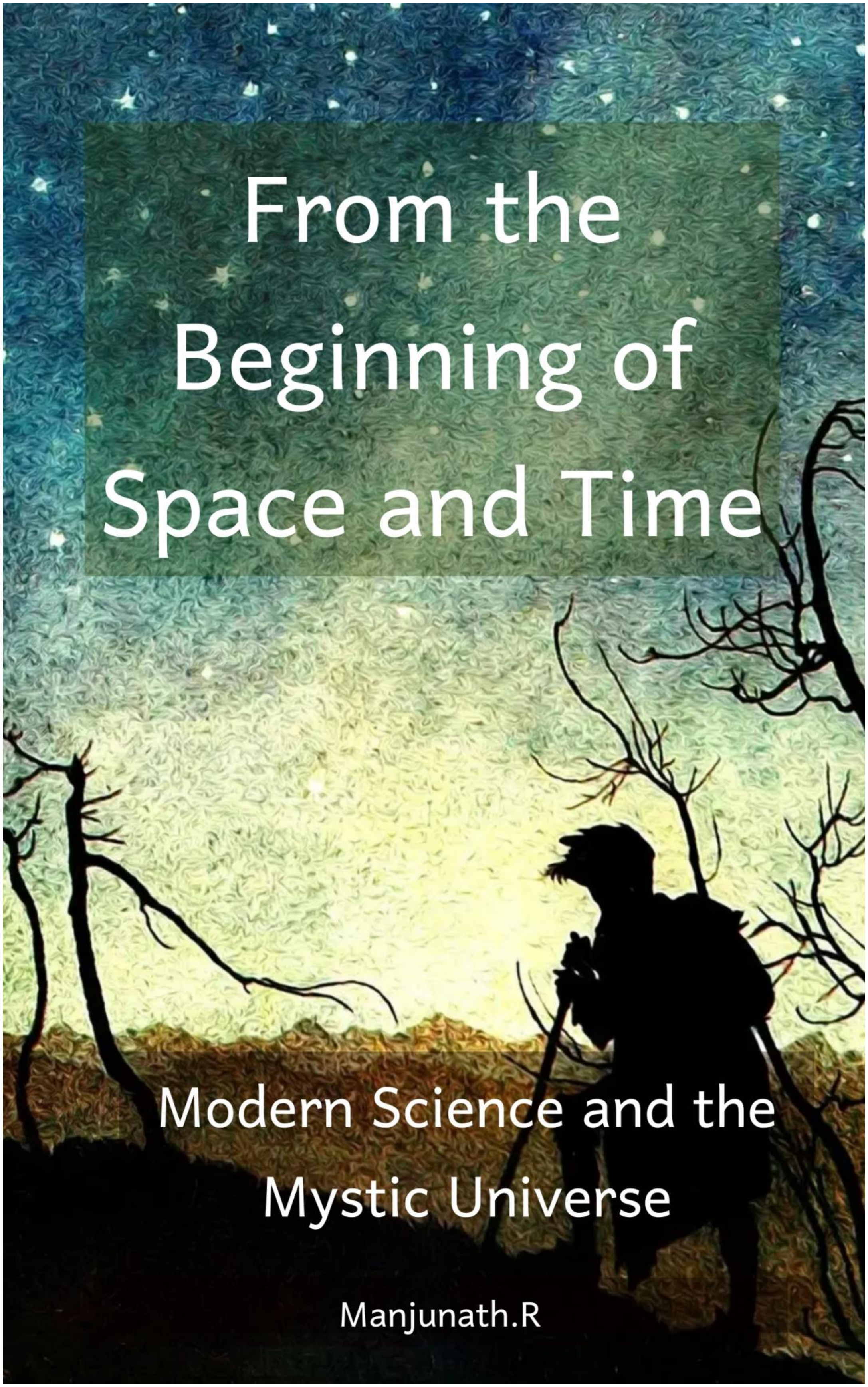
From the Beginning of Space and Time
Modern Science and the Mystic Universe
Manjunath.R

FROM THE BEGINNING OF SPACE AND TIME:

Modern Science and the Mystic Universe

Manjunath.R

manjunath5496@gmail.com

I dedicate this book to everyone who has contributed significantly to our understanding of the universe as a whole, why it is the way it is, and why it even exists.

"My goal is simple. It is a complete understanding of the universe, why it is as it is and why it exists at all."

- STEPHEN HAWKING

CONTENTS

"The universe's imagination always remains wider than our human imaginations."

― Julie J. Morley

INTRODUCTION

◆ ◆ ◆

We human beings − **who are ourselves mere collections of fundamental particles of nature and the product of quantum fluctuations in the very early universe** – unsure of the existence of more than one universe, dark matter, or dark energy, as well as other exotic conceptions − try to wonder, seek answers and gazing at the immense heavens above, we have always asked a multitude of questions: Which came first, the galaxy or the stars? What is Dark Matter? **What is Dark Energy?** What Came Before the Big Bang? **What's Inside a Black Hole?** Are We Alone? **How old is the Universe?** What is the currently most accepted model for the Universe? **What is the origin of the universe?** How did it come into existence, and what was the state of the universe in its earliest moments? **Does gravity travel at the speed of light?** Does the graviton have mass? **Is the Big Bang a Black Hole?** What is the structure of space-time just outside astrophysical black holes? Do their space times have horizons? What happens in a black hole? **Where did the Big Bang happen?** What is the evidence for the Big Bang? **How did life come to exist on Earth?** What conditions were necessary for the evolution of life, and is life unique to our planet or common throughout the universe? What is the nature of time and space? **How does the fabric of space-time behave, and what are the implications of this for our understanding of the universe?** How did the structure of the universe form and evolve over time? What role did dark matter and dark energy play in the formation of galaxies and galaxy clusters? If the production of microscopic black holes is feasible, can the **LHC** create a black hole that will eventually eat the world? **Many others!** These questions continue to trouble scientists despite the massive amounts of data coming in from observatories around the globe and from **particle physics experiments** like the **Large Hadron Collider** in Switzerland, as well as despite the countless hours that astronomers and physicists spend in front of a chalkboard or running computational simulations.

Cosmology is the scientific study of the universe as a whole, including its origin, evolution, and structure. It is an interdisciplinary field that draws on knowledge from astronomy, physics, and mathematics to understand the cosmos on the largest scales. It is one of the oldest branches of **human inquiry** and has its roots in ancient civilizations that tried to understand the nature of the cosmos. The earliest recorded cosmological ideas date back to ancient civilizations such as the Babylonians, **Egyptians**, and **Greeks**. These civilizations believed that the universe was ordered and that the gods controlled its workings. The **Babylonians** were the first to develop a systematic study of the heavens, and they recorded the movements of the planets and stars on clay tablets. The Egyptians also had a deep understanding of the cosmos and believed that the sun and stars were the manifestations of gods. In ancient Greece, philosophers such as **Thales**, **Anaximander**, and **Pythagoras** tried to explain the nature of the universe using reason and observation. However, it was the philosopher Aristotle who had the most significant impact on Greek cosmology. He believed that the universe was eternal, and the earth was at the center of the cosmos, with the stars and planets moving around it in perfect circles. The Greek astronomer **Ptolemy** developed a sophisticated cosmological model that was widely accepted for over a thousand years. According to this model, the earth was at the center of the universe, and the sun, moon, planets, and stars moved around it in a series of perfect circles. This model was refined over time, but it was unable to explain some of the observed phenomena in the night sky. The Polish astronomer **Nicolaus Copernicus** challenged the Ptolemaic model in the 16th century, proposing that the sun was at the center of the universe, and the planets, including the earth, orbited around it. This model, known as the heliocentric model, was later confirmed by the observations of the Italian astronomer **Galileo Galilei**, who used the newly invented telescope to study the planets and stars. In the 17th century, the English physicist **Isaac Newton** developed the laws of motion and gravity, which revolutionized our understanding of the cosmos. He proposed that the universe was governed by universal laws of physics, and that the same physical laws applied everywhere in the cosmos. This idea was later used to explain the motion of the planets, comets, and other celestial objects. The 20th century saw a major shift in cosmological thinking, with the development of new theories and technologies that enabled us to study the universe in new and innovative ways. One of the most significant developments was the discovery of cosmic microwave background radiation in 1965, which provided evidence for the Big Bang theory. This theory proposed that the universe began as a singularity and has been expanding ever since. In the latter part of the 20th century, advances in technology enabled us to observe the cosmos in new ways, such as using radio telescopes and space-based observatories. These observations led to the development of new theories, such as the **inflationary universe theory**, which proposed that the universe underwent a period of rapid expansion in the first few moments after the Big Bang. To sum up, the **history of cosmology** is a long and fascinating one that has been shaped by the ideas and observations of many cultures and individuals. While our understanding of the universe has come a long way, there is still much to learn, and cosmologists continue to work towards unraveling the mysteries of the cosmos. One of the major areas of inquiry in cosmology is the **origin of the universe**, known as the **Big Bang theory.** This theory proposes that the universe began as a **singularity,** an infinitely hot and dense point in space-time, around **13.8 billion years ago**. From this initial state, the universe rapidly expanded and cooled, eventually leading to the formation of atoms and the structure we see today. Another area of study in **cosmology** is the nature of dark matter and dark energy. Observations of galaxy motion and the **cosmic microwave background radiation** have provided strong evidence that the majority of the universe is composed of these mysterious, invisible substances. Despite extensive research, the true nature of **dark matter** and **dark energy** remains unknown, and their study is an active area of research in cosmology. The structure of the universe is also a central focus of **cosmology**. The large scale structure of the universe is thought to be comprised of galaxy clusters and superclusters, which are connected by vast cosmic voids. **Cosmologists** use computer simulations and observational data to study the formation and evolution of this structure. In recent years, **cosmology** has made significant progress due to advances in technology and data collection. The study of the **cosmic microwave background radiation** has provided us with valuable information about the universe's early history, and **large scale surveys of galaxies** have given us a detailed look at the universe's current structure. In essence, **cosmology** is a fascinating field of study that seeks to answer some of the most fundamental questions about the universe. From the origin of the universe to the nature of **dark matter** and **dark energy**, cosmologists are constantly working to expand our understanding of the cosmos.

Why does anything exist as opposed to nothing? What kind of thing is reality? **Why are the natural laws so perfectly balanced to make it possible for intelligent creatures like us to exist?** These questions serve as the framework for what is now known as the "**standard model**" of the beginning of the universe, which takes us on an amazing adventure starting from the Planck Epoch, the very beginning of the universe's history, and ending with the scientific breakthrough of the **Cosmic Microwave Background** and Albert Einstein's Theory of Relativity. And now, with advancement in cosmology, **quantum theory**, relativity and string theory, many researchers have been able to solve problems relating to almost everything from the **smallest quarks** to the largest **exploding stars**. Astrobiology **(often referred to as xenobiology or exobiology)** upholds its perspective on life elsewhere in the universe, holding that while the dimensions of the universe allows for the possibility of millions of **extraterrestrial civilizations**, there is no reliable evidence to support the claim that any of these civilizations have ever been to **Earth** to meet us. Only **4% of our universe** is made up of the matter that goes into making the **smallest atomic particles**, planets, stars, galaxies, black holes, and **wormholes**, which has caused some scientists in the community of theoretical physics to scramble to find an explanation for it in recent years. **The remaining 96% of the cosmos is a complete mystery.** Until now. The universe is full of mysteries. It might conceal dimensions of space in addition to the well-known three that we are familiar with. There may even be an undiscovered, invisible neighboring universe to our own.

The **question of why we exist** is one of the oldest and most profound philosophical questions, and it has been pondered by thinkers for centuries.

There is no one answer that can fully explain the reasons for our existence, as it is a complex and multifaceted question that can be approached from many different perspectives. From a **scientific perspective,** we can understand why we exist in terms of the laws of physics and the way they have shaped the universe and the development of life on Earth. For example, the **laws of physics**, such as **gravitation** and the **laws of thermodynamics**, have created the conditions that allowed for stars to form and eventually give birth to planets like Earth. Over time, life on Earth evolved through a process of **natural selection**, leading to the development of species like humans. From a religious perspective, the reasons for our existence may be understood in terms of a **higher power** or **deity** creating the universe and humanity for a specific purpose. Different religious traditions have different beliefs about **why we exist** and the role we play in the larger cosmic plan. Philosophically, the question of why we exist can be seen as a question about the **meaning and purpose of life**. Some **philosophers** argue that life has no inherent meaning, while others believe that our existence is imbued with purpose, either by a higher power or through our own actions and choices. Ultimately, the reasons for our existence are a subject of ongoing debate and discussion, and each person may have their own unique perspective based on their beliefs and experiences. There is no **one answer** that can fully explain **why we exist**, and the question may remain unanswered for some, but that does not diminish its importance or the continued effort to understand it.

Theories are models or frameworks that attempt to explain or predict a phenomenon. While theories are generally useful in providing a way to understand and make sense of complex phenomena, they are not infallible and can have limitations and failures. Here are a few examples of failures of theories:

Incomplete or inaccurate assumptions: The assumptions underlying a theory may not always be complete or accurate, leading to limitations or errors in the predictions or explanations the theory provides.

Limited applicability: The scope of a theory may be limited to a specific context or situation, and may not be applicable to other contexts or situations.

Contradictory evidence: New evidence or observations may contradict the predictions or explanations provided by a theory, calling into question its validity or usefulness.

Unfalsifiability: Some theories may be inherently unfalsifiable, meaning that it is impossible to prove or disprove them with empirical evidence. This makes them difficult to test or verify, and may limit their usefulness in explaining or predicting phenomena.

Inadequate testing: The testing of a theory may be inadequate or flawed, leading to incorrect conclusions about its validity or usefulness.

It is important to note that failures of theories do not necessarily mean that the **theory is useless or without value**. Rather, it highlights the need for continued refinement and improvement of theories through ongoing research and testing.

Seeking an answer to the fundamental puzzle of why do we exist at all?

There are just a few of the many questions that cosmologists seek to answer, and the field continues to evolve as new data and technology become available. The **study of cosmology** provides us with a deeper understanding of the universe and our place within it and it continues to be a source of wonder and discovery. This book provides a glimpse into the living story of our universe and a clear, readable and self-contained introduction to the **story of how our understanding of the cosmos has evolved significantly over time.** It fills the gap and addresses the issues that are important to everyone, or at least to everyone reading this book, and it inspires us to explore the black holes and time machines, **entire cosmos from creation to ultimate destruction**, with a wealth of secrets at every turn. It discusses the mind-bending nature of time and space, **God's involvement in creation**, the past and future of the universe, and more.

The **purpose of the universe** is a philosophical and scientific question that has been debated by **scholars** and **thinkers** for centuries. While there is no definitive answer, here are some perspectives on the purpose of the universe:

From a scientific perspective, the universe can be seen as the result of natural processes that have unfolded over billions of years. The purpose of the universe, in this view, is simply to exist and to continue to evolve according to the laws of physics.

From a religious perspective, the purpose of the universe may be tied to the beliefs of a particular faith. For example, some religious traditions hold that the universe was created by a deity or deities, and that its purpose is to serve as a manifestation of the divine.

From a human perspective, the purpose of the universe may be to provide a home for life, including human life, and to offer opportunities for growth, exploration, and understanding. In this view, the universe can be seen as a vast and complex environment that offers endless possibilities for discovery and learning.

Ultimately, the **purpose of the universe** is a deeply personal and subjective question that may depend on one's worldview, beliefs, and values.

Gravity was first described by **Sir Isaac Newton** in the 17th century, and is explained by his law of universal gravitation, which states that every object in the universe attracts every other object with a force that is proportional to the product of their masses and inversely proportional to the square of the distance between them. Gravity is the force that keeps us anchored to the Earth, and without it, we would float off into space. Despite its importance, the nature of gravity remains a mystery in many ways, and it is one of the most active areas of research in physics today. **Dark matter** is a type of matter that is thought to make up about 85% of the matter in the universe, but it does not interact with light or other forms of electromagnetic radiation. The nature of **dark matter** is still unknown, and scientists are working to develop new ways to detect it and understand its properties. **Dark energy** is a mysterious force that is thought to be responsible for the accelerating expansion of the universe. Its nature and origin are still unknown, and scientists are exploring different theories to explain it. According to **general relativity**, space and time are intimately linked and can be warped by matter and energy. However, the principles of general relativity and quantum mechanics seem to be incompatible, and scientists are searching for a **theory of quantum gravity** that can unify these two branches of physics. The **Big Bang theory** is the most widely accepted explanation for the origin of the universe, but it still leaves many unanswered questions, such as what caused the Big Bang, and what happened in the moments immediately after. While there is no conclusive evidence of **extraterrestrial life**, the vast size and age of the universe suggest that life may exist elsewhere. Scientists are exploring different techniques for detecting signs of life on other planets and moons, and searching for habitable environments beyond our solar system. The mysteries of the universe continue to captivate and challenge scientists. As technology and scientific knowledge advance, we may be able to unlock more of these secrets and gain a deeper understanding of the universe and our place within it.

Have we reached the end of physics? As far as our current understanding of the universe goes, there is no reason to believe that physics will ever come to an end. Physics is the study of the fundamental laws of nature, and these laws have been observed to be consistent and unchanging throughout the history of the universe. Of course, our understanding of physics is constantly evolving as new discoveries are made and new theories are developed. However, even if we were to discover a completely new set of physical laws that completely upended our current understanding of the universe, it is likely that the study of these new laws would simply become a new branch of physics. Furthermore, physics is intimately connected to the other natural sciences, such as chemistry, biology, and geology. As our understanding of these fields grows, it is likely that our understanding of physics will continue to grow as well. So, in short, there is no reason to believe that physics will ever come to an end. As long as there is a universe to observe and study, there will be a need to understand its fundamental laws. **Why something? Why not nothing?** Why is There Universe rather Than Nothing? Science scrambles, Nature mystifies. This book concentrates on presenting the subject from the understanding perspective of cosmology and brings the reader right up to date with curious aspects of cosmology established over the last few centuries. This book assumes cosmology a journey not a destination and the advance of knowledge is an infinite progression towards a goal that forever recedes. This book will be of interest to students, teachers and general science readers interested in fundamental ideas of **cosmology** from the Big Bang to the present day and on into the future. It encourages us to think about the universe and our place in it in unique and fascinating ways while focusing our attention on the ongoing quest for the enticing secrets at the centre of time and space. Just as the mind is a womb of wordless thoughts, the universe is a fountain where everything is conceived.

◆ ◆ ◆

CHAPTER 1

THE HISTORY OF THE UNIVERSE IN 1000 WORDS OR LESS

The effort to understand the universe is one of the very few things that lifts human life a little above the level of farce, and gives it some of the grace of tragedy.

− Steven Weinberg

◆ ◆ ◆

Cosmic Event in which our universe was born.

Cosmic Inflation in which the **Grand Unified Force** was separated into the Four Forces of Nature **(gravity, electromagnetic, the weak force and the strong force)** as We Now Know Them, and the space expanded by a factor of the order of 10^{26} over a time of the order of 10^{-36} to 10^{-32} seconds to Many Times Its Original Size in a Very Short Period of Time – Rapid expansion in which the universe super cooled, though not Quite as Quickly from about 10^{27} down to 10^{22} Kelvins.

There were 2 types of fundamental particles: quarks and leptons. Quarks felt the strong interaction, leptons did not. Both quarks and leptons felt the other three interactions.

PARTICLE-ANTIPARTICLE ANNIHILATION in which All the Antiparticles in the Universe Annihilated Almost All the Particles, Creating a Universe Made Up of Matter and Photons **(which did not possessed electrical charge nor did they had any rest mass)** and no antimatter. This process satisfied a number of conservation laws including:

Conservation of electric charge: The net charge before and after was zero.

Conservation of momentum and energy: The net momentum and energy before and after was zero.

If the positron and the electron were moving very slowly, then they went into orbit round each other producing a quasi-stable bound atom-like object called positronium. **Positronium** was very unstable: the positron and the electron invariably destroyed each other to produce high energetic gamma photons.

DEUTERIUM AND HELIUM PRODUCTION in which Many of the positively charged Protons and electrically neural Neutrons in the Early Universe Combined to Form **Heavy Hydrogen** and Helium. The **proton** was composed of two up quarks and one down quark and the **neutron** was composed of two down quarks and one up quark.

