficient alternatives, MIT researchers, in November 2019, devised a novel circuit design that enables precise control of computing with magnetic waves, with no electricity needed.

"People are beginning to look for computing beyond silicon. Wave computing is a promising alternative," says Luqiao Liu, a professor in the Department of Electrical Engineering and Computer Science (EECS) and principal investigator of the Spintronic Material and Device Group in the Research Laboratory of Electronics. "By using this narrow domain wall, we can modulate the spin wave and create these two separate states, without any real energy costs. We just rely on spin waves and intrinsic magnetic material."

A BREAKTHROUGH IN 'DISTRIBUTED DEEP LEARNING'

When we try to search for a product during online shopping, the main challenge for the Computer Scientists is to match those unspecific words in a world with millions of products and shoppers. Computer Scientists from Rice University and Amazon have used a Divide-and-Conquer approach to show that they can train the equivalent of a 100-billion parameter distributed deep learning network on a single machine in less than 35 hours for product search and similar complex classification problems.

Computer Scientists at the University of Waterloo have created an inexpensive and battery-free device for wearable computer input, which works just by touching the fingertips together in different ways.

Tip-Tap uses radio frequency identification (RFID) tags to sense when fingertips touch. Thus, the device could be added to disposable surgical gloves, allowing surgeons to access preoperative planning diagrams in an operating room.

"One of the many possible applications of the device is in surgeries. What typically happens now with operation digital pre-planning is that an assistant is responsible for navigating the computer and communicating with the surgeon, but this is slow and difficult," said Daniel Vogel, a professor in Waterloo's David R. Cheriton School of Computer Science. "If the surgeon tries to navigate it themselves using a touchscreen or a mouse, it's problematic because it would require constant sterilization, and current alternatives such as big gestures tracked by computer vision can get very tiring.

"The idea is if you mount Tip-Tap in surgical gloves, surgeons could navigate the computer themselves from where they are, and it won't affect their other actions like picking up the scalpel."

Researchers created the prototype of Tip-Tap as part of a new partnership with the National Research Council of Canada (NRC).

Tip tap

QUANTITATIVE COLOUR PATTERN ANALYSIS

Humans are now very close to seeing through the eyes of animals!

Quantitative Colour Pattern Analysis (QCPA), an innovative framework developed by researchers from the University of Queensland and the University of Exeter have made it possible. QCPA is a collection of innovative digital processing techniques and analytical tools designed to solve the problem of seeing complex visual information or colour patterns in nature.

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ANSWER KEY FOR CROSSWORDS

1.

ACROSS :-

1. ALTRUISM. 2. PHILTRUM. 3. PUBMED. 4. PROLINE. 5. IMIDAZOLE. 6. RIBOZYME. 7. POLLEN. 8. HEPARIN

DOWN :-

1. ANERGIC. 8. HAT. 9. ALDEHYDE. 10. TEM. 11. EEL. 12. DAG. 13. MIC. 14. DOM.

2.

ACROSS:-

2. DERMIS. 5. PH . 6. FAD. 7. LIPOIC. 9. OMEGA. 11. PT. 12. CANCER. 14. AG. 16. NB. 18. TRYP-TOPHAN. 22. AR. 23. PI. 24. AGAR. 26.PB. 27. GAG. 28. SKIN. 31.TYR. 32. INTRON. 34.EDDY. 36.EDEN. 41.BILE. 42. EAR. 44. MITOSIS. 45.NI. 46. WEB. 47. LED. 48. GLY

DOWN:-

1. RFLP. 2. DDT. 3. MHO. 4.NIACIN. 5. PC. 8. INCUBATE. 10. MN. 13. RNA. 14.AT. 15.GOLGI. 17. BR. 18.TPP. 19.RIBOSOME. 20. PEG. 21. HOST. 24. ANNELID. 25. RYDBERG. 29.KREB. 30. IODINE. 32. RDNA. 35. TNT. 37. NE. 39. RIB. 40. ASP. 43. RAY

3.

ACROSS:- 3. RATTLESNAKE. 5. ELEPHANT. 7. LION. 11. WALLABY. 12. SHRIMP. 13. GRIZZLY. 15. EMU. 16. CACHALOT. 17. ANTEATER. 18. OSTRICH.

DOWN:- 1. PIRANHA. 2. KOROWAI. 4. ELK. 6. HIPPOPOTAMUS. 8. CAIMAN. 9. WILDEBEEST. 10. GIRAFFE. 11. WALRUS. 12. SOW. 14. CANTHAXANTHIN.

ANSWER KEY FOR CROSSWORDS

4.

ACROSS:-

3. AMPHIPROTIC.   5. MAGNETOSPHERE.   8. VIROLOGY.   11. DENDROCHRONOLOGY.   12. JURRASIC.   14. KUIPERBELT.   15. ENTROPY.   16. MACHNUMBER.   17. ANAPHYLAXIS

DOWN:-

1. AGORAPHOBIA.   2. CUVETTE   4. FACULA.   6. EUTROPHICATION.   7. PHORONOMICS.   9. ROENTGENIUM.   1O. NORTHERNBLOTTING.   13. QUARK

PEBBLES

2020

SCIΣNCΣ
association

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ST. XAVIER'S COLLEGE (AUTONOMOUS), KOLKATA