Charge on the up quark was $+ 2/3 \times 1.6 \times 10^{-19}$ coulombs

Charge on the down quark was $-1/3 \times 1.6 \times 10^{-19}$ coulombs

The charge on the proton was approximately $+ 1.6 \times 10^{-19}$ coulombs and that on the electron was -1.6×10^{-19} coulombs.

Intrinsic energy of a proton or a neutron was =
Kinetic Energy of quarks + Potential Energy of
quarks + intrinsic energy of quarks

RECOMBINATION in which Electrons Combined with Hydrogen and Helium Nuclei, Producing Neutral Atoms. A neutrino was passed through matter then it reacted with a proton to produce a positively charged particle with the same mass as the electron — this particle was the positron. The properties of the strong force were such that the quarks did not all stick together in one large mass **(otherwise the newly born universe would have been a huge lump of fundamental constituent of matter)**. The **strong force** ensured that quarks and antiquarks could only stick together in groups of **three:**

2 up quarks + 1 down quark → **Proton**

or

2 up antiquarks + 1 down antiquark → **Antiproton**

or as a quark and an **antiquark pair** (up quark + up antiquark).

GALAXY FORMATION in which the Milky Way Galaxy **(consisted of ≈10^{11} stars)** was Formed – **TURBULENT FRAGMENTATION** in which a Giant Cloud of Gas Fragments broke into Smaller Clouds, which later Became Protostars – **MASSIVE STAR FORMATION** in which a Massive Star was Formed. The star's gravity tried to squeeze the star into the smallest ball possible. But the nuclear fusion reaction in the star's core created strong outward radiation pressure. This outward radiation pressure resisted the inward squeeze of a force called **gravity**.

STELLAR EVOLUTION in which Stars Evolved and Eventually Died – **IRON PRODUCTION** in which Iron was Produced in the Core of a Massive Star, Resulting in a Disaster called **SUPERNOVA EXPLOSION** in Which a Massive Star Ended Its Life by Exploding outpouring electromagnetic radiation over a very short period of time – **STAR FORMATION** in which the Sun was Formed within a cloud of gas in a **spiral arm of the Milky Way Galaxy**. There was a mass limit to neutron stars. It was approximately about 4 solar mass. Beyond this limit the degenerate neutron pressure was not sufficient to overcome the gravitational contraction and the star collapsed to black holes. **There was no mass limit to the mass of a black hole.**

PLANETARY DIFFERENTIATION in which the vast disk of gas and debris that swirled around the sun giving birth to planets, moons, and asteroids. Planet Earth was the third planet out − **VOLATILE GAS EXPULSION** in which the Atmosphere of the Earth was Produced – **MOLECULAR REPRODUCTION** in which Life on Earth was created.

PROTEIN CONSTRUCTION in which Proteins were built from organic compounds that contain amino and carboxyl functional groups **(Amino Acids)** – **FERMENTATION** in which Microorganisms Obtained Energy by converting sugar into alcohol – **CELL DIFFERENTIATION** in which dividing cells changed their functional or phenotypical type and **Eukaryotic Life** had a beginning.

RESPIRATION in which Eukaryotes Evolved to Survive in an Atmosphere with Increasing Amounts of Oxygen – **MULTICELLULAR**

ORGANISMS CREATION In Which Organisms Composed of Multiple Cells emerged – **SEXUAL REPRODUCTION** in Which a New Form of Reproduction Occurred and with the **invention of sex**, two organisms exchanged whole paragraphs, pages and books of their DNA helix, producing new varieties for the **sieve of natural selection**. And the **natural selection** was a choice of stable forms and a rejection of unstable ones. And the variation within a species occurred randomly, and that the survival or extinction of each organism depended upon its ability to adapt to the environment. And organisms that **found sex uninteresting quickly** became extinct.

EVOLUTIONARY DIVERSIFICATION in which the Diversity of Life Forms on Earth Increased Greatly in a Relatively Short Time – **TRILOBITE DOMINATION** In Which Trilobites **(an extremely successful subphylum of the arthropods that were at the top of the food chain in Earth's marine ecosystems for about 250 million years**) Ruled the Earth.

LAND EXPLORATION In Which Animals First Venture was On to Land – **COMET COLLISION** in which a Comet smashed the Earth – **DINOSAUR EXTINCTION** In Which an asteroid or comet slammed into the northern part of the Yucatan Peninsula in Mexico. This world-wide cataclysm brought to an end the long age of the **fossil reptiles of the Mesozoic era** (**dinosaurs**)

MAMMAL EXPANSION in which Many Species of warm-blooded animals with hair and backbones was developed – **HOMO SAPIENS**

MANIFESTATION In Which our caveman ancestors Appeared in Africa from a line of creatures that descended from apes.

LANGUAGE ACQUISITION in which something called curiosity ensued which triggered the breath of perception and our caveman ancestors became conscious of their existence and they learned to talk and they Developed Spoken Language – **GLACIATION** in which the formation, movement and recession of glaciers Began.

INNOVATION in which Advanced Tools were Widely made and Used – **RELIGION** In Which a Diversity of Beliefs emerged – **ANIMAL DOMESTICATION** in which Humans Domesticated Animals.

FOOD SURPLUS PRODUCTION In Which Humans Developed and promoted the practice of cultivating plants and livestock – **INSCRIPTION** In Which Writing was Invented and it allowed the communication of ideas.

WARRING NATIONS In Which Nation Battled Nation for Resources – **EMPIRE CREATION AND DESTRUCTION** In Which the First Empire in Human History Came and went – **CIVILIZATION** In Which Many and Sundry Events Occurred.

CONSTITUTION In Which a Constitution was Written to determine the powers and duties of the government and guarantee certain rights to the people in it – **INDUSTRIALIZATION** in Which Automated

Manufacturing and Agriculture Revolutionized the World – **WORLD CONFLAGRATIONS** In Which Most of the World was at War.

FISSION EXPLOSIONS In Which Humans Developed the most dangerous weapons on earth **(Nuclear Weapons)** – **COMPUTERIZATION** In Which Computers were Developed to carry out sequences of arithmetic or logical operations automatically.

SPACE EXPLORATION In Which Humans Began to Explore Outer Space which fuelled interest in exploring and discovering new worlds − pushing the boundaries of the known − and expanding scientific and technical knowledge – **POPULATION EXPLOSION** In Which the Human Population of the Earth Increased at a Very Rapid Pace.

SUPERPOWER CONFRONTATION In Which Two Powerful Nations Risked it All – **INTERNET EXPANSION** In Which a Network of Computers Developed to carry out a vast range of information resources and services.

RESIGNATION In Which One Human Quitted His Job – **REUNIFICATION** In Which a Wall went Up and Then Came Down.

WORLD WIDE WEB CREATION In Which a New Medium was Created to meet the demand for automated information-sharing between scientists in universities and institutes around the world – **COMPOSITION** In Which a Book was Written – **EXTRAPOLATION** In Which Future

Events were Discussed (sharing our understanding of the workings of the universe, opening our eyes to the grandeur of the cosmos).

◆ ◆ ◆

CHAPTER 2

A BRIEFER HISTORY OF TIME

Nothing happens until something moves.

— Albert Einstein

◆ ◆ ◆

Ever since the beginning of human civilization, we have not been in a state of satisfaction to watch things as incoherent and unexplainable. While we have been thinking whether the universe began at the **big bang singularity** and would come to an end either at the **big crunch singularity**, we have converted at least a thousand joules of energy in the form of thoughts. This has decreased the disorder of the human brain by about few million units. Thus, in a sense, the evolution of human civilization in understanding the universe has established a small corner of the order in a human brain. However, the burning questions still remain unresolved, which set the human race to keep away from such issues. Many early native postulates have fallen or are falling aside – and there now alternative substitutes. In short, while we do not have an answer, we now have a whisper of the grandeur of the problem. With our **limited brains and tiny knowledge**, we cannot hope to have a complete picture of unlimited speculating about the gigantic universe we live in.

Stories of creation are a fundamental part of many cultures and traditions, serving as a way to explain the origins of the universe and humanity. These stories can be found in religious texts, cultural myths, and traditional tales and they often reflect the beliefs and values of the society in which they originated. Here are a few examples of creation stories from different cultures.

The Bible: The Biblical Creation Story Can Be Found In The **Book Of Genesis**, And It Describes How **God** Created The Universe In Six Days And Rested On The Seventh. On The First Day, **God** Created Light, And On Subsequent Days, He Created The Sky, The Seas, The Land, Plants, Animals, And Finally Humans, Who Were Created In His Own Image.

Hinduism: In Hinduism, The Creation Of The Universe Is Described In The Hindu Scriptures Known As The Vedas. One Of The Most Well-Known Hindu Creation Stories Is That Of The **God Brahma**, Who Emerged From The Cosmic Egg And Created The Universe And All Living Things.

Ancient Greek Mythology: In Ancient Greek Mythology, The Universe Was Created From The Remains Of The **Titans**, A Race Of Giant Beings Who Were Defeated By The **Gods Of Olympus**. According To The Myth, The **God Chronos** Swallowed His Children, But His Son Zeus Eventually Defeated Him And Became The Ruler Of The Universe.

Indigenous Cultures: Many Indigenous Cultures Have Their Own Creation Stories That Reflect Their Beliefs And Traditions. For Example, Some Native American Tribes Have Creation Stories That Describe How The World Was Formed From The Body Of A Giant Animal Or The Actions Of A Great Spirit.

Chinese Mythology: In Chinese Mythology, The Universe Was Created By The Goddess **Nüwa**, Who Molded Humans From Clay And Separated The Sky From The Earth. She Also Created The Four Seasons And Set The Laws Of Nature In Motion.

These are just a few examples of the many creation stories that exist across **cultures** and **traditions**. Regardless of their specific details, these stories often serve as a way to provide meaning and context for the universe and humanity, and they continue to play an important a part in influencing our **perspective** and **beliefs**.

In 1911, fresh from completion of his PhD, the young Danish physicist **Niels Bohr** left Denmark on a foreign scholarship headed for the **Cavendish Laboratory** in Cambridge to work under **J. J. Thomson** on the structure of atomic systems. At the time, Bohr began to put forth the idea that since light could no long be treated as continuously propagating waves, but instead as discrete energy packets **(as articulated by Planck and Einstein)**, why should the classical Newtonian mechanics on which **Thomson's model** was based hold true? It seemed to Bohr that the atomic model should be modified in a similar way. If electromagnetic energy is quantized, i.e. restricted to take on only integer values of **hυ**, where υ is the frequency of light, then it seemed reasonable that the mechanical energy associated with the energy of atomic electrons is also quantized. However, Bohr's still somewhat vague ideas were not well received by **Thomson**, and **Bohr** decided to move from Cambridge after his first year to a place where his concepts about quantization of electronic motion in atoms would meet less opposition. He chose the **University of Manchester**, where the chair of physics was held by **Ernest Rutherford**. While in Manchester, Bohr learned about the nuclear model of the atom proposed by **Rutherford**. To overcome the difficulty associated with the classical collapse of the electron into the nucleus, **Bohr** proposed that the orbiting electron could only exist in certain special states of motion - called **stationary states**, in which no electromagnetic radiation was emitted. In these states, the angular momentum of the electron "**L** " takes on integer values of Planck's constant divided by 2π, denoted by $\hbar = h/2\pi$ **(pronounced h-bar)**. In these stationary states, the electron angular momentum can take on values $\hbar$, $2\hbar$, $3\hbar$... but never non-integer values. This is known as **quantization of angular momentum**, and was one of **Bohr's key hypotheses**. Bohr Theory was very successful in predicting and accounting the energies of line spectra of hydrogen **i.e. one electron system.** It could not explain the line spectra of atoms containing more than one electron. For lack of other theories that can accurately describe a large class of arbitrary elements to must make definite predictions about the results of future observations, we forcibly adore the theories like the **big bang**, which posits that in the beginning of evolution all the observable galaxies and every speck of energy in the universe was jammed into a very tiny mathematically indefinable entity called the singularity **(or the primeval atom named by the Catholic priest Georges**

Lemaitre, who was the first to investigate the origin of the universe that we now call the big bang). This extremely dense point exploded with unimaginable force, creating matter and propelling it outward to make the billions of galaxies of our vast universe. It seems to be a **good postulate** that the anticipation of a mathematically indefinable entity by a scientific theory implies that the theory has ruled out. It would mean that the usual approach of **science** of building a scientific model could anticipate that the universe must have had a beginning, but that it could not prognosticate how it had a beginning. Between 1920s and 1940s there were several attempts, most notably by the British physicist **Sir Fred Hoyle** **(a man who ironically spent almost his entire professional life trying to disprove the big bang theory)** and his co-workers: **Hermann Bondi** and **Thomas Gold**, to avoid the cosmic singularity in terms of an elegant model that supported the idea that as the universe expanded, new matter was continually created to keep the density constant on average. The universe didn't have a beginning and it continues to exist eternally as it is today. This idea was initially given priority, but a **mountain of inconsistencies** with it began to appear in the mid 1960's when observational discoveries apparently supported the evidence contrary to it. However, **Hoyle** and his supporters put forward increasingly contrived explanations of the observations. But the final blow to it came with the observational discovery of a faint background of microwaves (whose wavelength was close to the size of water molecules) throughout space in 1965 by **Arno Penzias** and **Robert Wilson**, which was the "**the final nail in the coffin of the big bang theory**" i.e., the discovery and confirmation of the cosmic microwave background radiation **(which could heat our food stuffs to only about −270 degrees Centigrade − 3 degrees above absolute zero, and not very useful for popping corn)** in 1965 secured the **Big Bang** as the best theory of the origin and evolution of the universe. Though **Hoyle** and **Narlikar** tried desperately, the **steady state theory** was abandoned.

With many bizarre twists and turns of Humanity's deepest desire for knowledge, **super strings** − a generalized extension of string theory which predicts that all matter consists of tiny vibrating strings and the precise number of dimensions: ten and has a curious history **(It was originally invented in the late 1960s in an attempt to find a theory to describe the strong force)**. The usual three dimensions of space − **length, width, and breadth** − and one of time are extended by six more spatial dimensions − blinked into existence. Although the mathematics of **super strings** is so complicated that, to date, no one even knows the exact equations of the theory **(we know only approximations to these equations, and even the approximate equations are so complicated that they as yet have been only partially solved)** − The best choice we have at the moment is the **super strings**, but no one has seen a **superstring** and it has not been found to agree with experience and moreover there's no direct evidence that it is the correct description of what the universe is. **String theory** has the potential to reconcile two of the biggest theories in physics: **general**

relativity, which describes the behavior of gravity on large scales, and **quantum mechanics**, which governs the behavior of matter on very small scales. However, it remains a highly theoretical and mathematically complex area of research, and much of its predictions are difficult to test experimentally. Nonetheless, **string theory** has made significant contributions to our understanding of the fundamental nature of the universe and remains an active area of research in **theoretical physics**.

The idea of **extra dimensions** is motivated by a number of theoretical and experimental considerations. One of the most important is the search for a **unified theory of all the fundamental forces of nature**, including gravity, electromagnetism, and the strong and weak nuclear forces. In many of these theories, the **extra dimensions** are necessary to unify the different forces into a single, coherent framework. Are there only 4 dimensions or could there be more: **x, y, z, t) + w, v, …?** Can we experimentally observe evidence of higher dimensions? What are their shapes and sizes? Are they classical or quantum? Are dimensions a fundamental property of the universe or an emergent outcome of chaos by the mere laws of nature **(which are shaped by a kind of lens, the interpretive structure of our human brains**)? And if they exist, they could provide the key to unlock the deepest secrets of nature and Creation itself? We humans look around and only see four **(three spatial dimensions and one time dimension i.e., space has three dimensions, I mean that it takes three numbers –**

length, breadth and height− to specify a point. And adding time to our description, then space becomes space-time with 4 dimensions) – why 4 dimensions? Where are the other dimensions? Are they rolled the other dimensions up into a space of very small size, something like a **million million million million millionth of an inch** − so small that our most powerful instruments can probe? Up until recently, we have found no evidence for signatures of **extra dimensions**. No evidence does not mean that extra dimensions do not exist. However, being aware that we live in more dimensions than we see is a great prediction of **theoretical physics** and also something quite futile even to imagine that we are entering what may be the golden age of **cosmology** even our best **technology** cannot resolve their shape. For **n** spatial dimensions: The **gravitational force** between two massive bodies is: $F_G = GMm / r^{n-1}$, where G is the gravitational constant (**which was first introduced by Sir Isaac Newton - who had strong philosophical ideas and was appointed president of the Royal Society and became the first scientist ever to be knighted - as part of his popular publication in 1687 "Philosophiae Naturalis Principia Mathematica" and was first successfully measured by the English physicist Henry Cavendish**), M and m are the masses of the two bodies and r is the distance between them. The **electrostatic force** between two charges is: $F_E = Qq / 4\pi\varepsilon_0 r^{n-1}$, where ε_0 is the absolute permittivity of free space, Q and q are the charges and r is the distance between them. **What do we notice about both of these forces?** Both of these forces are proportional to 1 / r^{n-1}. So in a 4 dimensional universe (**3 spatial dimensions + one time dimension**) forces are proportional to 1 / r^2; in the 10 dimensional universe (**9 spatial dimensions + one time dimension**) they're proportional to 1 / r^8. Not surprisingly, at present **no experiment** is smart enough to solve the problem of whether or not the universe exists in 10 dimensions or more **(i.e., to prove or disprove both of these forces are proportional to 1 / r^8 or proportional to a value greater than 1 / r^8)**. However, yet mathematically we can imagine many spatial dimensions but the fact that that might be realized in nature is a profound thing. So far, we presume that the universe exists in extra dimensions because the **mathematics of superstrings** requires the presence of **ten distinct dimensions** in our universe or because a **standard four dimensional theory** is too small to jam all the forces into one mathematical framework. But what we know about the **spatial dimensions** we live in is limited by our own abilities to think through many approaches, many of the most satisfying are scientific. Among many that we can develop, the most well-known, believed theory at the present is the **standard four dimensional theory**. However, development and change of the **theory always occurs as many questions still remain about our universe we live in**. And if space was **2 dimensional** then force of gravitation between two bodies would have been = GMm / r **(i.e., the force of gravitation between two bodies would have been far greater than its present value)**. And if the force of gravitation between two bodies would have been far greater than its present value, the **rate of emission of gravitational radiation** would have been sufficiently high enough to cause the earth to spiral onto the **Sun even before the sun become a black hole** and swallow the earth. While if space was **1 dimensional** then force of gravitation between two bodies would have been = GMm **(i.e., the force of gravitation between two bodies would have been independent of the distance between them)**.

The **hierarchy problem in particle physics and other theoretical issues** can both be resolved with the aid of extra dimensions. This problem arises from the fact that the **strength of gravity** is much weaker than the other **fundamental forces**, despite the fact that they are all thought to arise from the same underlying framework. One possible explanation for this discrepancy is that the extra dimensions are responsible for **"diluting"** the strength of gravity at larger scales. The quest for **dark matter** and **dark energy** may be significantly impacted by the existence of **extra dimensions**. Although their nature and characteristics are not completely known, it is believed that these enigmatic substances make up a significant fraction of the universe.According to certain theories, they may be connected to the **extra dimensions**, which may open up new pathways for discovering and comprehending these mysterious entities. Despite their importance, the existence of **extra dimensions** remains a highly theoretical and speculative area of research. Many of the predictions of extra dimensional theories are difficult to test experimentally, and so far no direct evidence of extra dimensions has been observed. Nonetheless, the study of **extra dimensions** is an active area of research in theoretical physics, and may hold the key to unlocking some of the **deepest mysteries** of the universe.

A **"theory of everything"** is a theoretical framework that seeks to unify all the fundamental forces and particles of nature into a single, coherent framework. In other words, it is an attempt to explain the **entire universe** and all of its physical phenomena with a single set of equations or principles. The quest for a **theory of everything** has been a major goal of theoretical physics for decades. The current framework that describes the universe, known as the **Standard Model**, does an excellent job of explaining the behavior of subatomic particles and the electromagnetic, strong, and weak nuclear forces. However, it does not include a **description of gravity**, which is currently described by **Einstein's theory of general relativity**. Attempts to unify the forces of nature into a single theory have led to a number of theoretical frameworks, including **superstring theory**, **loop quantum gravity,** and various versions of **M-theory**. These theories propose that the universe is made up of tiny, vibrating strings or loops, which interact with one another to produce all of the particles and forces we observe. One of the challenges of developing a theory of everything is that it must be consistent with all of the existing **experimental data** and **observations**. This can be difficult, as many of the phenomena that a **theory of everything** must explain occur at extremely small scales, where our current experimental techniques are limited. Another challenge is that a **theory of everything** must be able to describe the behavior of the universe at all times, from the **Big Bang** to the **present day**. This requires a deep understanding of the physics of the early universe, which is currently an area of active research. Despite the challenges, the quest for a **theory of everything** remains a major goal of theoretical physics. If successful, it would represent a major breakthrough in our understanding of the universe and the laws that govern it. However, it remains a highly theoretical and **speculative area of research**, and more work is needed to develop and test the various proposed theories.

The **selection principle** that we live in a region of the universe that is suitable for intelligent life which is called the **Anthropic principle (a term coined by astronomer Brandon Carter in 1974)** would not have seemed to be enough to allow for the development of complicated beings like us. The universe would have been vastly different than it does now and, no doubt, life as we know it would not have existed. And if spacial dimensions would have been greater than 3, the **force of gravitation** between two bodies would have been decreased more rapidly with distance than it does in three dimensions. **(In three dimensions, the gravitational force drops to 1 / 4 if one doubles the distance. In four dimensions it would drops to 1 / 5, in five dimensions to 1 / 6, and so on)**. The significance of this is that the orbits of planets, like the earth, around the sun would have been unstable to allow for the **existence of any form of life** and there would been no intelligent beings to observe the effectiveness of extra dimensions. The **anthropic principle** is a philosophical and scientific idea that suggests that the observed properties of the universe and the conditions necessary for life are not accidental, but rather are a result of the fact that we, as conscious beings, exist to observe them. In other words, the universe appears to be fine-tuned for the emergence of life because we exist to observe it. The **anthropic principle** has been used to explain a variety of phenomena in physics and cosmology, such as the apparent coincidence of the physical constants and the structure of the universe that allow for the emergence of life. **Proponents of the anthropic principle** argue that the universe must have been designed in some way to produce life, because otherwise, we would not be here to observe it. There are several different versions of the anthropic principle, including the **weak anthropic principle**, the **strong anthropic principle**, and the **participatory anthropic principle**. The **weak anthropic principle** suggests that the universe must have the properties necessary for the emergence of life, because otherwise, we would not exist to observe it. The **strong anthropic principle** takes this idea further, suggesting that the universe is in some sense compelled to produce conscious observers. The **participatory anthropic principle** argues that observers are not just passive observers of the universe, but that they actively shape it through their observations. The **anthropic principle** has been the subject of debate and controversy in both scientific and philosophical circles. **Critics of the anthropic principle** argue that it is a form of circular reasoning, in which the existence of life is used to explain the properties of the universe that allow for life. Others argue that the **anthropic principle** is a valid scientific idea, and that it can be used to make testable predictions about the nature of the universe. Overall, the anthropic principle is an idea that attempts to explain the **apparent fine-tuning of the universe for the emergence of life**. While it remains a controversial idea, it has sparked a great deal of discussion and debate among scientists and philosophers.

Although the proponents of **string theory (which occupies a line in space at each moment of time)** predict absolutely everything is built out of strings **(which are described as patterns of vibration that have length but no height or width — like infinitely thin pieces of string)**, it could not provide us with an answer of what the string is made up of? And one model of potential multiple universes called the **M Theory** − has **eleven dimensions**, **ten of space and one of time**, which we think an explanation of the laws governing our universe that is currently the only viable candidate for a **"theory of everything"**: the unified theory that **Einstein** was looking for, which, if confirmed, would represent the **ultimate triumph of human reason** − predicts that our universe is not only one giant hologram. The concept of a **multiverse**, or the idea that there may be many universes beyond our own, has become a popular topic of discussion in both science and popular culture. However, there are several problems and challenges associated with the idea of a **multiverse**, including:

Lack of empirical evidence: While the idea of a multiverse is theoretically possible, there is currently no empirical evidence to support its existence. This means that it is difficult to test many of the predictions and hypotheses associated with the multiverse.

Complexity: The idea of a multiverse can be very complex and difficult to understand. It requires the acceptance of concepts such as infinite space, infinite time, and infinite copies of ourselves, which can be challenging to grasp.

Lack of testability: Many of the predictions and hypotheses associated with the multiverse are difficult or impossible to test experimentally. This can make it difficult to determine whether the theory is true or not.

Occam's razor: The concept of a multiverse is often criticized for violating the principle of Occam's razor, which states that the simpler theories to be chosen over more complicated ones or that explanation for enigmatic events be looked out first using known quantities. The idea of a multiverse, with its infinite possibilities and universes, is much more complex than the idea of a single universe.

Philosophical implications: The idea of a multiverse has significant philosophical implications, such as the potential for a lack of meaning or purpose in life if there are infinite copies of ourselves and infinite versions of reality.

Overall, the idea of a **multiverse** remains a highly theoretical and speculative area of research, with many unanswered questions and challenges. While it is an intriguing concept, more research and evidence is needed to determine whether it is a **valid theory** or not.

Albert Einstein is one of the most famous and influential scientists in history. He is particularly well-known for his groundbreaking contributions to the field of theoretical physics, especially his development of the theory of general relativity. Einstein's work revolutionized our understanding of space and time, and his famous equation, $E=mc^2$, demonstrated the relationship between matter and energy. He also made important contributions to the development of quantum mechanics, and was a key figure in the development of the atomic bomb. Einstein was also a public figure and advocate for social justice, using his fame and influence to promote pacifism, civil rights, and other causes. He was awarded the Nobel Prize in Physics in 1921, and his work continues to inspire and influence scientists and non-scientists alike to this day. Overall, **Albert Einstein** is famous for his groundbreaking contributions to physics, his revolutionary theories of space and time, and his influence on the development of modern science and technology. He remains an important and widely celebrated figure in both the scientific and popular imagination. He published several important papers throughout his career, but here are five of his most famous ones that changed the face of Physics:

"On a Heuristic Viewpoint Concerning the Production and Transformation of Light" (1905): In this paper, Einstein introduced the idea of photons and the quantization of light energy, which helped to explain the **photoelectric effect** and led to the development of **quantum mechanics.**

"On the Electrodynamics of Moving Bodies" (1905): This paper introduced **Einstein's special theory of relativity**, which fundamentally changed our understanding of space and time and showed that they are not absolute but relative to the observer's frame of reference.

"Does the Inertia of a Body Depend Upon Its Energy Content?" (1905): In this paper, Einstein derived the famous equation **$E=mc^2$**, which describes the relationship between mass and energy. It has significant implications for our understanding of the universe and has had a profound impact on many areas of science and technology. In addition, the mass-energy equivalence has important implications for the development of energy technologies, such as **nuclear power** and **renewable energy sources**. It has also led to the development of medical technologies, such as **positron emission tomography** (PET) scanners, which use the conversion of matter into energy to create images of the body.

"On the Generalized Theory of Gravitation" (1916): This paper introduced **Einstein's theory of general relativity**, which extended the principles of special relativity to include gravity as a curvature of spacetime. This theory has important implications for our understanding of the universe, including the existence of **black holes** and the **expansion of the universe**.

"Can Quantum-Mechanical Description of Physical Reality be Considered Complete?" (1935): In this paper, Einstein, along with **Boris Podolsky** and **Nathan Rosen**, presented the famous **EPR paradox**, which challenged the completeness of quantum mechanics and led to important developments in our understanding of **quantum entanglement** and the nature of reality.

Einstein's papers were of great importance to the field of physics and had a profound impact on our understanding of the universe. Here are some reasons why:

Special and General Relativity: Einstein's papers on special and general relativity fundamentally changed our understanding of space, time, and gravity. According to **special theory of relativity**, all observers, regardless of their relative motion, are subject to the same physical laws. **General relativity** went further to show that gravity is not a force but a **curvature of spacetime** caused by the presence of matter and energy. These theories have been extensively tested and confirmed through experiments and have important implications for our understanding of the universe.

Quantum Mechanics: Einstein's work on quantum mechanics was groundbreaking and helped to establish the field. His paper on the photoelectric effect showed that light behaves like a particle, which was one of the first pieces of evidence for the existence of photons. He also challenged the completeness of quantum mechanics with the **Einstein–Podolsky–Rosen (EPR) paradox**, which led to important developments in our understanding of quantum entanglement and the nature of reality.

Energy and Mass Equivalence: Einstein's famous equation **$E=mc^2$**, which he derived in his paper on the relationship between mass and energy, showed that mass and energy are equivalent and can be converted into each other. The equation shows that a small amount of mass contains an enormous amount of energy. **For example, if you were to convert one gram of matter into energy, you would release around 90 trillion joules of energy, which is roughly equivalent to the energy released by detonating 20,000 tons of TNT.** This equation has important implications in the field of nuclear physics, where it is used to explain the energy released during **nuclear reactions** such as fission and fusion. It is also used in the development of **nuclear**

power and **nuclear weapons**. Additionally, the equation has broader implications for our understanding of the relationship between matter and energy, and has contributed to many other areas of physics research.

Contributions to Cosmology: Einstein's theory of general relativity had important implications for our understanding of the universe as a whole. It predicted the existence of **black holes** and led to the development of the **Big Bang theory,** which describes the origin and evolution of the universe.

Overall, **Einstein's papers** contributed to some of the most important developments in physics in the 20th century and continue to inspire new research and discoveries today.

Many **theoretical physicists** and **quantum scientists** of a fast developing science have discussed about mass annihilation at different times. **Mass annihilation**, also known as **particle-antiparticle annihilation**, refers to the process by which a particle and its corresponding antiparticle come together and annihilate each other, converting their mass into energy according to **Einstein's famous equation** **$E=mc^2$**. In particle physics, every particle is associated with an antiparticle, which has the same mass but opposite charge. **For example,** the antiparticle of the electron is the **positron**, which has the same mass as the electron but a positive charge instead of a negative charge. When a particle and its antiparticle come into contact with each other, they can annihilate each other, producing energy in the form of **gamma rays**, which are highly energetic photons. The process of **annihilation** occurs when the particle and antiparticle come together and interacts, causing their mass to be converted into energy. The energy produced by the **annihilation** is equal to the total mass of the particles multiplied by the speed of light squared (**$E = mc^2$**), which is an enormous amount of energy. For example, the **annihilation** of an electron and a positron produces **1.02 MeV** of energy, which is released in the form of gamma rays. **Mass annihilation** is a key process in the field of particle physics and has important implications for understanding the behavior of particles and their interactions. It is also a source of energy in certain types of **nuclear reactions**, such as those that occur in the core of the sun, where protons and antiprotons can destroy one another, generating **gamma rays** as energy. Overall, **mass annihilation** is an important phenomenon in the study of particle physics and the behavior of matter and energy in the universe.

The **Standard Model of particle physics** is a theoretical framework that describes the fundamental particles and forces that make up the universe. It is a mathematical model that explains the behavior of subatomic particles, including quarks, leptons, and force-carrying particles, known as bosons. The **Standard Model** consists of three fundamental forces: the electromagnetic force, the strong nuclear force, and the weak nuclear force. These forces are mediated by the exchange of **force-carrying particles**: photons for the electromagnetic force, gluons for the strong force, and W and Z bosons for the weak force. The **Standard Model** also includes the Higgs boson, which gives particles mass. The Higgs boson is the only scalar particle in the **Standard Model**, meaning it has no spin, and it is responsible for breaking the electroweak symmetry, which is responsible for the differences between the electromagnetic and weak forces. The **Standard Model** describes matter as being made up of two types of fundamental particles: quarks and leptons. **Quarks** are the building blocks of protons and neutrons and come in six types, or flavors: up, down, charm, strange, top, and bottom. **Leptons** come in three types: electrons, muons, and tau particles, each with their associated neutrinos. The **Standard Model** has been extensively tested through high-energy particle collider experiments, such as those carried out at the **Large Hadron Collider**

(LHC) at CERN. These experiments have confirmed the existence of most of the particles predicted by the **Standard Model**, including the Higgs boson. However, despite its successes, the **Standard Model** is not a complete theory of the universe. There are several known limitations and failures, which are discussed below:

Dark Matter: The Standard Model does not account for the existence of dark matter, which makes up around 27% of the universe. Dark matter is a form of matter that does not interact with light or other electromagnetic radiation, making it invisible to telescopes. Its existence has been inferred from its gravitational effects on visible matter, but its nature and properties are still unknown.

Neutrino Mass: The Standard Model assumes that neutrinos are massless, but experiments have shown that they do have a very small mass. This discrepancy suggests that the Standard Model is incomplete and that a more comprehensive theory is needed to explain the properties of neutrinos.

CP Violation: The Standard Model predicts that the laws of physics should be the same for matter and antimatter (known as CP symmetry), but experiments have shown that this symmetry is violated in certain particle interactions. This suggests that the Standard Model is incomplete and that there are undiscovered particles or interactions that could explain this violation.

Gravity: The Standard Model does not include gravity, which is one of the four fundamental forces of nature. Gravity is described by Einstein's theory of General Relativity, but this theory is incompatible with the Standard Model at the quantum level. This has led to efforts to develop a theory of **quantum gravity** that can incorporate both General Relativity and the Standard Model.

Hierarchy Problem: The Standard Model does not explain why the Higgs boson, which gives particles mass, has such a small mass itself. The Higgs boson's mass is much smaller than would be expected based on the energy scale of the Standard Model, leading to what is known as the hierarchy problem. This problem suggests that there may be undiscovered particles or interactions that could help explain the Higgs boson's mass.

Strong CP Problem: The Standard Model predicts that the strong force should violate a fundamental symmetry called CP symmetry, but experiments have shown that this violation is much smaller than would be expected. This discrepancy is known as the strong CP problem and suggests that there may be undiscovered particles or interactions that could help explain the smallness of CP violation in the strong force.

To sum up, while the **Standard Model** has been highly successful in explaining the behavior of subatomic particles, it is not a complete theory of the universe. There are several known limitations and failures of the **Standard Model**, including the absence of an explanation for dark matter, the mass of neutrinos, and the **violation of CP symmetry** in certain particle interactions, among others. These limitations suggest that there may be undiscovered particles or interactions that could help complete our understanding of the fundamental nature of the universe.

Photons are elementary particles that are the carriers of the electromagnetic force. They are massless, electrically neutral particles that move at the speed of light, which makes them unique among the particles in the Standard Model. They exhibit both **wave-like** and **particle-like behavior**, which is known as wave-particle duality. When traveling through space, they behave like waves with a specific frequency and wavelength. However, when interacting with matter, they behave like particles, transferring discrete amounts of energy to the material. Their interactions with matter are responsible for a wide range of physical phenomena, and their properties have important applications in many areas of science and technology including **telecommunications**, solar cells, and **medical imaging**, among others. According to the currently accepted theory of physics, the **Standard Model**, photons are believed to be massless particles that travel at the speed of light. This means that they have **no rest mass** and travel at the speed of light. The idea of a photon having mass is often associated with the concept of a hypothetical particle called the **Higgs**

boson, which is believed to be responsible for giving particles mass through the **Higgs mechanism**. However, the **Higgs mechanism** only applies to particles that have interactions with the Higgs field, and since photons are not thought to interact with the **Higgs field**, they are not believed to acquire mass through this mechanism. **Experimental evidence** also supports the notion that photons are massless. **For example**, High-energy photons can be produced in particle accelerators, and their properties can be studied in experiments. The behavior of **high-energy photons** is consistent with the idea that they have zero rest mass.

From the relativistic energy equation:

$$E^2 = p^2c^2 - m_0^2c^4$$

For a photon with no rest mass can still have **relativistic energy**. If $m_0 = 0$, then

$$E = pc$$

Overall, the currently accepted theory of physics, as well as experimental evidence, supports the notion that photons are massless particles. This idea is a fundamental part of our understanding of the nature of light and the universe as a whole. **Quantum mechanics** and **general theory of relativity** are two highly successful theories that describe the behavior of matter and gravity, respectively. However, they are incompatible, and some physicists believe that a theory of **quantum gravity** is needed to reconcile the two. The behavior of photons in a **theory of quantum gravity** may be different from what is currently understood.

General relativity is a theory of gravity that was developed by **Albert Einstein** in 1915. It is based on the idea that gravity is not a force between masses, as described by **Isaac Newton's theory of gravity**, but rather a curvature of spacetime caused by the presence of mass and energy. In other words, matter and energy warp the fabric of spacetime, causing objects to move on curved paths. Here are some key features of **general relativity**:

Spacetime: In general relativity, spacetime is a four-dimensional continuum that includes the three dimensions of space and the dimension of time. The presence of mass and energy warps the fabric of spacetime, causing objects to move on curved paths.

Curvature: The curvature of spacetime is described by the Einstein field equations, which relate the curvature of spacetime to the distribution of mass and energy. These equations are highly nonlinear and difficult to solve, but they have been used to make many successful predictions.

Gravitational waves: According to general relativity, gravitational waves are ripples in the fabric of spacetime that are caused by the acceleration of massive objects. These waves travel at the speed of light and have been detected by the **Laser Interferometer Gravitational-Wave Observatory** (LIGO).

Black holes: General relativity predicts the existence of black holes, which are regions of spacetime where the curvature becomes so extreme that nothing, not even light, can escape. The event horizon is the name given to a black hole's boundary.

Cosmology: General relativity is the basis of modern cosmology, which studies the large-scale structure and evolution of the universe. The theory predicts that the universe is expanding, and that the expansion is accelerating due to the presence of dark energy.

Tests and confirmations: General relativity has been tested and confirmed in a variety of experiments and observations, including the bending of light by massive objects, the precession of the orbit of Mercury, and the detection of gravitational waves.

General relativity is a highly successful and influential theory, and it has led to many important advances in our understanding of the universe. However, there are some areas where general relativity appears to break down, or where it is unable to explain certain phenomena. Some examples of the failures of **general relativity** include:

Dark matter: General relativity cannot account for the observed amount of gravitational mass in the universe, which has led astronomers to hypothesize the existence of dark matter.

Dark energy: General relativity cannot explain the observed acceleration of the expansion of the universe, which has led astronomers to hypothesize the existence of dark energy.

Quantum gravity: General relativity is a classical theory, which means it does not take into account the principles of quantum mechanics. This has led to the development of theories of quantum gravity, which attempt to reconcile general relativity with quantum mechanics.

Singularities: General relativity predicts the existence of singularities, which are points of infinite density and curvature. These singularities occur in the centers of black holes and at the beginning of the universe, and are seen as a failure of the theory to provide a complete description of these phenomena.

The conservation laws:

CONSERVATION OF ELECTRICAL CHARGE: In any reaction the total charge of all the particles entering the reaction = the total charge of all the particles after the reaction.

LEPTON CONSERVATION: In any reaction the sum of lepton numbers before the interaction = the sum of lepton numbers after the interaction.

CONSERVATION OF BARYON NUMBER: In any reaction the sum of baryon numbers before the interaction = the sum of baryon numbers after the interaction.

have far-reaching implications as fundamental to our understanding of the physical world which we do not see violated. They serve as a strong constraint on any thought-out explanation for observations of the **natural world in any branch of science**. These laws govern the behavior of nature at the scale of atoms and subatomic particles. As a result of the particle-particle interaction 2 things may happen:

Particles are attracted or repelled

The particles are changed into different particles

The **conservation laws of physics** are fundamental principles that describe the behavior of physical systems, and they play a crucial role in many areas of physics, from **classical mechanics** to **quantum field theory**. The conservation laws state that certain physical quantities are conserved over time, meaning that they cannot be created or destroyed, but can only be transformed from one form to another. The **conservation laws** have practical applications in a wide range of fields, from engineering to medicine. For example, **energy conservation** is important in designing energy-efficient buildings, while **momentum conservation** is crucial for understanding the behavior of fluids in pipes. They are the foundation of many physical theories, including **classical mechanics**, **electromagnetism**, and **quantum mechanics**. The conservation of energy, for example, is a key principle of **thermodynamics**, while the conservation of momentum is fundamental to the **laws of motion**. Overall, the conservation laws of physics play a fundamental role in our understanding of the physical world, and they have numerous **practical applications** in many areas of science and engineering. The **conservation laws** enable us to create and optimize systems to better satisfy our needs and to investigate the underlying principles that control the behavior of **matter and energy** in the universe by offering a framework for projecting the behavior of physical systems.

Like the formation of bubbles of steam in boiling water − Great many **holograms** of possible shapes and inner dimensions were created, started off in every possible way, simply because of an uncaused accident called **spontaneous creation**. Our universe was one among a zillion of holograms simply happened to have the right properties − with particular values of the physical constants right for stars and galaxies and planetary systems to form and for intelligent beings to emerge due to random physical processes and develop and ask questions, **Who or what governs the laws and constants of physics?** Are such laws the products of chance or a mere cosmic accident or have they been designed? How do the laws and constants of physics relate to the support and development of life forms? **Is there any knowable existence beyond the apparently observed dimensions of our existence?** However, **M theory** sounds so bizarre and unrealistic that there is no experiment that can credit its validity. **Nature** has not been quick to pay us any hints so far. That's the fact of it; grouped together everything we know about the history of the universe is a fascinating topic for study, and trying to understand the meaning of them is one of the key aspects of **modern cosmology** − which is rather like plumbing, in a way.

The **fine-tuning of the universe** refers to the remarkable observation that the fundamental physical constants and parameters of the universe appear to be finely tuned to allow the emergence of life. If even a slight change was made to these constants, life as we know it would not be possible. Here are some examples of the fine-tuning of the universe:

Strong nuclear force: The strong nuclear force is responsible for binding protons and neutrons together in the nuclei of atoms. If the strength of this force were slightly weaker, stable atomic nuclei could not exist, and complex chemistry and life would not be possible.

Weak nuclear force: The weak nuclear force is responsible for nuclear decay and is involved in the process of nuclear fusion that powers stars. If this force were slightly stronger or weaker, the abundance of certain elements in the universe would be vastly different, which could affect the conditions for life.

Electromagnetic force: The electromagnetic force is responsible for the behavior of electrically charged particles, which is crucial for the stability of atoms and molecules. If this force were slightly different, atoms could not form stable bonds, and the chemistry required for life would not be possible.

Gravitational force: The gravitational force is responsible for the large-scale structure of the universe and the formation of stars and galaxies. If this force were significantly weaker, the universe would have expanded too quickly for stars and galaxies to form, while if it were too strong, stars would burn out too quickly and would not have time to support life.

Cosmological constant: The cosmological constant is a measure of the energy density of space itself, and it affects the expansion rate of the universe. If this constant were different, the universe could have either collapsed too quickly or expanded too quickly for stars and galaxies to form.

These are just a few examples of the **fine-tuning of the universe**. The fact that the universe appears to be finely tuned has led some scientists and philosophers to speculate that it may be the result of design or intention. Others have suggested that it may be a consequence of a multiverse, where many different universes with different physical constants exist, and we happen to live in one that is suitable for life. However, there is currently no definitive answer to the question of why the universe appears to be finely tuned, and it remains an active area of research and debate.

Max Planck is famous for his groundbreaking work in the field of theoretical physics and for his discovery of the fundamental relationship between energy and frequency, which is now known as Planck's law. German physicist **Max Planck** lived from 1858 until 1947. In 1900, he developed the **theory of quantum mechanics**, which revolutionized the field of physics and paved the way for the development of many modern technologies, including transistors, lasers, and computer chips. Planck's work on **blackbody radiation**, in particular, was a major breakthrough that led to the development of quantum mechanics. He showed that the energy of light is not continuous, as was previously believed, but rather comes in discrete packets or **"quanta."** This discovery fundamentally changed the way scientists thought about energy and matter and opened up new avenues of research in physics. Planck was awarded the **Nobel Prize in Physics in 1918** for his work on quantum theory, making him one of the most celebrated and influential physicists of the 20th century. His work continues to be studied and built upon by scientists today. He was a man of indomitable will and had other talents beyond physics. He was a skilled piano player, formed music, preceded as an artist and furthermore followed up on the stage and one of the founders of quantum physics. His long life had a tragic side. In 1909, his first wife, Marie Merck, the daughter of a Munich banker, died after 22 years of cheerful marriage, leaving Planck with two sons and twin daughters. The elder son, Karl, was killed in action in World War I, and both of his daughters died quite young in childbirth **(1918 and 1919)**. His home was totally annihilated in **World War II**. He lost everything − scientific manuscripts and notes, diaries, family keepsakes, all he had accumulated over a lifetime − all burned up and gone. His youngest son Erwin was arrested. He was suspected of involvement in the attempted assassination of Hitler and was executed in a gruesome manner by Hitler's henchmen. That merciless act destroyed Planck's will to live. In the end, **Planck** was taken by the Allies to a surviving relative in Gottingen where he died in 1947.

The idea of a **spontaneous creation** of the universe is a controversial topic that has been the subject of much scientific and philosophical debate. Here are some potential pros and cons of this idea:

Pros:

Offers a potential explanation for the origin of the universe: If the universe was created spontaneously, it may help to explain how the universe came into existence in the first place, which has been a longstanding mystery.

Provides a naturalistic explanation: A spontaneous creation of the universe may be seen as a naturalistic explanation for the origin of the universe, in contrast to a creationist or religious explanation.

Fits with current scientific knowledge: The idea of a spontaneous creation of the universe is consistent with many of the current scientific theories and observations, including the Big Bang theory and the cosmic microwave background radiation.

Cons:

Lacks empirical evidence: While the idea of a spontaneous creation of the universe may be a possible explanation for the origin of the universe, there is currently no empirical evidence to support it.

Raises questions about causality: If the universe was created spontaneously, it raises questions about what caused this to happen and whether causality as we understand it can be applied to the creation of the universe.

Philosophical implications: The idea of a spontaneous creation of the universe has profound philosophical implications, such as questions about the nature of existence, the purpose of the universe, and whether there is a greater meaning to life.

Difficulty in testing: Because the spontaneous creation of the universe occurred before the existence of the laws of physics and the scientific method, it may be difficult or impossible to test the hypothesis.

Overall, the idea of a spontaneous creation of the universe is a complex and multifaceted topic with both potential pros and cons. It remains an area of active research and debate in both the scientific and philosophical communities.

And as more space comes into existence, more of the dark energy would appear. **Dark energy** is a mysterious phenomenon that is thought to be responsible for the accelerating expansion of the universe. The term "dark energy" was first coined by cosmologist **Michael Turner** in 1998 to describe the unknown force causing this acceleration. The discovery of **dark energy** was made by studying distant **supernovae**, which revealed that the universe's expansion is accelerating rather than slowing down. This observation was unexpected and led scientists to conclude that some unknown force must be pushing the galaxies apart at an ever-increasing rate. Despite more than two decades of intense research, scientists still do not know exactly what dark energy is. It is called **"dark"** because it cannot be directly observed, as it does not interact with light or any other form of electromagnetic radiation. **Dark energy** is believed to be a property of space itself and is thought to be evenly distributed throughout the universe. There are numerous hypotheses regarding what **dark energy** might be. One of the most prominent theories is that it is the energy of empty space, known as the **cosmological constant**. According to this theory, empty space has a constant energy density that is driving the expansion of the universe. Another theory is that **dark energy** is a scalar field, a type of energy field that fills space and exerts a repulsive force. This theory is known as **quintessence** and suggests that dark energy is not constant but varies over time. Other theories propose that **dark energy** may be related to modifications of **general relativity**, the theory of gravity developed by Albert Einstein. These theories suggest that gravity behaves differently on large scales and that this could explain the observed acceleration of the universe's expansion. Despite decades of research, no one at the present time has any understanding of where this **"undetected substance"** comes from or what exactly it is. Is it a pure cosmological constant or is it a sign of extra dimensions? What is the cause of the dark energy? Why does it exist at all? Why is it so different from the other energies? Why is the composition of dark energy so large? **The nature of dark energy remains one of the biggest mysteries in cosmology.** Continued observations and experiments may provide new insights into the nature of dark energy and the fundamental nature of the universe itself.

Quantum physics, also known as **quantum mechanics**, is a branch of physics that studies the behavior of matter and energy at the atomic and subatomic level. It is a fundamental theory that provides a description of the physical world that is different from classical physics, which describes the behavior of macroscopic objects. **Quantum mechanics** is based on several fundamental principles, including the **wave-particle duality**, **Heisenberg's uncertainty principle**, and the **principle of superposition**.

> The **wave-particle duality principle** states that particles, such as electrons or photons, can exhibit wave-like properties, such as diffraction and interference, in addition to their particle-like behavior. This principle led to the development of wave mechanics, which describes the behavior of particles as waves.
>
> **Heisenberg's uncertainty principle** states that it is impossible to measure certain properties of a particle, such as its position and momentum, with complete precision at the same time. The more precisely one measures one of these properties, the less precisely one can measure the other. This principle is a fundamental limitation on the precision of measurements in quantum mechanics.
>
> **The principle of superposition** states that a quantum system can exist in multiple states simultaneously. For example, an electron can be in multiple positions at the same time until it is measured and its wave function collapses into a single position.

One of the most famous applications of **quantum mechanics** is the **Schrödinger equation**, which describes the evolution of a quantum system over time. The **Schrödinger equation** predicts the probabilities of various outcomes for a given experiment or measurement. Another important concept in quantum mechanics is **entanglement**, which occurs when two particles become linked in a way that their states are correlated with each other. This phenomenon has been demonstrated experimentally and has important applications in **quantum computing and communication**. **Quantum mechanics** also has important implications for our understanding of the nature of reality. The **Copenhagen interpretation**, one of the most widely accepted interpretations of quantum mechanics, suggests that particles do not have a definite state until they are observed, and that the act of observation itself affects the outcome of an experiment. To sum up, **quantum mechanics** is a fundamental theory that has revolutionized our understanding of the behavior of matter and energy at the atomic and subatomic level. Its principles, such as the wave-particle duality, **Heisenberg's uncertainty principle**, and the principle of superposition, have important applications in fields such as quantum computing, communication, and cryptography. However, like any **scientific theory**, it is not perfect, and there are some areas where it does not provide a complete or satisfactory explanation of certain phenomena. Here are a few examples:

Measurement problem: The measurement problem is a fundamental issue in quantum mechanics that has to do with the act of observation. According to the Copenhagen interpretation, particles do not have a definite state until they are observed, and the act of observation itself affects the outcome of an experiment. However, this interpretation is controversial and has been criticized for not providing a complete explanation of the role of measurement in quantum mechanics.

Quantum entanglement: While quantum entanglement has been experimentally demonstrated and has important applications in fields like quantum computing, the mechanism by which it occurs is not well understood. It is also not clear how entanglement can be maintained over large distances or how it can be used to transmit information faster than the speed of light, as it appears to violate the principles of relativity.

The nature of the wave function: The wave function is a central concept in quantum mechanics, describing the state of a quantum system. However, it is not clear what the wave function represents physically, and different interpretations have been proposed, including the many-worlds interpretation and the pilot-wave theory.

The problem of non-locality: Quantum mechanics predicts that particles can be instantaneously correlated with each other, even if they are separated by large distances, which appears to violate the principle of locality. While this phenomenon has been experimentally confirmed, it is not well understood and has been the subject of much debate.

Overall, while **quantum mechanics** is a highly successful theory, it is not without its limitations and open questions. These failures and limitations have led to ongoing research and debate in the field of **quantum physics**, as scientists continue to refine and expand our understanding of the quantum world.

String theory gives us a clue, but there's no definitive answer. Well, all know is that it is a sort of cosmic accelerator pedal or an invisible energy what made the universe bang and if we held it in our hand; we couldn't take hold of it. In fact, it would go right through our fingers, go right through the rock beneath our feet and go all the way to the majestic swirl of the **heavenly stars**. It would reverse direction and come back from the stately waltz of orbiting binary stars through the intergalactic night all the way to the edge of our feet and go back and forth. How near are we to understand the dark energy? The question lingers, answer complicates and challenges everyone who yearns to resolve. And once we understand the dark energy, can we understand the birth and the death of everything in the **mankind's**

observable universe, from a falling apple to the huge furnace and the earth is also an ? **Dark energy** is one of the biggest mysteries in modern astrophysics. It is a theoretical form of energy that is thought to permeate all of space and is believed to be responsible for the accelerating expansion of the universe. Here are some reasons why dark energy is considered to be one of the biggest mysteries in physics:

Unexplained acceleration of the universe: The biggest mystery of dark energy is the unexplained acceleration of the expansion of the universe. Dark energy is thought to be responsible for this acceleration, but we don't understand the physics behind it. We don't know what dark energy is made of or how it works, and we don't know how it interacts with other forms of matter and energy.

Inconsistencies in measurements: There are inconsistencies in measurements of the expansion of the universe, which make it difficult to accurately determine the properties of dark energy. Different methods of measuring the expansion rate have produced different results, and we don't yet have a consistent and accurate picture of the properties of dark energy.

Lack of a theoretical explanation: We have no good theoretical explanation for dark energy. We don't know what it is or how it behaves, and we don't have any models that can accurately predict its behavior. This lack of understanding makes it difficult to develop a coherent and testable theory of dark energy.

No direct detection: Dark energy has never been directly detected. We can only infer its existence based on its effects on the universe. This makes it difficult to study and understand, as we have no way of observing it directly or measuring its properties.

In essence, **dark energy** is one of the biggest mysteries in modern physics. Despite its potential importance for understanding the fundamental nature of the universe, we still don't know what it is or how it works. This makes it a major focus of ongoing research in astrophysics and cosmology.

String theory is a theoretical framework in physics that attempts to reconcile **general relativity** and **quantum mechanics** by describing the fundamental building blocks of the universe as one-dimensional objects called **strings**. While string theory has the potential to provide a unified description of the fundamental forces of nature, it also faces a number of problems and challenges, including the following:

Testability: One of the main criticisms of string theory is that it is not yet testable by experiment. String theory predicts the existence of additional dimensions beyond the four we observe in our everyday lives, but these extra dimensions are thought to be too small to detect with current technology. This lack of experimental verification has led some to question whether string theory can be considered a scientific theory.

Complexity: String theory is an extremely complex and mathematically demanding theory, with many different variations and possible formulations. Some critics argue that the theory is too complex to be understood or tested, and that it is more like a mathematical construct than a physical theory.

Multiple solutions: String theory has many possible solutions, which describe different universes with different physical laws and constants. Some critics argue that this undermines the theory's explanatory power, as it can be used to describe a wide range of physical phenomena.

Background independence: String theory assumes the existence of a fixed background geometry in which strings propagate, which is at odds with the principles of general relativity. Some researchers are exploring approaches to string theory that are background-independent, but this remains an active area of research.

Connection to the real world: String theory has yet to make testable predictions about the observable universe, and it is not clear whether it can be used to explain existing experimental data or to make new predictions. While the theory has had some success in explaining certain phenomena in theoretical physics, it has yet to provide a complete and compelling picture of the universe.

Overall, while string theory has the potential to be a powerful and **unifying theory of physics,** it still faces many challenges and open questions. These problems have led to ongoing research and debate in the field, as scientists work to refine and develop the theory and to test its predictions through experiment.

Entropy is a fundamental concept in thermodynamics that refers to the degree of disorder or randomness in a system. The entropy of the universe is a measure of the total disorder of all the matter and energy in the universe. It is a fundamental aspect of our understanding of the universe, and has implications for everything from the evolution of stars and galaxies to the fate of the universe itself. The entropy of the universe is always increasing, in accordance with the **second law of thermodynamics**. This law states that the total entropy of a closed system cannot decrease over time, meaning that the disorder of the system will always increase or remain constant. Since the universe is considered to be a closed system, its total entropy is always increasing. The universe started out in a state of very low entropy at the time of the **Big Bang**, and has been increasing ever since.

This is because as the universe expands, the matter and energy within it become more dispersed and spread out, leading to a higher degree of disorder. The formation of stars, galaxies, and other structures in the universe is a manifestation of this tendency towards increased entropy, as these structures represent **localized decreases in entropy** within an overall system that is becoming increasingly disordered. The concept of the entropy of the universe is closely related to the concept of the heat death of the universe. The **heat death scenario** predicts that as the universe continues to expand and matter and energy become increasingly dispersed, the entropy of the universe will eventually reach a maximum value. At this point, all of the matter in the universe will be evenly distributed and there will be no more sources of usable energy to power any kind of work. This would result in a state of maximum entropy, where the universe is effectively "dead", with no further change or activity possible. To sum it all up, the **entropy of the universe** is a fundamental aspect of our understanding of the universe and its evolution over time. It is a measure of the degree of disorder in the matter and energy of the universe, and is always increasing due to the **second law of thermodynamics**. The concept of the entropy of the universe has important implications for our understanding of the evolution of stars and galaxies, as well as for the ultimate fate of the universe itself. There are several theories that attempt to explain the formation of the universe, including the **Big Bang theory**, the **steady state theory**, the **cyclic model**, the **ekpyrotic model**, and the **multiverse** theory. Here is a brief overview of each of these theories:

Big Bang Theory: This is currently the most widely accepted theory for the formation of the universe. It states that the universe began as a hot, dense, and infinitely small point known as a singularity, which rapidly expanded in a massive explosion about 13.8 billion years ago. The universe has been expanding and cooling ever since, and is still expanding today.

Steady State Theory: This theory, proposed in the 1940s, states that the universe has always existed and is in a constant state of expansion. According to this theory, new matter is continuously being created to maintain a constant density of matter in the universe.

Cyclic Model: This theory proposes that the universe undergoes an infinite series of cycles, in which it expands and contracts repeatedly. During each cycle, matter and energy are recycled, and the universe is renewed.

Ekpyrotic Model: This theory suggests that the universe was formed as a result of a collision between two parallel, three-dimensional universes (known as branes) in a higher-dimensional space. This collision created a massive explosion that formed our universe.

Multiverse Theory: This theory suggests that our universe is just one of many universes that exist in a larger multiverse. According to this theory, the universe formed as a result of a quantum fluctuation in the multiverse.

Of these theories, the **Big Bang theory** is the most widely accepted, as it is supported by a large body of observational and experimental evidence, including the **cosmic microwave background radiation**, the abundance of light elements in the universe, and the **large-scale structure of the universe**. However, the other theories continue to be studied and refined as scientists work to better understand the origins of the universe.

Time dilation is a phenomenon predicted by Albert Einstein's theory of special and general relativity, which states that time appears to slow down for objects that are moving at high speeds or experiencing a strong gravitational field. **This effect has been experimentally verified and has important implications for our understanding of the nature of time and the universe.** However, there are certain situations where time dilation may not be a significant factor or may not behave as predicted. One example is when an object is moving at very slow speeds. Another example is when the gravitational field is weak. **Explaining everything** ... is one of the greatest challenges we have ever faced. Hence, it has been an endeavor of science to find a single theory which could explain everything, where every partial theory that we've read so far (in school) is explained as a case of the one cogent theory within some special circumstances. Despite being a mystery skeptic, the **Unified Field Theory** **(which Albert Einstein sought [but never realized] during the last thirty years of his life and capable of describing nature's forces within a single, all-encompassing, coherent framework)** presents an infinite problem. This is embarrassing. Because we now realize before we can work for the theory of everything, we have to work for the ultimate laws of nature. At the present, we’re clueless as to what the ultimate laws of nature really are. Are there new laws beyond the apparently observed dimensions of our universe? **Do all the fundamental laws of nature unify?** At what scale? Ultimately, however, it is likely that answers to these questions in the form of unified field theory may be found over the next few years or by the end of the century we shall know can there really be a complete unified theory that would presumably solve our problems? **Or are we just chasing a mirage?** Is the ultimate unified theory so compelling, that it brings about its own existence? However, if we − a puny and insignificant on the scale of the cosmos − do discover a **unified field theory**, it should in time be understandable in broad principle by everyone, not just a few people. Then we shall all be able to take part in the discussion of the questions of how and when did the universe begin? Was the universe created? **Has this universe been here forever or did it have a beginning at the Big Bang?** If the universe was not created, how did it get here? If the Big Bang is the reason there is something rather than nothing, and then before the **Big Bang** there was **NOTHING** and then suddenly we got **A HUGE AMOUNT OF ENERGY** where did it come from? What powered the Big Bang? What is the fate of the Universe? Is the universe heading towards a **Big Freeze** (the end of the universe when it reaches near absolute zero), a **Big Rip**, a **Big Crunch** (the final collapse of the universe), or a **Big Bounce**? Or is it part of an infinitely recurring cyclic model? **Is inflation a law of Nature?** Why the universe started off very hot and cooled as it expanded? Is the Standard Big Bang Model right? Or is it the satisfactory explanation of the evidence which we have and therefore merits our provisional acceptance? **Is our universe finite or infinite in size and content?** What lies beyond the existing space and time? What was before the event of creation? Why is the universe so uniform on a large scale (even though **uncertainty principle** − which fundamentally differentiates quantum from classic reasoning − discovered by the German physicist **Werner Heisenberg** in 1927 − implies that the universe cannot be completely uniform because there are some uncertainties or fluctuations in the positions and velocities of the particles)? **Why does it look the same at**

all points of space and in all directions? In particular, why is the temperature of the **cosmic microwave back-ground radiation** so nearly the same when we look in different directions? Why are the galaxies distributed in clumps and filaments? When were the first stars formed, and what were they like? Or if **string theory** (which is part of a grander synthesis: **M-theory** and have captured the hearts and minds of much of the **theoretical physics** community while being apparently disconnected from any realistic chance of definitive experimental proof) is right i.e., every particle is a tiny one dimensional vibrating string of **Planck length** (the smallest possible length i.e., **Planck time** multiplied by the speed of light)?

The only planet in the cosmos that is known to host life is **Earth**, which is the third planet from the Sun. It has a diameter of approximately 12,742 kilometers (7,918 miles) and a mass of 5.97×10^{24} kilograms. The Earth is the fifth-largest planet in the **Solar System** and is believed to be around 4.54 billion years old. **Earth** is a complex and dynamic planet that is still being explored and studied by scientists around the world. Its diverse range of ecosystems and organisms make it a unique and fascinating place to live. **Human activity** has had a significant impact on the Earth's environment, with factors such as deforestation, pollution, and climate change contributing to global environmental problems. However, efforts to reduce human impact and preserve the planet's ecosystems are ongoing. While Earth may not be a perfect environment for human life, it is still a very hospitable planet, and it is uniquely suited to our existence. Here are a few justifications:

The right distance from the sun: Earth is located in the "habitable zone" around our sun, which is the region where temperatures are just right for liquid water to exist on the surface. This is important because water is essential for life as we know it, and it plays a crucial role in many of the chemical processes that occur in our bodies.

A stable climate: Earth's atmosphere and climate are relatively stable and predictable, which allows for the development of complex ecosystems and the growth of agriculture. While there are natural variations in the climate over time, Earth's climate has been relatively stable for thousands of years, which has allowed for the development and evolution of human civilization.

A protective atmosphere: Earth's atmosphere is made up of a combination of gases, including oxygen, nitrogen, and carbon dioxide, that help to regulate the temperature and protect us from harmful radiation from the sun. The ozone layer, in particular, helps to shield us from harmful ultraviolet radiation that can cause skin cancer and other health problems.

Rich biodiversity: Earth is home to an incredibly diverse range of life forms, from tiny microbes to giant whales, and everything in between. This biodiversity is essential for maintaining healthy ecosystems, and it provides us with a rich array of resources and raw materials that we rely on for our survival.

While there are certainly challenges and problems associated with living on **Earth**, including issues like climate change and environmental degradation, the planet is still incredibly well-suited for human life, and we are fortunate to call it our home.

The **laws of physics** are the fundamental principles that describe how the physical world works. These laws explain the behavior of matter, energy, space, and time, and they form the basis of many scientific disciplines, including **mechanics**, thermodynamics, **electromagnetism**, and quantum mechanics. Here are some examples of the laws of physics:

Newton's laws of motion: These laws describe how objects move and interact with each other. They state that unless acted upon by an external force, an object will continue to be at rest or moving at a uniform speed.

Conservation laws: These laws state that certain properties, such as energy, momentum, and angular momentum, are conserved in a closed system. This means that the total amount of these properties in the system remains constant, even as they are exchanged and transformed within the system.

Maxwell's equations: These equations describe the behavior of electric and magnetic fields and their interaction with matter. They form the basis of classical electromagnetism and explain a wide range of phenomena, from the behavior of light to the operation of electric motors.

The laws of thermodynamics: These laws describe how energy is transferred and transformed between different forms, and they govern the behavior of heat engines, refrigerators, and other energy conversion systems.

The theory of relativity: This theory describes how the laws of physics operate in the presence of massive objects or in situations where objects are moving at very high speeds. It explains the nature of space and time and how they are affected by the presence of matter and energy.

Quantum mechanics: This theory describes the behavior of matter and energy at the microscopic level and explains phenomena such as the behavior of atoms and molecules, the structure of solids, and the behavior of subatomic particles.

These are just a few examples of the laws of physics. The **laws of physics** are our current best understanding of the way the physical universe works, based on empirical observations and experimental evidence. They are the result of the collective work of many scientists over centuries, and have been tested and refined over time. While the **laws of physics** are extremely accurate and can be used to make very precise predictions about the behavior of physical systems, they are not necessarily "correct" in an absolute sense. In science, **theories and laws** are always subject to revision and refinement as new evidence and observations are made. It's also worth noting that **our current understanding of physics** is incomplete, and there may be phenomena that are not yet fully explained by the existing laws. **For example**, the laws of classical physics are not sufficient to explain the behavior of objects at very high speeds or on very small scales, which requires the use of more advanced theories such as quantum mechanics and relativity.

Why most of the matter in the Universe is dark? Is anthropic principle a natural coincidence? If we find the answers to them, it would be the **ultimate triumph of human reason** i.e., we might hold the key to address the eternal conundrum of some of the most difficult issues in modern physics. Yet those difficult issues are also the most exciting, for those who address big, basic questions: **What do we really know about the universe?** How do we know it? **Where did the universe come from, and where is it going?** It would bring to an end a long and glorious lesson in the history of mankind's intellectual struggle to understand the universe. For then we would know whether the **laws of physics** started off the universe in such an incomprehensible way or not. Chances are that these questions will be answered long after we're gone, but there is hope that the beginnings of those answers may come within the next few years, as some aspects of bold scientific theory that attempts to reconcile all the physical properties of our universe into a **single unified and coherent mathematical framework** begin to enter the realm of theoretical and experimental formulation.

Up until recently, a **multitude of revolutions** in various domains, from literature to experimental science, has prevailed over established ideas of modern age in a way never seen before. But we do not know about what is the exact mechanism by which an implosion of a dying star becomes a specific kind of explosion called a **supernova**. All that we know is that: When a massive star runs out of nuclear fuel, the gravitational contraction continues increasing the density of matter. And since the internal pressure is proportional to the density of matter, therefore the internal pressure will continually increase with the density of matter. And at a certain point of contraction, internal pressure will be very much greater than **gravitational binding pressure** and will be sufficiently high enough to cause the star to explode, spraying the manufactured elements into space that would flung back into the gas in the galaxy and would provide some of the raw material for the next generation of stars and bodies that now orbit the sun as planets like the Earth. The total energy released would outshine all the other stars in the galaxy, approaching the **luminosity of a whole galaxy** (will nearly be the order of 10^{42} Joules). In the aftermath of the **supernova**, we find a totally dead star, a neutron star – a cold star, supported by the **exclusion principle repulsion** between neutrons – about the size of **Manhattan** (i.e., ten to 50 times the size of our sun).

Why are there atoms, molecules, solar systems, and galaxies? What powered them into existence? How accurate are the physical laws and equations, which control them? Why do the **Fundamental Constants of**

Nature have the precise values they do? The answers have always seemed well beyond the reach of **Dr. Science** since the dawn of humanity − until now **(some would claim the answer to these questions is that there is a transcendent God** (a cosmic craftsman – a transcendent being than which no being could be more virtuous) **who chose to create the universe that way according to some perfect mathematical principle. Then the question merely reflects to that of who or what created the God)**. But the questions are still the picture in the mind of many scientists today who do not spend most of their time worrying about these questions, but almost worry about them some of the time. **All that science could say is that:** The universe is as it is now. But it could not explain why it was, as it was, just after the **Big Bang**. This is a disaster for science. It would mean that science alone, could not predict how the universe began. Every attempt is made to set up the connection between **theoretical predictions** and experimental results but some of the experimental results throw cold water on the theoretical predictions.

Planck units are a set of natural units of measurement named after the German physicist **Max Planck**, who first proposed them in 1899. These units are derived solely from **fundamental constants of nature**, such as the speed of light, the gravitational constant, and Planck's constant, and are often used in theoretical physics, particularly in attempts to unify the different **fundamental forces of nature** and to understand the nature of space and time at the most fundamental level. They also have practical applications in fields such as **black hole physics** and **quantum gravity**. However, because the **Planck units** are so small and so far beyond the range of our current experimental capabilities, they remain purely theoretical constructs at this time. The fundamental **Planck units** are:

The **Planck length**, denoted as L_{Planck}, is a unit of length in the **International System of Units** (SI), named after the physicist Max Planck. It is defined as the distance that light travels in a vacuum during the **Planck time**, which is the time it takes light to travel one Planck length. In mathematical terms, the Planck length is defined as: $L_{Planck} = (\hbar G/c^3)^{1/2}$ where ħ is the reduced Planck constant, G is the gravitational constant, and c is the speed of light in a vacuum. The value of the **Planck length** is approximately 1.616×10^{-35} meters. The Planck length is significant because it is thought to be the smallest possible length scale that has any physical meaning. At distances smaller than the **Planck length**, it is believed that the laws of physics as we currently understand them break down, and a more complete theory of quantum gravity is needed. This is because the **Planck length** represents the scale at which the effects of both quantum mechanics and general relativity become important. Furthermore, the **Planck length** is also used in the study of black holes, as it is thought to represent the minimum size of a black hole. If a mass were to be compressed to a size smaller than the Planck length, it would be a black hole with a **Schwarzschild radius** equal to the Planck length. It is important to note that the Planck length is an incredibly small distance that is currently impossible to measure directly. Nonetheless, it is a fundamental concept in physics and serves as a useful theoretical tool in the study of the most fundamental aspects of the universe.

The **Planck time**, denoted as t_{Planck}, is a unit of time in the **International System of Units** (SI), named after the physicist Max Planck. It is defined as the time it takes for light to travel one Planck length in a vacuum, and is given by: $t_{Planck} = L_{Planck}/c$ where L_{Planck} is the Planck length and c is the speed of light in a vacuum. In mathematical terms, the Planck time is approximately equal to 5.391×10^{-44} seconds. The **Planck time** is significant because it is thought to be the smallest possible unit of time that has any physical meaning. The existing understanding of the principles of physics breaks at timescales smaller than the **Planck time**, and to correctly explain the behavior of matter and energy, a more comprehensive theory of quantum gravity is required. The Planck time is also related to the concept of the **Planck epoch**, which is the earliest period of time in the history of the universe. During this epoch, which occurred approximately 10^{-43} seconds after the **Big Bang**, the universe was incredibly hot and dense, and the **four fundamental forces of nature** (gravity, electromagnetism, the strong nuclear force, and the weak nuclear force) were unified into a single force. It is thought that a full understanding of the nature of the universe during the **Planck epoch** will require a theory of quantum gravity, which is currently a topic of active research. Overall, the **Planck time** is a fundamental concept in physics, representing the smallest possible unit of time that has any physical meaning. It plays a critical role in the study of the most fundamental aspects of the universe, including the nature of space, time, and the fundamental forces of nature.

The **Planck energy,** denoted as E_{Planck}, is a unit of energy in the **International System of Units** (SI), named after the physicist Max Planck. It is defined as the energy that corresponds to the Planck mass according to the equation $E = m_{Planck}c^2$, where m_{Planck} is the Planck mass and c is the speed of light in a vacuum. In mathematical terms, the Planck energy is given by: $E_{Planck} = (\hbar c^5/G)^{1/2}$ where ħ is the reduced Planck constant and G is the gravitational constant. In numerical terms, the **Planck energy** is approximately equal to 1.956×10^9 joules. The Planck energy is significant because it is thought to be the maximum amount of energy that can be contained in a single particle. At energies greater than the **Planck energy**, the effects of **quantum gravity** become important, and a more complete theory of physics is needed to accurately describe the behavior of matter and energy. The **Planck energy** is also related to the concept of the **Planck temperature**, which is the maximum possible temperature that can be reached in the universe. According to the **Stefan-Boltzmann law**, the energy radiated by a black body is proportional to the fourth power of its temperature. At temperatures greater than the **Planck temperature**, the energy radiated by a black body would be greater than the **Planck energy**, which is not physically possible. The Planck energy is also important in the study of the early universe. During the **Planck epoch**, which occurred approximately 10^{-43} seconds after the Big Bang, the universe was so small and dense that quantum effects were as important as gravitational effects. It is thought that a full understanding of the nature of the universe during the **Planck epoch** will require a theory of quantum gravity, which is currently a topic of active research. Overall, the **Planck energy** is a fundamental concept in physics, representing the maximum possible amount of energy that can be contained in a single particle. It plays a critical role in the study of the most fundamental aspects of the universe, including the nature of space, time, and the fundamental forces of nature.

The **Planck temperature**, denoted as T_{Planck}, is a unit of temperature in the International System of Units (SI), named after the physicist Max Planck. It is defined as the temperature that would correspond to the energy of a particle with a mass equal to the **Planck mass**. In mathematical terms, the Planck temperature is given by: $T_{Planck} = (\hbar c^5/Gk_B^2)^{1/2}$ where ħ is the reduced Planck constant, c is the speed of light in a vacuum, G is the gravitational constant, and k_B is the Boltzmann constant. In numerical terms, the Planck temperature is approximately equal to 1.416×10^{32} Kelvin. The **Planck temperature** is significant because it is thought to be the maximum possible temperature that can be reached in the universe. At temperatures greater than the Planck temperature, the effects of **quantum gravity** become important, and a more complete theory of physics is needed to accurately describe the behavior of matter and energy. The **Planck temperature** is also related to the concept of the **Planck length**, which is the minimum length that can be measured in the universe. According to the **Heisenberg uncertainty principle**, the product of the uncertainty in position and the uncertainty in momentum must be greater than or equal to a constant value, given by ħ/2. This leads to the concept of a minimum length scale, which is approximately equal to the **Planck length**. At temperatures greater than the Planck temperature, particles would have enough energy to probe distances smaller than the **Planck length**, and the structure of spacetime itself would become uncertain. The **Planck temperature** is also important in the study of the early universe. During the **Planck epoch**, which occurred approximately 10^{-43} seconds after the **Big Bang**, the universe was so small and dense that quantum effects were as important as gravitational effects. It is thought that a full understanding of the nature of the universe during the **Planck epoch** will require a theory of quantum gravity, which is currently a topic of active research. To sum up, the **Planck temperature** is a fundamental concept in physics, representing the maximum possible temperature that can be reached in the universe. It plays a critical role in the study of the most fundamental aspects of the universe, including the nature of space, time, and the fundamental forces of nature.

The **Planck charge** is a unit of electric charge that is derived from Planck's constant, one of the fundamental constants of nature. It can be calculated by dividing the electron's elementary charge by the square root of the fine structure constant. The **Planck charge** is given by the formula:

$q_{Planck}= (4\pi\varepsilon_0\hbar c)^{½}$ where ħ is the reduced Planck constant, c is the speed of light, ε_0 is the vacuum permittivity, and G is the gravitational constant. Using these constants' values as substitutes, we obtain:

$$q_{Planck}=1.875545956 \times 10^{-18} \text{ Coulombs}$$

The **Planck charge** is an extremely small value, about 20 orders of magnitude smaller than the charge of an electron. It is used primarily in theoretical physics and cosmology to study the behavior of electromagnetic fields and the interactions between particles at extremely small scales, such as in the **early universe** or **black holes**. The significance of the **Planck charge** lies in its relationship to other fundamental constants, and the fact that it represents the maximum electric charge that can be confined to a volume smaller than the **Planck length**, which is another fundamental constant.

The **Planck force** is a fundamental constant in physics that represents the maximum force that can be achieved in the universe. It is defined in terms of other fundamental constants, specifically the **Planck length** (L_{Planck}), the **Planck mass** (m_{Planck}), and the **Planck time** (t_{Planck}), as follows: $F_{Planck} = c^4 / G$, where c is the speed of light in a vacuum and G is the gravitational constant. Using the known values of these constants, the **Planck force** is approximately equal to 1.21027×10^{44} Newtons. The **Planck force** is significant because it represents the maximum force that can be achieved in nature, and any force greater than the **Planck force** would result in the formation of a black hole. The **Planck force** is also relevant in theories of **quantum gravity**, which seek to unify the principles of quantum mechanics and general relativity. The **Planck force** can be related to the **Planck energy**, which is the maximum energy that can exist in the universe, and is given by $E_{Planck} = m_{Planck} c^2$. The **Planck force** is equal to the **Planck energy** divided by the **Planck length**, $F_{Planck} = E_{Planck} / L_{Planck}$. This relationship shows that the **Planck force** is directly related to the curvature of spacetime at the Planck length scale, which is a key feature of theories of quantum gravity.

Back in 1700s, people thought the stars of our galaxy structured the universe, that the galaxy was nearly static, and that the universe was essentially unexpanding with neither a beginning nor an end to time. A situation marked by difficulty with the idea of a static and unchanging universe, was that according to the **Newtonian theory of gravitation**, each star in the universe supposed to be pulled towards every other star with a force that was weaker the less massive the stars and farther they were to each other. It was this force caused all the stars fall together at some point. So how could they remain static? Wouldn't they all collapse in on themselves? A balance of the predominant attractive effect of the stars in the universe was required to keep them at a constant distance from each other. Einstein was aware of this problem. He introduced a term so-called **cosmological constant** in order to hold a static universe in which gravity is a predominant attractive force. This had an effect of a repulsive force, which could balance the predominant attractive force. In this way it was possible to allow a static cosmic solution. Enter the American astronomer **Edwin Hubble**. In 1920s he began to make observations with the hundred inch telescope on **Mount Wilson** and through detailed measurements of the spectra of stars he found something most peculiar: stars moving away from each other had their spectra shifted toward the red end of the spectrum in proportion to the distance between them **(This was a Doppler effect of light: Waves of any sort − sound waves, light waves, water waves − emitted at some frequency by a moving object are perceived at a different frequency by a stationary observer. The resulting shift in the**

spectrum will be towards its red part when the source is moving away and towards the blue part when the source is getting closer). And he also observed that stars were not uniformly distributed throughout space, but were gathered together in vast collections called galaxies and nearly all the galaxies were moving away from us with recessional velocities that were roughly dependent on their distance from us. He reinforced his argument with the formulation of his well- known **Hubble's law**. The observational discovery of the stretching of the space carrying galaxies with it completely shattered the previous image of a static and unchanging cosmos **(i.e., the motivation for adding a term to the equations disappeared, and Einstein rejected the cosmological constant a greatest mistake)**.

The mysteries of the universe are vast and fascinating, and some of the biggest questions in science remain unanswered. We story telling animals **(who TALK ABOUT THE nature of the universe and discuss such questions as whether it has a beginning or an end)** often claim that we know so much more about the universe. But we must beware of overconfidence. We have had false dawns before. At the beginning of this century, for example, it was thought that earth was a **perfect sphere**, but latter experimental observation of variation of value of **"g"** over the surface of earth confirmed that earth is not a perfect sphere. Today there is almost universal agreement that space itself is stretching, carrying galaxies with it, though we are experimentally trying to answer whether cosmic **[expansion**

will] continue forever or slow to a halt, reverse itself **[and]** lead to a **cosmic implosion**. However, personally, we're sure that the accelerated expansion began with a state of infinite compression and primeval explosion called the **hot Big Bang**. But will it expand forever or there is a limit beyond which the average matter density exceeds a **hundredth of a billionth of a billionth** of a billionth (10^{-29}) of a gram per cubic centimeter so called **critical density** **(the density of the universe where the expansion of the universe is poised between eternal expansion and recollapse)...** then a large enough gravitational force will permeate the cosmos to halt and reverse the expansion or the expansion and contraction are evenly balanced? We're less sure about that because events cannot be predicted with complete accuracy but that there is always a degree of uncertainty.

Astrophysics is the branch of physics that deals with the study of celestial objects and phenomena, including stars, galaxies, black holes, and the origins of the universe itself. While **astrophysics** has made tremendous progress in advancing our understanding of the cosmos, there have been some notable failures or limitations in our knowledge. One of the most significant failures in **astrophysics** is the inability to fully explain the nature of **dark matter** and **dark energy**. These two mysterious substances make up the vast majority of the mass-energy in the universe, but their exact nature remains a mystery. While there are many theories and hypotheses about what dark matter and dark energy could be, there is currently no way to directly observe or measure them, making it difficult to fully understand their properties and behavior. Another failure in **astrophysics** is the inability to predict certain types of **astronomical events**

with complete accuracy. **For example**, while astrophysicists can predict the motion of the planets with great precision, there are still some phenomena, such as **supernovae**, that cannot be predicted with complete certainty. These unpredictable events can make it difficult to plan space missions and observe certain celestial objects. Additionally, there are limitations to the technology and instruments used in **astrophysics**, which can limit the accuracy and depth of our observations. **For example**, some astronomical objects are so distant that their light takes billions of years to reach us, and by the time it does, it has been redshifted and distorted in ways that make it difficult to study. Despite these limitations and failures, **astrophysics** continues to make important contributions to our understanding of the universe. Advances in technology and new theoretical developments are opening up new avenues for research and exploration, and it is likely that many of the **current limitations** and **failures** will be overcome in the future.

The picture of **standard model of the Forces of Nature** (a sensible and successive quantum mechanical description developed by 1970s physicists) is in good agreement with all the observational evidence that we have today and remains consistent with all the measured properties of matter made in our most sophisticated laboratories on Earth and observed in space with our most powerful telescopes. Nevertheless, it leaves a number of important questions unanswered like the unanswered questions given in The **Hitchhiker's Guide to the Galaxy** (by **Douglas Adams**): Why are the strengths of the fundamental forces **(electromagnetism, weak and strong forces, and gravity)** are as they are? Why do the force particles have the precise masses they do? Do these forces really become unified at sufficiently high energy? **If so how?** Are there unobserved fundamental forces that explain other unsolved problems in physics? What is the Higgs boson and why is it important? How does the standard model explain the unification of forces? **Why is gravity so weak?** May because of hidden extra dimensions? Very likely, we are missing something important that may seem as obvious to us as the **earth orbiting the sun** – or perhaps as ridiculous as a **tower of tortoises**. Only time **(whatever that may be)** will tell.

The **theory of evolution** is a scientific explanation of how living organisms have changed and diversified over time through the process of **natural selection**. While the **theory of evolution** has been incredibly successful in explaining a wide range of biological phenomena, there have been some limitations and failures in our understanding of evolution.

Incomplete Fossil Record: One limitation of the theory of evolution is the incomplete fossil record. While we have found a large number of fossils from many different time periods, there are still gaps in our knowledge of the evolutionary history of many species. These gaps can make it difficult to reconstruct the complete lineage of an organism, and can leave unanswered questions about the mechanisms of evolutionary change.

Non-Darwinian mechanisms: Another limitation of the theory of evolution is that it was initially proposed to explain natural selection as the main mechanism driving evolutionary change. However, since Darwin's time, other mechanisms of evolution, such as genetic drift, have been identified and are now recognized as important factors in evolutionary change. These non-Darwinian mechanisms can create limitations in our understanding of how evolution works and how it may have occurred in the past.

Hybridization: A third challenge to the theory of evolution is hybridization, or the interbreeding of different species, which can lead to the formation of new species. While hybridization is not a new concept, recent genetic studies have shown that it may be more common than previously thought. Hybridization can create a problem for evolutionary theory because it is often difficult to determine whether two related species share a common ancestor or are the result of hybridization.

Despite these limitations and challenges, the **theory of evolution** remains one of the most powerful and well-supported scientific theories of all time. As our understanding of genetics, development, and ecology continues to grow, new insights into the mechanisms of evolution may emerge, providing a more comprehensive understanding of how life has evolved and diversified over time. Like raisins in **expanding dough**, galaxies that are further apart are increasing their separation more than nearer ones. And as a result, the light emitted from distant galaxies and stars is shifted towards the **red end of the spectrum**. Observations of galaxies indicate that the universe is expanding: the distance D between almost any pair of galaxies is increasing at a rate $V = HD$ − beautifully explained by the **Hubble's law**. The **Hubble law** is a fundamental principle in cosmology that describes the relationship between the distance of galaxies from us and their recessional velocity. The law was proposed by the astronomer **Edwin Hubble** in the 1920s. While the **Hubble law** has been an incredibly useful tool for studying the large-scale structure of the universe, there are some limitations to its application. Here are some of the major limitations of the Hubble law:

Local environment: The Hubble law assumes that the expansion of the universe is uniform and isotropic, which means that the universe looks the same in all directions. However, this assumption may not be entirely valid, as the local environment of a galaxy can affect its motion. For example, a galaxy that is near a large cluster of galaxies may be gravitationally attracted to that cluster, causing it to move at a different velocity than expected from the Hubble law.

Inhomogeneities: The Hubble law assumes that the universe is homogeneous, meaning that its properties are the same on large scales. However, recent observations have shown that the universe is not perfectly homogeneous, but contains structures such as galaxy clusters, filaments, and voids. The presence of these structures can affect the velocity of galaxies and cause deviations from the Hubble law.

Uncertainties in the Hubble constant: The value of the Hubble constant, which relates the velocity of galaxies to their distance, is not precisely known. Different methods of measurement can yield different values, and the current value has an uncertainty of about 10%. This uncertainty can affect the accuracy of the Hubble law and its application to cosmological studies.

Redshift measurement errors: The recessional velocity of a galaxy is typically measured by its redshift, which is the shift in the wavelength of light emitted by the galaxy due to the Doppler effect. However, redshift measurements can be affected by a variety of factors, such as the gravitational pull of nearby objects or the peculiar motion of the galaxy, which can introduce errors into the measurement of the velocity.

Despite these limitations, the **Hubble law** remains a powerful tool for studying the large-scale structure of the universe and has provided some of the strongest evidence for the **expansion of the universe** and the **Big Bang theory**. Ongoing efforts to refine our measurements of the Hubble constant and study the effects of inhomogeneities and local environments will continue to improve our understanding of the universe and its evolution. And **quantum theory** (The revolutionary theory of the last century clashed with everyday experience which has proved enormously successful, passing with flying colors the many stringent laboratory tests to which it has been subjected for almost a hundred years) predicts that entire space is not continuous and infinite but rather quantized and measured in units of quantity called **Planck length (**10^{-33} cm **– the length scale found at the big bang in which the gravitational force was as strong as the other forces and at this scale, space-time was "foamy," with tiny bubbles and wormholes appearing and disappearing into the vacuum)**. However, at the present there is no conclusive evidence in favor of quantization of space and time and moreover nobody knows why no spatial or time interval shorter than the **Planck values** exists?

For length: Planck length **(a hundred billion billion times [10^{20}] smaller than an atomic nucleus)** $\approx 1.6 \times 10^{-33}$ centimeter.

For time: Planck time $\approx 5 \times 10^{-44}$ seconds.

On the other hand, there is no evidence against what the quantum model inform us about the true nature of reality. But in order to unify **Albert Einstein's general relativity (a theoretical framework for understanding the universe on the largest of scales: the immense expanse of the universe itself and it breaks down at times less than the Planck time and at distances smaller than the Planck length, predicts the existence of wormhole − a passageway between two universes – gives us a better way of grasping reality than Newtonian mechanics, because it tells us that there can be black holes, because it tells us there's a Big Bang)** with the quantum physics that describe fundamental particles and forces, it is necessary to quantize space and perhaps time as well. And for a universe to be created out of nothing, the positive energy of motion should exactly cancel out the negative energy of gravitational attraction i.e., the net energy of the universe should be = zero. And if that's the case, the spatial curvature of the universe, $\boldsymbol{\Omega_k}$, should be = **0.0000** (i.e., perfect flatness). But the **Wilkinson Microwave Anisotropy Probe** (WMAP) satellite has established the spatial curvature of the universe, $\boldsymbol{\Omega_k}$, to be between **− 0.0174** and **+ 0.0051**. Then, how can it cost nothing to create a universe, **how can a whole universe be created from nothing?** On the other hand, there is a claim that the sum of the energy of matter and of the gravitational energy is equal to zero and hence there is a possibility of a universe appearing from nothing and thus the universe can double the amount of positive matter energy and also double the negative gravitational energy without **violation of the conservation of energy.** However, **energy of matter + gravitational energy is = zero** is only a claim based on **Big Bang implications**. No human being can possibly know the precise energy content of the entire universe. In order to verify the claim that the total energy content of the universe is exactly zero, one would have to account for all the forms of energy of matter in the universe, add them together with gravitational energy, and then verify that the sum really is exactly zero. But the attempt to verify that the sum really is exactly zero is not an easy task. **We need precision experiments to know for sure.**

Gazing at the at the blazing celestial beauty of the night sky and asking a multitude of questions that have puzzled and intrigued humanity since our beginning − **WE'VE DISCOVERED** a lot about our celestial home; however, we still stand at a critical cross road of knowledge where the choice is between **spirituality and science** to accomplish the **hidden truth** behind the early evolution of the universe. In order to throw light on a multitude of questions that has so long occupied the mind of scientists and the people who have argued over the years about the nature of reality and whose business it is to ask why, the **philosophers:** Where did we and the universe come from? Where are we and the universe going? What makes us and the universe exists? Why we born? Why we die? Whether or not the universe had a beginning? **If the universe had a beginning, why did it wait an infinite time before it began?** What was before the beginning? Is our universe tunneled through the chaos at the **Planck time** from a prior universe that existed for all previous time? We must either build a sound, balanced, effective and extreme imaginative knowledge beyond our limit. **Many theories were put forth by the scientists** to look into the early evolution of the universe but none of them turned up so far. And if, like me, you have wondered looking at the star, and tried to make sense of what makes it shine the way it is. Did it shine forever or was there a limit beyond which it cannot or may not shine? **And, where did the matter that created it all come from?** Did the matter have a beginning in time? Or had the matter existed forever and didn't have a beginning? In other words, what cause made the matter exist? And, what made that cause exist? Some would claim the answer to this question is that matter could have popped into existence **13.9 billion years ago** as a result of just the eminent physical laws and constants being there. **Any "meta" or "hyper" laws of physics** that would allow (even in postulate) a matter to pop into existence are completely outside our experience. The eminent laws of physics, as we know them, simply are not applicable here. Invoking the laws of physics doesn't quite do the trick. And the **laws of physics** are simply the human-invented ingredients of models that we introduce to describe observations. They are all fictitious, as far as we find a reference frame in which they are observed. The question of matter genesis is clear, and deceptively simple. **It is as old as the question of what was going on before the Big Bang**. Usually, we tell the story of the matter by starting at the Big Bang and then talking about what happened after. The answer has always seemed well beyond the reach of science. Until now.

Over the decades, there have been several heroic attempts to explain the origin of matter, all of them proven wrong. One was the so-called **Steady State theory**. The idea was that, as the galaxies moved apart from each other; new galaxies would form in the spaces in between, from matter that was spontaneously being created. The **matter density of the universe would continue to exist**, forever, in more or less the same state as it is today. In a sense disagreement was a credit to the model, every attempt was made to set up the connection between theoretical predictions and experimental results but the **Steady State theory** was disproved even with limited observational evidence. The theory therefore was abandoned and the idea of **spontaneous creation** of matter was doomed to fade away into mere shadows. As crazy as it might seem, the matter may have come out of **nothing!** The meaning of nothing is somewhat ambiguous here. It might be the pre-existing space and time, or it could be nothing at all. **After all, no one was around when the matter began, so who can say what really**

happened? The best that we can do is work out the most vain imaginative and foolish theories, backed up by numerous lines of scientific observations of the universe.

Cats are alive and dead at the same time. But some of the most incredible mysteries of the quantum realm **(a jitter in the amorphous haze of the subatomic world)** get far less attention than **Schrödinger's famous cat**. Due to the **fuzziness of quantum theory** (that implies: the cosmos does not have just a single existence or history), **and specifically Heisenberg's uncertainty principle** (which fundamentally differentiates **quantum** from **classic reasoning** − discovered by the German physicist **Werner Heisenberg** in 1927), one can think of the vacuum fluctuations as **virtual matter–antimatter pairs** that appear together at some time, move apart, then come together and annihilate one another and revert back to energy. Spontaneous births and deaths of roiling frenzy of particles so called **virtual matter–antimatter pairs** momentarily occurring everywhere, all the time – is the evidence that mass and energy are interconvertible; they are two forms of the same thing. If one argue that matter was a result of such a fluctuation. So then the next question is what cause provided enough energy to make the **virtual matter – antimatter pairs** materialize in real space. And if we assume some unknown cause has teared the pair apart and boosted the separated **virtual matter–antimatter** into the **materialized state**. The question then is what created that cause. **In other words, what factor created that cause?** And what created that factor. Or perhaps, the cause, or the factor that created it, existed forever, and didn't need to be created. The argument leads to a never-ending chain that always leaves us short of the ultimate answer. Unfortunately, **Dr. Science cannot answer these questions**. So, the problem remains. However, quantum origin and separation of the matter still delights theoretical physicists but boggles the mind of mere mortals, is the subject of my thought; have the **quantum laws** found a genuinely convincing way to explain matter existence apart from **divine intervention**? If we find the answer to that, **it would be the ultimate triumph of human reason** – for then we would know the ultimate Cause of the Matter. Over the decades, we're trying to understand how the matter began and we're also trying to understand all the other things that go along with it. This is very much the beginning of the story and that story could go in, but I think there could be surprises that no one has even thought of. Something eternal can neither be created nor destroyed. The **first law of thermodynamics** (a version of the law of conservation of energy, adapted for thermodynamic systems) asserts that matter or energy can neither be created nor destroyed; it can be converted from one form to another. The overwhelming experience of **experimental science (science based on experimental research that plays the role of testing hypothesis, typically in controlled laboratory settings)** confirms this first law to be a fact. But if the matter prevails in the boundary of understanding in that it neither started nor it ends: it would simply be. What place then for an evidence exposing that we live in a finite **expanding universe** which has not existed forever, and that all matter was once squeezed into an infinitesimally small volume, which erupted in a cataclysmic explosion which has become known as the **Big Bang**. However, what we believe about the origin of the matter is not only sketchy, but uncertain and based purely on human perception. There is no reliable and genuine evidence to testify about how the matter began and what may have existed before the beginning of the matter. **The laws of physics tell us that the matter had a beginning, but they don’t answer how it had begun**. Mystery is running the universe in a hidden hole and corner, but one day it may wind up the clock work with might and main. The physical science can explain the things after **big bang** but fails to explain the things before big bang. We know that matter can be created out of energy, and energy can be created out of matter. This doesn't resolve the dilemma because we must also know where the original energy came from.

Constants are fundamental and unchanging physical quantities that play a crucial role in the behavior of the universe. Constants like the **speed of light**, the **gravitational constant**, and the **Planck constant** are fundamental to the behavior of the universe. They define the way that energy, matter, and forces interact with each other, and provide a framework for understanding the physical laws that govern the universe. The value of certain constants can reveal important insights about the nature of the universe. **For example**, the value of the **cosmological constant**, which describes the expansion of the universe, has deep implications for the **ultimate fate of the universe**. Constants like the fine structure constant or the electron charge-to-mass ratio are used in a wide range of scientific calculations, from **quantum mechanics** to **astrophysics**. These constants provide precise values that allow for accurate and reliable predictions of physical phenomena. Overall, constants are important because they define the basic properties of the universe, allow for precise calculations, reveal insights about the nature of the universe, provide a basis for comparison, and enable the development of new technologies. **The electrostatic and gravitational forces** according to **Coulomb's** and **Newton's laws** are bot**h inverse square forces**, so if one takes the ratio of the forces, the distances cancel. **For the electron and proton**, the ratio of the forces is given by the equation: $F_E / F_G = e^2 / 4\pi\varepsilon_0 G m_p m_e$, where e is the charge = 1.602×10^{-19} Coulombs, G is the gravitational constant, ε_0 is the **absolute permittivity of free space** = 8.8×10^{-12} *F/ m*, m_p is the mass of the proton = 1.672×10^{-27} kg and m_e is the mass of the electron = 9.1×10^{-31} kg. Plugging the values we get: $F_E / F_G = 10^{39}$ **which means:** F_E is greater than F_G. So, it was argued by a **German mathematician**, theoretical physicist and philosopher (some say it was **Hermann Weyl**), if the gravitational force between the proton and electron were not much smaller than the **electrostatic force between them**, then the hydrogen atom would have collapsed to neutron long before there was a chance for stars to form and life to evolve. $F_E > F_G$ must have been numerically **fine-tuned** for the existence of life. Taking $F_E / F_G = 10^{39}$ as an example in most **physics literature** we will find that **gravity** is the weakest of all forces, many orders of magnitude weaker than **electromagnetism**. But this does not make sense any way and it is not true always and in all cases. Note that the ratio F_E / F_G **is not a universal constant**; it's a number that depends on the particles we use in the calculation. For example: For two particles each of **Planck mass** (mass on the order of **10 billion billion times** that of a proton) and **Planck charge** the ratio of the forces is 1 i.e., F_E / F_G = 1. Moreover, when the **relativistic variation of electron mass with velocity** is taken into account then the ratio F_E / F_G becomes velocity dependent. The **first law of thermodynamics** sometimes referred to as the **law of conservation of energy**, holds that energy can only be changed from one form to another and cannot be generated or destroyed. While this law is fundamental to the study of thermodynamics, it does have some limitations:

> The **first law of thermodynamics** tells us whether energy is conserved or not, but it does not tell us anything about whether a process will occur spontaneously or require an external energy input. The **second law of thermodynamics** comes into play in this scenario.
> The **first law of thermodynamics** does not distinguish between the transfer of heat from a hotter object to a cooler one, and the reverse process. This is referred as the **"arrow of time"** problem in thermodynamics.

Does our universe exist inside a black hole of another universe? The question lingers, unanswered until now. Even though the existence of alternative histories with black holes, suggests this might be possible i.e., our universe lies inside a **black hole** of another universe, we cannot prove or disprove this conjecture any way. Meaning that the **event horizon of a black hole** is boundary at which nothing inside can escape and then how might one can cross its event boundary and testify whether or not our universe exist inside a black hole of another universe. Thus we cannot answer the central question in **cosmology**: Does our universe exist inside a black hole of another universe? However, the fact that we are simply an advanced breed of **talking monkeys** surviving on a sumptuous planet, have been reckoning at least from last hundred years − turning unproved belief into unswerving existence through the power of perception and spending our brief time in the sun working at understanding the deepest mysteries of nature by doing repeated calculations and getting some answer that seem very likely makes us feel something very special − a bit premature to buy tickets to the nearest galaxy to visit the next goldilocks planet or hunt **dinosaurs**. It is currently unknown whether the entire universe exists inside a **black hole,** and the idea is purely speculative. There are some theories that suggest that our universe could exist inside a black hole, but these are highly speculative and not supported by any direct evidence. **These theories are based on the idea that a black hole could be a gateway to another universe or that our universe could be the result of a black hole in another universe.** However, these ideas are still highly theoretical and have not been supported by any concrete evidence or observations. It is also important to note that our current understanding of black holes is still limited, and much more research is needed to fully understand their properties and behavior. Therefore, while it is an interesting and thought-provoking idea, the notion that the entire universe exists inside a black hole remains purely speculative at this time.

The physicist has been spending a month, as he or she does each year, sequestered with colleagues, such as fellow **theoretical physicists**, to discuss many great mysteries of the cosmos. But despite its simple approximation as a force, and its beautifully subtle description as a property of **space-time** which in turn can be summarized by **Einstein's famous equation**, which essentially states: **Matter-energy → curvature of space-time**, we've come to realize over the past century that we still don't know what gravity actually is. It has been a closed book ever since the **grand evolution**

of human understanding and all physicists hang this book up on their wall and distress about it. Unhesitatingly you would yearn to know where this book comes from: is it related to **metaphysical science** or perhaps to the greatest blast puzzles of physics still to be discovered, like **cosmic string** and **magnetic monopoles**? Nobody knows and for the moment, nature has not said yes in any sense. It's one of the **10,000 bits puzzling cosmic story** with a cracking title. You might say the laws of physics designed that book, and we don't know how they designed that book. The elevated design of this book, an extract of which appears in the cosmic art gallery, sets out to the belief that it must have designed as it could not have created out of chaos. In some sense, the origin of the **cosmic problem** today remains what it was in the time of **Newton** **(who not only put forward a theory of how bodies move in space and time, but he also developed the complicated mathematics needed to analyze those motions)** – one of the greatest challenges of **21st Century science** certainly keep many an aficionado going. Yet, we toasting each other with champagne glasses in laboratories around the world − have made a bold but brilliant move. In less than a hundred years, we have found a new way to wonder what gravity is. The usual **approach of science of constructing** a set of rules and equations cannot answer the question of why if you could turn off gravity, space and time would also vanish. In short, we don't have an answer; we now have a whisper of the grandeur of the problem. We don't know exactly how it is intimately related to space and time. It's a mystery that we're going to chip at from quantum theory (the theory developed from **Planck's quantum**

principle and **Heisenberg's uncertainty principle** which deals with phenomena on extremely small scales, such as a millionth of a millionth of an inch). However, when we try to apply **quantum theory to gravity,** things become more complicated and confusing.

Mankind's deepest desire for scientific intervention introduced a **new idea that of time**. Time is a complex and multifaceted concept that plays a fundamental role in our understanding of the universe and our place in it. Its nature has been the subject of scientific and philosophical inquiry for centuries, and it continues to be a subject of study and fascination today. Most of the underlying assumptions of **physics** are concerned with time. The nature of time has been the subject of philosophical debate for centuries. Some philosophers view time as an objective reality, while others see it as a human invention or a product of the mind. Time may sound like a **genre of fiction**, but it is a well-defined genuine concept. Some argue that **time is not yet discovered by us** to be objective features of the mundane world: even without considering time an intrinsic feature of the mundane world, we can see that things in the physical world change, seasons change, people adapt to that drastic changes. The fact that the physical change is **an objective feature of the physical world**, and time is independent of under whatever circumstances we have named it. Others think **time** as we comprehend it does not endure beyond the bounds of our **physical world**. Beyond it, maybe one could run forward in time or just turn around and go back. This could probably mean that one could fall rapidly through their former selves. In a bewildering world, the question of whether the time never begin and has always been ticking, or whether it had a beginning at the big bang, is really a concern for physicists: either science could account for such an inquiry. If we find the answer to it, it would be the ultimate triumph of human justification for our continuing quest. **And, our goal of a complete description of the universe we live in is self-justified.** Time is relative, meaning that the passage of time can be affected by the relative motion of an observer. This is known as **time dilation**, and it is a consequence of the theory of relativity. According to this theory, the faster an object moves, the slower time passes for that object. The understanding we have today is that time is not an illusion like what age-old philosophers had thought, but rather it is well defined mathematical function of an inevitable methodical framework for systematizing our experiences. If one believed that the time had a beginning, the obvious question was how it had started? The problem of whether or not the time had a beginning was a great concern to the German Philosopher, **Immanuel Kant** (who believed that every human concept is based on observations that are operated on by the mind so that we have no access to a mind- independent reality). He considered the entire human knowledge and came to the conclusion that time is not explored by humans to be objective features of the mundane world domain, but is a part of an inevitable systematic framework for coordinating our experiences. How and when did the time begin? No other scientific question is more fundamental or provokes such spirited debate among physicists. **Time travel** is a popular concept in science fiction, but it is not currently possible in reality. However, some theories, such as the theory of relativity, suggest that time travel might be possible in the future, although it would require the ability to travel faster than the speed of light or to create a wormhole in space-time. Since the early part of the 1900s, one explanation of the **origin and fate of the universe**, the **Big Bang theory**, has dominated the discussion. Although singularity theorem (a theorem showing that a singularity, a point where **general relativity** **(a theory which predicts that time would come to an end inside a black hole – an invisible astrophysical entity that no one has seen, but scientists have observed gravitational evidence consistent with predictions about it, so most scientists believe it exists)** breaks down, must exist under certain circumstances; in particular, that the universe must have started with a singularity) predicted that the time, the space, and the matter or energy itself had a beginning, they didn't convey how they had a beginning. It would clearly be nice for **singularity theorems** if they had a beginning, but how can we distinguish whether they had a beginning? In as much as the time had a beginning at the **Big Bang** it would deepen implication for the role of **supreme divine creator** **(that much of humanity worships as the source of all reality)** in the grand design of creation. But if it persists in the bounds of reason in that it has neither beginning nor end and nothing for a **Creator** to do. What role could ineffable benevolent creator have in creation? Life could start and new life forms could emerge on their own randomly sustaining themselves by reproducing in the environment fitted for the functional roles they perform. Personally, we're sure that the time began with a hot Big Bang. **But will it go on ticking forever?** If not, when it will wind up its clockwork of ticking? We're much less sure about that.

However, we are just a willful gene centered breed of **talking monkeys** on a minor planet of a very average galaxy. But we have found a new way to question ourselves and we have learned to do them. That makes us something very special. Moreover, everything we think we understand about the universe would need to be reassessed. Every high school graduate knows **cosmology**, the very way we think of things, would be forever altered. The distance to the stars and galaxies and the age of the universe **(13.7 billion years − number has now been experimentally determined to within 1% accuracy)** would be thrown in doubt. Even the **expanding universe theory**, the **Big Bang theory**, and **black holes** would have to be re- examined. The Big Bang theory of universe assumes the present form of the universe originated from the hot fire ball called singularity and it assumes time did not exist before the Big Bang. But **Erickcek** deduced on the basis of **NASA's**, **Wilkinson Microwave Anisotropy Probe** (WMAP) that the existence of time and empty space is possible before the Big Bang.

But what would happen if you travel back in time and kill your grandfather before he conceives your father? This creates a **paradox** where you cannot exist in the present because you never would have been born. **Would the arrow of time reverse?** Because motion makes the clock tick slower, can we travel back in time and kill our grandfather before he conceive our father? If not, why the universe avoids the paradox? **Time Travel − Science Fiction**? Taking the **laws of physics** and punching them in the stomach and throwing them down the stairs – it's possible for you to break the universal speed limit. **It is mind boggling to think about it – you're actually travelling backwards in time.** What if you went back in time and prevented **big bang** from happening? You would prevent yourself from ever having been born! But then if you hadn't been born, you could not have gone back in time to **prevent big bang from happening.** The concept of **time travel** may sound something impressive and allow science fiction like possibilities for people who survived from the past, but somewhat it seems to be incredible like seeing broken tea cups gathering themselves together off the floor and jumping back on the table promoting **cup manufacturers** go out of business. However, travelling through time may not be the farfetched science fiction theory. At the same time, can we open a portal to the past or find a shortcut to the future and master the time itself is still in question and forbidden by the **second law of thermodynamics (which states that in any closed system like universe randomness, or entropy, never decreases with time)**. Of course, we have not seen anyone from the past (**or have we?**). As of now, time travel remains purely in the realm of science fiction, and we have yet to discover any means of time travel that could be theoretically possible according to our current understanding of physics.

We asked how stars are powered and found the answer in the transformations of **atomic nuclei**. But there are still simple questions that we can ask. And one is: Is our universe merely the byproduct of a cosmic accident? If the universe were merely the **by-product of a grand accident**, then our universe could have been a conglomeration of objects each going its own way. But everything we see in the universe obeys rules which are governed by **a set of equations**, without exception − which give **philosophy** a lot more attention than science. However, this does not mean that the **universe obey rules** because it exists in a plan which is created and shaped by a grinding hand.

Maybe the universe is a **lucky coincidence** of a grand accident emerged with ingredients such as space, time, mass, and energy exist in one-to-one correspondence with the elements of reality, and hence it obeys a set of **rational laws without exception**. At this moment it seems as though **Dr. Science** will never be able to raise the curtain on the **mystery of creation**. Moreover, traditional philosophy is dead, that it has not kept up with modern developments in science, and there is no reason at justifying the grinding hand because **the idea of God is extremely limited** and goes no further than the opening sentence of the **classical theology** (which has always rejected the idea that God can classified or defined), and much is still in the speculative stage, and we must admit that there are yet no empirical or observational tests that can be used to test the idea of an accidental origin. No evidence. **No scientific observation. Just a speculation**. For those who have lived by their faith in the power of reason, the story may end like a bad dream since free will is just an illusion.

From the **Big Bang** to the Bodies such as stars or **black holes** including basic facts such as particle masses and force strengths, the entire universe works because the **laws of physics make things happen.** But if **Meta or hyper laws of physics** were whatever produced the universe then what produced those laws. Or perhaps, the laws, or the cause that created them, existed forever, and didn't need to be created. We must admit that there is ignorance on some issues, that is, we don't have a complete set of laws …. We are not sure exactly does the existing laws hold everywhere and at all time. **Dr. Science** gives us a clue, but there's no definitive answer to provide a purely natural, non-causal explanation for the existence of laws of physics and our place in it. So let's just leave it at the hypothetical laws of physics. The question, then, is **why are there laws of physics?** And we could say, well, that required a **biblical deity**, who created these **laws of physics** and the spark that took us from the laws of physics to the notions of time and space. Well, if the laws of physics popped into existence **13.8 billion years ago** with divine help whatsoever, like **theologians** say, why aren't we seeing a at least one evidence of an ineffable creator in our observable universe every now and then? The origin of the **Meta or hyper laws of physics** remains a mystery for now. However, recent breakthroughs in physics, made possible in part by **fantastic revolutionary understanding** of the true nature of the mathematical quantities and theories of physics, may suggest an answer that may seem as obvious to us as the earth orbiting the sun – or perhaps as ridiculous as earth is a perfect sphere. We don't know whatever the answer may be because the **Meta** or

hyper laws of physics are completely beyond our experience, and beyond our imagination, or our mathematics. This fact leads us to a **big mystery** and awaits the next generation of high energy experiments, which hope to shed light on the far- reaching answer that might be found in the laws that govern elemental particles.

Who are we? We find that we intelligent apes who have only recently left the trees, live on an fragile planet of a humdrum star by a matter of sheer luck or by divine providence, lost in a galaxy tucked away in some forgotten corner of a universe in which there are far more galaxies than people. Sending the **Beatles song across the Universe** and pointing the telescopes in Deep Space Network towards the North Star, **Polaris**, we seek to find intellectual beings like us outside the sheer number of planets, vast ocean of existence, our solar system, and our own **Milky Way galaxy**. How awe hunting for them across the empty stretches of the universe would be to acquire a bit of confirmation that either we're alone in this universe or we are not. However, we are not the only life-form in the universe, is reasonable to expect since we have no reason to assume that ours is the only possible form of life. Some sort of life could have happened in a universe of greatly different form, but where's the evidence? The **Burden of evidence** is only on the people who regard themselves as **reliable witnesses** that sightings of **UFOs** are evidence that we are being visited by someone living in another galaxy who are much more advanced enough to spread through some hundred thousand million galaxies and visit the Earth. An alien, like the teapot, is a hypothesis that requires evidence. The question of whether aliens exist is a topic of much debate and speculation. The universe is incredibly vast, with billions of stars and planets, and it is statistically likely that there are other forms of life out there. However, despite extensive searches for **extraterrestrial life**, we have not yet found any definitive evidence of its existence. Some scientists believe that microbial life may exist in our own solar system, such as on Mars or one of Jupiter's moons, where conditions may be suitable for life. However, the search for intelligent extraterrestrial life is a more difficult task, as it involves **detecting signals** from other civilizations that may be millions or billions of light-years away. Many theories have been proposed about what alien life forms might look like or how they might behave, but without concrete evidence, it is difficult to say for sure. Popular culture often portrays aliens as humanoid or having **advanced technology**, but the reality could be much different. It's important to note that even if aliens do exist, there are many factors that could limit our ability to detect or communicate with them. These factors include distance, the limitations of our technology, and the possibility that other civilizations may not want to communicate with us or even exist in a form that is recognizable to us. Ultimately, the question of whether aliens exist remains unanswered, but as our understanding of the universe expands and our technology improves, we may one day discover evidence of extraterrestrial life.

The **known forces of nature** can be divided into four classes:

> **Gravity:** This is the weakest of the four; it acts on everything in the universe as an attraction. And if not for this force, we would go zinging off into outer space and the sun would detonate like trillions upon trillions of hydrogen bombs.

Electromagnetism: This is much stronger than gravity; it acts only on particles with an electric charge, being repulsive between charges of the same sign and attractive between charges of the opposite sign. More than half the gross national product of the earth, representing the accumulated wealth of our planet, depends in some way on the electromagnetic force. It light up the cities of New York, fill the air with music from radios and stereos, entertain all the people in the world with television, reduce housework with electrical appliances, heat their food with microwaves, track their planes and space probes with radar, and electrify their power plants.

Weak nuclear force: This causes radioactivity and plays a vital role in the formation of the elements in stars. And a slightly stronger this force, all the neutrons in the early universe would have decayed, leaving about 100 percent hydrogen, with no deuterium for later use in the synthesizing elements in stars.

Strong nuclear force: This force holds together the protons and neutrons inside the nucleus of an atom. And it is this same force that holds together the quarks to form protons and neutrons. Unleashed in the hydrogen bomb, the strong nuclear force could one day end all life on earth.

These four fundamental forces of nature are responsible for all the physical interactions that occur in the universe. They are fundamental because they cannot be explained in terms of other forces or interactions, and they are present in all interactions that occur in the universe. Understanding the **fundamental forces of nature** is essential to understanding the behavior of matter in the universe, and it is a critical component of many fields of study, including physics, chemistry, and astronomy. The **inherent goal of unification** is to show that all of these forces are, in fact, manifestations of a single super force. We can't perceive this unity at the low energies of our everyday lives, or even in **our most powerful accelerators** (capable of accelerating particles nearly up to the speed of light) at **Fermi lab** or **LHC, the Large Hadron Collider, at CERN** (European Centre for Nuclear Research), in Switzerland. But close to the **Big Bang temperatures**, at inconceivably high energies… If the forces unify, the protons − which make up much of the mass of ordinary matter − can be unstable, and eventually decay into lighter particles such as antielectrons. Indeed, several experiments were performed in the **Morton Salt Mine in Ohio** to yield definite evidence of proton decay. But none have succeeded so far. However, the probability of a proton in the universe gaining sufficient energy to decay is so small that one has to wait at least a **million million million million million** years i.e., longer than the time since the big bang, which is about ten thousand million years. The eminent laws do not tell us why the initial configuration was such as to produce what we observe. For what purpose? Must we turn to the **anthropic principle** for an explanation? **Was it all just a lucky chance?** That would seem a counsel of despair, a negation of all our hopes of understanding the unfathomable order of the universe. However, this is an extended metaphor for many puzzles in physics uncovered with painstaking labor, and it is especially relevant to particle physics. Still, **particle physics** remains unfathomable to many people and a bunch of scientists chasing after tiny invisible objects.

If **string theory** is correct, then every particle is nothing but a vibrating, oscillating, dancing filament named a string. A string does something aside from moving – it oscillates in different ways. Each way represents a particular mode of vibration. Different modes of vibration make the string appear as a dark energy or a cosmic ray, since different modes of vibration are seen as different masses or spins.

If **Higgs theory** (which is the last piece of the Standard Model that has still eluded capture – which is one of the theories LHC experimentalists hope to discover and it is the capstone for conventional big bang cosmology − which biblical creationists reject) is correct, then a new field called the

Higgs field which is analogous to the familiar electromagnetic field but with new kinds of properties permits all over the space (considered the origin of mass in Grand Unified Theory – a theory that unifies the weak, strong, and electromagnetic interactions, without gravity). Different masses of the particles are due to the different strengths of interaction of the particle with the Higgs field (more the strength of interaction of the particle with the Higgs field, more the mass of the particle). To make this easier for you, let's say it is cosmic high-fructose corn syrup − the more you go through it, the heavier you get.

Which explanation is right?

Higgs theory runs rampant in the popular media claiming that **String Theory Is Not The Only Game In Town**. While the theory has been highly successful in predicting the behavior of subatomic particles, there are still some limitations to its application. Here are a few:

> **Naturalness problem:** The Higgs theory predicts the existence of a massive Higgs boson, which is responsible for the mechanism by which particles acquire mass. However, the predicted mass of the Higgs boson is much larger than what one might expect from the theory, which suggests that there may be some as yet unknown physical mechanism that cancels out the large quantum corrections to the Higgs boson mass.
>
> **Dark matter:** The Higgs theory does not provide a clear explanation for the existence of dark matter, which is a form of matter that does not interact with light or other forms of

electromagnetic radiation. Dark matter is believed to make up a significant fraction of the total mass of the universe, but its existence and properties are still not well understood.

Incomplete theory: The Higgs theory is part of the Standard Model of particle physics, which is a highly successful theory that explains the behavior of subatomic particles. However, the Standard Model is incomplete, as it does not explain some important phenomena such as gravity, dark matter, or the nature of neutrino masses.

Fine-tuning problem: The Higgs theory requires the existence of a scalar field, which must be finely tuned to a very specific value to explain the masses of particles. This has been criticized by some physicists as requiring an unnecessary amount of precision, and suggesting that there may be more elegant theories that can explain particle masses without such fine-tuning.

Despite these limitations, the **Higgs theory** remains a critical concept in **particle physics**, and its discovery in 2012 was a major milestone in our understanding of the universe. Ongoing research aims to address some of these limitations and to develop more complete theories of particle physics. However, by the end of the decade, the new physics will point to even more discoveries at the **TeV scale** and opens the door beyond the Standard Model and raise new questions in cosmology, and scientists continue to study the universe to unlock its secrets and understand its mysteries. The **Big Bounce theory** is a cosmological model that suggests that our universe goes through cycles of expansion and contraction, with each cycle ending in a **"Big Crunch"** that is followed by a **"Big Bounce"** that leads to a new cycle of expansion. The theory suggests that the universe has no true beginning or end and that it is eternal. The idea of the **Big Bounce** is based on the principles of **General Relativity** and **Quantum Mechanics**. General Relativity predicts that the universe must have started from a singularity, a point of infinite density and zero volume. However, **Quantum Mechanics** suggests that space and time are not continuous, but rather discrete and granular. This means that there is a limit to how small a length or time interval can be. Therefore, the singularity predicted by **General Relativity** cannot be a true description of the origin of the universe. The **Big Bounce theory** proposes that the universe began with a **"Big Bang"** that was not a true singularity, but rather a highly compressed state of matter that expanded rapidly. As the universe expanded, it cooled down and became less dense. At some point, the expansion slowed down and the universe started to contract under the influence of gravity. This contraction would continue until the matter in the universe reached a highly compressed state once again, which would then lead to another **Big Bang** and a new cycle of expansion. The **Big Bounce theory** also proposes that each cycle of expansion and contraction is a **quantum process**, meaning that the universe is in a superposition of all possible states of expansion and contraction until it is observed or measured. This interpretation of the universe is known as the "Many Worlds" interpretation of quantum mechanics. The Big Bounce theory has not been fully developed and is still a topic of active research in **theoretical physics**. However, if the theory is correct, it would provide an alternative explanation to the traditional **Big Bang theory**, and it would also suggest that the universe is eternal and has no true beginning or end.

Cosmic inflation is a brief period of exponential expansion that occurred shortly after the Big Bang, and it is thought to be responsible for some of the large-scale structure of the universe. However, the cause of cosmic inflation is still not fully understood. The **Big Bang theory** provides a framework for understanding the universe's evolution since its inception, but there are still many unanswered questions about the very first moments after the Big Bang. **Dr. Science** remains silent on the profound questions. Ultimately, however, one would hope to find complete, consistent answers that would include all the mathematical techniques as approximations. The quest for such answers is known as the **grand unification of the two basic**

partial theories: the **general theory of relativity** (which states that space and time are no longer absolute, no longer a fixed background to events. Instead, they are dynamical quantities that are shaped by the matter and energy in the universe) and **quantum mechanics** (a theory of the microcosm which has upended many an intuition, but none deeper than this one − developed by 1900 physicists in response to a number of glaring problems that arose when 19th century conceptions of physics were applied to the microscopic world, where subatomic particles are held together by particle like forces dancing on the sterile stage of **space-time**, which is viewed as an empty arena, devoid of any content). Unfortunately, however, these two theories are inconsistent with each other – i.e., **quantum mechanics** and **general relativity** do not work together. **How the ideas of general relativity can be consolidated with those of quantum theory is still a ?** Until we progress closer toward the laws that govern our universe.

Astrochemistry is the study of the chemical composition and processes in astronomical objects, including stars, planets, and interstellar and intergalactic space. It involves the study of the **chemical reactions** and physical processes that occur in the universe, as well as the study of the chemical elements and molecules that are present in space. One of the key goals of **astrochemistry** is to understand the origins of the chemical elements and the formation of **complex molecules** in space. This involves studying the life cycles of stars, including how they form, evolve, and die, and how they produce and distribute elements through the universe. It also involves the study of the chemical reactions that occur in the interstellar medium, which is the gas and dust that exists between stars.

Astrochemistry also plays an important role in the search for life beyond Earth. By studying the chemical processes that occur in the environments of other planets and moons, **astrochemists** can gain insights into the conditions necessary for life to arise and the chemical traces that could point to the existence of life. Another important area of research in astrochemistry is the study of the chemical processes that occur in the early universe. This involves the study of the **cosmic microwave background radiation**, which is the afterglow of the Big Bang, and the study of the early galaxies and quasars that formed in the early universe. **Astrochemistry** is a multidisciplinary field that draws on techniques and methodologies from a range of other scientific disciplines, including chemistry, physics, astronomy, and planetary science. It is a rapidly growing field, driven by advances in technology and observational capabilities, and it has important implications for our understanding of the **origins of the universe**, the formation of planetary systems, and the search for life beyond Earth. **Astrochemistry** is a rapidly growing field of study that has made significant contributions to our understanding of the chemical processes and composition of astronomical objects, but like any scientific field, there are still limitations and challenges. Here are some potential failures or challenges of astrochemistry:

Limited observational data: Although telescopes and other instruments have allowed us to observe and study many astronomical objects, there are still many limitations to the data that we can collect. For example, not all regions of space are accessible or observable, and we may not have the ability to observe certain chemical processes in detail.

Complexity of chemical processes: The chemical reactions that occur in space can be incredibly complex and can involve a large number of variables. It can be challenging to understand and model these processes, particularly when we do not have detailed information about the conditions and environments in which they occur.

Limited laboratory experiments: Many of the chemical reactions and processes that occur in space are difficult or impossible to replicate in a laboratory setting. This means that much of our understanding of astrochemistry is based on theoretical models and observational data, rather than experimental data.

Uncertainty in chemical models: Astrochemists often use theoretical models to predict the chemical processes and composition of astronomical objects. These models can be affected by uncertainties in the underlying physical and chemical parameters, which can lead to uncertainties in the predictions and results.

Interdisciplinary challenges: Astrochemistry is a multidisciplinary field that draws on expertise from a range of other scientific disciplines. This can create challenges in terms of communication and collaboration, as well as challenges in understanding and integrating data and methodologies from different fields.

Despite these challenges, **astrochemistry** continues to make significant contributions to our understanding of the universe, and new technologies and observational techniques are constantly expanding our ability to study and observe the chemical processes of astronomical objects.

The latest theory of subatomic particles **(the quantum theory)** gives an estimated value of vacuum energy density that is about **120 orders of magnitude** larger than the measured value − claiming our best theory cannot calculate the value of the largest energy source in the entire universe. **Dr. Science** advances over the wreckage of its theories by continually putting its ideas to experimental test; no matter how beautiful its idea might be; it must be discarded or modified if it is at odds with experiment. It would have been clearly be nice for **quantum theory** if the value of **vacuum energy density** were in the order of **10^{96} kg per cubic meter**, but the measured value were in the order of **10^{-27} kg per cubic meter**. Thus, the best candidate we have at the moment, the **quantum theory**, brought about its downfall by predicting the value of vacuum energy density that is about **120 orders of magnitude** larger than the measured value.

We a lot of exposure with darkness and disbelief and a state of not having an immediate conclusion, and this vulnerability is of great significance, I think. When we don't comprehend the mind of nature, we are in the middle of darkness. **When we have an intuitive guess as to what the outcome is;** we are unsealed. And when we are fairly damn sure of what the final result is going to be, we are still in some uncertainty. And uncertainty being too complex to come about randomly is evidence for human continuing quest for justification. Sometimes, very hard, impossible things just strike and we call them thoughts. In most of the self-reproducing organisms the conditions would not be right for the generation of thoughts to predict things more or less, even if not in a simplest way, only in the few complex organisms like us spontaneous thoughts would generate and what is it that breathes fire into a perception. The **human perception** is enormous; it’s extensive and unlimited, and outrageous that we can ask simple questions. And they are: What the dark energy is up to? What it is about? Why this mysterious form of energy permeates all of space blowing the galaxies farther and farther apart? How accurate are the physical laws **(which are essentially the same today as they were at the time of Newton despite**

the scientific revolutions and paradigm shifts), which control it? Why it made the universe bang? Unfortunately, the laws that we are using are not able to answer these questions because of the prediction that the universe started off with infinite density at the **big bang singularity (where all the known laws would break down)**. However, if one looks in a commonsense realistic point of view the laws and equations which are considered as inherent ingredients of reality − are simply the man-made ingredients introduced by the **rational beings** who are free to observe the universe as they want and to draw logical deductions from what they see − to describe the objective features of reality. The scientific data is fallible, changeable, and influenced by scientific understanding is refreshing. Here's an example of what I mean. In most physics textbooks we will read that the strength of the electromagnetic force is measured by the dimensionless parameter $\alpha = e^2 / 4\pi\hbar c\varepsilon_0$ (where e is the charge = 1.602×10^{-19} Coulombs, ε_0 is the absolute permittivity of free space = 8.8×10^{-12} *F/m*, c is the speed of light in vacuum **(an awkward conversion factor for everyday use because it's so big. Light can go all the way around the equator of the Earth in about 0.1 seconds)** and ħ is the reduced Planck's constant), called the **fine structure constant**, which was taught to be constant became variant when the standard model of elementary particles and forces revealed that α actually varies with energy.

The **Quantum theory of electrodynamics** (a relativistic quantum field theory or a quantum field theory – arguably the most precise **theory of natural phenomena** ever advanced which seems to govern everything small – through which we have been able to solidify the role of photons as the "**smallest possible bundles of light**" and to reveal their interactions with electrically charged particles such as electrons, in a mathematically complete, predictive, and convincing framework) and **General Relativity** (which dominates large things and is now called a **classical theory** which predicts that the universe started off with infinite density at the **big bang singularity**) both try to assign mass to the **singularity**. But according to generally accepted history of the universe, according to what is known as the hot big bang model. At some finite time in the past i.e., between ten and twenty thousand million years ago. At this time, all matter (which is characterized by the physical quantity we define as mass) would have been on top of each other − which is called the **singularity**, the density would have been **INFINITE**. Under such conditions, all the known laws of science would break down. However, a good **mathematical theory** can prove anything with that amount of wiggle room, and findings are really determined by nothing except its desire. For all theoreticians and tens of thousands of **university graduates** at least know, the universe started off with infinite density at the hot big bang singularity with infinitely hot temperatures. And at such high temperatures that are reached in thousands of **H-bomb explosions**, the strong and weak nuclear forces and the gravity and electromagnetic force were all unified into a single force. What was before the Big Bang? **Was the Big Bang created?** If the **Big Bang** was not created, how was this Big Bang accomplished, and what can we learn about the agent and events of creation? **Is it the product of chance or was been designed?** What is it that blocked the **pre-Big Bang** view from us? Is Big Bang singularity an impenetrable wall and we cannot, in physics, go beyond it? To answer one question, another question arises. **Erickcek's model** suggests the possibility of existence of space and time before the big bang. But the world famed **Big Bang theory** abandons the existence of space and time before the **big bang**. Both the theories are consistent and based upon sophisticated experimental observations and theoretical studies. Truth must be prejudiced with honest scientific inquiry to **illuminate the words of Genesis**. And this is possible only if the modern scientific community would simply open its eyes to the truth.

Do black holes really exist? **If they exist, why we haven't observed one hole yet?** Can black holes be observed directly, and if so, how? If the production of the tiny black holes is feasible, can **particle accelerators**, such as the **Large Hadron Collider** (LHC) in Switzerland at the famed **CERN** nuclear laboratory create a **micro black hole** that will eventually eat the world? If not − if there are no black holes, what are the things we detect ripping gas off the surface of other stars? What is the structure of space-time just outside the black hole? **Do their space times have horizons?** : **are the major questions in theoretical physics today that haunts us.** The effort to resolve these complex paradoxes is one of the very few things that lifts human mind a little above the level of farce, and gives it some of the grace of province inspiring new ideas and **new experiments.** Since **gravity weakens with distance**, the earth pulls on your head with less force than it pulls on your feet, which are a meter or two closer to the earth's center. The difference is so tiny we cannot feel it, but an astronaut near the surface of a **black hole** would be literally torn apart. Most people think of a black hole as a voracious whirlpool in space, sucking down everything around it. But that's not really true! **A black hole is a place where gravity has gotten so strong that even light cannot escape out of its influence.**

How a black hole might be formed?

The slightly denser regions of the nearly uniformly distributed atoms (mostly hydrogen) which lack sufficient energy to escape the **gravitational attraction** of the nearby atoms, would combine together and thus grow even denser, forming giant clouds of gas, which at some point become gravitationally unstable, undergo **fragmentation** and would break up into smaller clouds that would collapse under their **own gravity**. As these collapses, the atoms within them collide with one another more and more frequently and at greater and greater speeds – the gas heats up i.e., the temperature of the gas would increase, until eventually it become hot enough to start nuclear fusion reactions. And a consequence of this is that the stars like our sun **(which are made up of more than one kind of gas**

particle) are born to radiate their energy as heat and light. But the stars with a physical radius smaller than its **Schwarzschild radius** further collapse to produce dark or frozen stars **(i.e., the mass of a star is concentrated in a small enough spherical region, so that its mass divided by its radius exceeds a particular critical value, the resulting space-time warp is so radical that anything, including light, that gets too close to the star will be unable to escape its gravitational grip)**. And these dark stars are sufficiently massive and compact and possess a **strong gravitational field** that prevent even light from escaping out its influence: any light emitted from the surface of the star will be dragged back by the star's gravitational attraction before it could get very far. Such stars become **black voids in space** and were coined in 1969 by the American scientist **John Wheeler** "the **black holes**" (i.e., black because they cannot emit light and holes because anything getting too close falls into them, never to return). Classically, the gravitational field of the black holes **(which seem to be among the most ordered and organized objects in the whole universe)** is so strong that they would prevent any information including light from escaping out of their influence i.e., any information is sent down the throat of a black hole or swallowed by a **black hole** is forever hidden from the outside universe (this goes by the statement that "**black holes have no hair**" − that is, they have lost all information, all hair, except for these three parameters: its mass, spin and charge), and all one could say of the gravitational monster what the poet **Dante** said of the entrance to Hell: "**All hope abandon, ye who enter here**." Anything or anyone who falls through the black hole will soon reach the region of infinite density and the end of time. However, only the laws of classical general relativity does not allow anything **(not even light)** to escape the gravitational grip of the black hole but the inclusion of quantum mechanics modifies this conclusion− **quantum fields** would scatter off a black hole. Because energy can be created out of nothing, the pair of short-lived virtual particles **(one with positive energy and the other with negative energy)** appears close to the event horizon of a black hole. The gravitational might of the black hole inject energy into a pair of virtual particles ... that tears them just far enough apart so that one with negative energy gets sucked into the hole even before it can annihilate its partner ... its forsaken partner with positive energy... gets an energy boost from the gravitational force of the black hole ... escape outward to infinity (an abstract mathematical concept that was precisely formulated in the work of mathematician **Georg Cantor** in the late nineteenth century)... where it appear as a **real particle** (and to an observer at a distance, it will appear to have been emitted from the black hole). Because **$E = mc^2$ (i.e., energy is equivalent to mass)**, a fall of negative energy particle into the black hole therefore reduces its mass with its horizon shrinking in size. As the black hole loses mass, the temperature of the black hole **(which depends only on its mass)** rises and its rate of emission of particle increases, so it loses mass more and more quickly. We don't know does the emission process continue until the black hole dissipates completely away or does it stop after a finite amount of time leaving black hole remnants.

Hawking radiation is a theoretical concept in physics that was first proposed by **Stephen Hawking** in 1974. It describes a process by which a black hole can emit particles and lose mass over time, eventually evaporating entirely. **Hawking radiation** has important implications for our understanding of black holes and the universe. It suggests that black holes are not truly "black," but instead emit radiation and eventually evaporate entirely. Additionally, it provides a link between quantum mechanics and general relativity, two fundamental theories of physics that have long been difficult to reconcile. The study of Hawking radiation and its implications continues to be an active area of research in theoretical physics. The attempt to understand the **Hawking radiation** has a profound impact upon the understanding of the black hole thermodynamics, leading to the description of what the **black hole entropic energy** is.

Black hole entropic energy = Black hole temperature × Black hole entropy

This means that the **entropic energy** makes up half of the mass energy of the black hole. For a black hole of one solar mass ($M = 2 \times 10^{30}$ kg), we get an **entropic energy** of 9×10^{46} joules – much higher than the **thermal entropic energy of the sun**.

Microblack holes are hypothetical black holes with very small masses, on the order of a few micrograms or less. Some theories suggest that microblack holes could be created in particle accelerators such as the **Large Hadron Collider** (LHC). However, the creation of **microblack holes** is a topic of much debate among physicists, as there are many factors that make their creation unlikely or difficult to observe. One theoretical scenario for creating microblack holes involves colliding two particles with extremely high energies. According to the **theory of general relativity**, the higher the energy density of a region of space, the greater the **curvature of spacetime** and the stronger the gravitational field. If the energy of the particles is high enough, their collision could create a region of spacetime with a high energy density and curvature, which could then collapse into a microblack hole. However, there are several factors that make the creation of **microblack holes** difficult to observe or unlikely to occur. **For example:**

The energy required to create a microblack hole is very high, and the probability of two particles colliding with enough energy to create a microblack hole is extremely low.

Even if a **microblack hole** were created, it would be very small and would evaporate very quickly due to Hawking radiation. This means that any microblack holes created in a particle accelerator would be too short-lived to be detected.

The effects of gravity are much weaker at the subatomic scale, so any microblack hole created would not have a significant effect on its surroundings.

Despite these challenges, some physicists continue to explore the possibility of creating and studying **microblack holes** in **particle accelerators**. The study of microblack holes remains an active area of research in theoretical physics. Though the **emission of particles** from the **primordial black holes** is currently the most commonly accepted theory within scientific community, there is some disputation associated with it. There are some issues incompatible with **quantum mechanics** that it finally results in **information being lost**, which makes physicists discomfort and this raises a serious problem that strikes at the heart of our understanding of science. However, most physicists admit that **black holes** must radiate like hot bodies if our ideas about **general relativity** and **quantum mechanics** are correct. Thus even though they have not yet managed to find a primordial black hole emitting particles after over two decades of searching. Despite its strong theoretical foundation, the existence of this phenomenon is still in question. Alternately, those who don't believe that black holes themselves exist are similarly unwilling to admit that they emit particles.

Black hole thermodynamics is the study of the thermodynamic properties of black holes. It is based on the idea that black holes have entropy, a temperature, and other thermodynamic properties that are similar to those of ordinary systems in **thermodynamic equilibrium**. The concept of black hole thermodynamics was first proposed by **Jacob Bekenstein** in the 1970s, and it was later developed by Stephen Hawking. Bekenstein suggested that black holes have entropy proportional to their event horizon area, and that this **entropy** is related to the amount of information that can be stored in the black hole. Hawking, using **quantum field theory** in curved spacetime, showed that black holes emit radiation with a temperature proportional to their surface gravity, which is related to their mass and size. The **thermodynamic properties of black holes** have led to several important discoveries and insights in physics. **For example,** the laws of black hole thermodynamics are analogous to the laws of thermodynamics in ordinary systems, and they provide a deeper understanding of the behavior of black holes. The discovery of **black hole thermodynamics** has also led to the development of the holographic principle, which suggests that the information in a system can be encoded on its boundary, and that the bulk of the system can be described in terms of this boundary information. **Black hole thermodynamics** has also been studied in the context of string theory, which is a theoretical framework that attempts to unify gravity with the other fundamental forces of nature. In **string theory**, black holes are described as extended objects called **branes**, and their thermodynamic properties are related to the properties of the branes. The study of **black hole thermodynamics** in string theory has led to several important insights into the nature of **quantum gravity** and the **structure of spacetime**.

The study of black holes involves combining two of the most successful theories in physics - **general relativity** and **quantum mechanics** - in order to understand how these objects form, evolve, and interact with their environment. It has important implications for our understanding of the universe, as **black holes** are thought to play a key role in the formation and evolution of galaxies, and may also be responsible for some of the most energetic phenomena in the cosmos, such as quasars and gamma-ray bursts. Black hole physics is a complex and fascinating field of study that has many limitations and challenges. Some of the most significant limitations include:

Information loss: One of the biggest limitations of black hole physics is the problem of information loss. According to classical physics, once matter falls into a black hole, it is lost forever. This means that any information that was contained in the matter is also lost, which is a violation of the principle of unitarity in quantum mechanics.

Unobservable interior: Another major limitation is the fact that the interior of a black hole is unobservable. This is because the gravitational pull of a black hole is so strong that even light cannot escape it. Therefore, scientists cannot directly observe what happens inside a black hole.

Singularities: Black holes are thought to contain singularities, which are points in space where the laws of physics break down. The existence of singularities is a major limitation of our current understanding of physics, as it suggests that our current theories are incomplete or incorrect.

Theoretical challenges: The study of black holes involves combining two of the most successful theories in physics - general relativity and quantum mechanics. However, these two theories are fundamentally incompatible, and there is no agreed-upon framework for how to combine them in a consistent way. This makes it challenging to make accurate predictions about the behavior of black holes.

Lack of observational data: Despite their widespread theoretical interest, black holes are relatively rare and difficult to observe directly. This means that there is still much we do not know about their properties and behavior, which limits our ability to make accurate predictions and test theoretical models.

Overall, while **black hole physics** is a fascinating and important field of study, there are still many limitations and challenges that must be overcome in order to gain a deeper understanding of these enigmatic objects.

Albert Einstein presented his general theory of relativity in 1916, but for an entire century nobody could find physical proof of black holes. In 2016, scientists finally detected **gravitational waves** that emitted from two black holes colliding, proving that such weird things not only exists, but that **Einstein** was right all along. **Albert Einstein's general theory of relativity** suggests that the sun's gravity bends the path of light from distant stars. It's a testable prediction, but only during a total solar eclipse. If you fall into black hole, you will able to see both the Universe beginning and ending due to Time Dilation. Although the **Cosmic microwave background** is nearly uniform, there are tiny fluctuations in its temperature due to variations in the density of the early universe. These tiny fluctuations reveal the early stages of galactic structure formation. For **small black holes** whose Schwarzschild radius is much closer to the **singularity**, the tidal forces would kill even before the **astronaut** reaches the **event horizon**. Material, such as gas, dust and other stellar debris that approach the **black hole** prevent themselves from falling into it by forming a flattened band of spinning matter around the event horizon called the **accretion disk**. And since the spinning matter accelerates to tremendous speeds ($v \approx c$) by the huge gravity of the black hole the heat and powerful X-rays and gamma rays are released into the universe.

If we could peer into the fabric of **space-time** at the **Planck length** (the distance where the smoothness of relativity's space-time and the quantum nature of reality begin to rub up against each other), we would see the 4 dimensional fabric of **space-time** is simply the lowest energy state of the universe. It is neither empty nor uninteresting, and its energy is not necessarily zero (which was discovered by **Richard Dick Feynman**, a colorful character who worked at the California Institute of Technology and played the bongo drums at a strip joint down the road− for which he received Nobel Prize for physics in 1965). Because $\mathbf{E = mc^2}$, one can think that the virtual particle-antiparticle pairs of mass m are continually being created out of energy "E" of the 4 dimensional fabric of space-time consistent with the **Heisenberg's uncertainty principle of quantum**

mechanics (which tells us that from a microscopic vantage point there is a tremendous amount of activity and this activity gets increasingly agitated on ever smaller distance and time scales), and then, they appear together at some time, move apart, then come together and annihilate each other giving energy back to the space-time without violating the **law of energy conservation** (which has not changed in four hundred years and still appear in **relativity** and **quantum mechanics**). Spontaneous births and deaths of virtual particles so called **quantum fluctu**ations occurring everywhere, all the time − is the conclusion that **mass and energy are interconvertible**; they are two different forms of the same thing. However, spontaneous births and deaths of so called **virtual particles** can produce some remarkable problem, because infinite number of virtual pairs of mass "**m**" can be spontaneously created out of energy "E" of the 4 dimensional fabric of space-time, does the 4 dimensional fabric of **spacetime** bears an infinite amount of energy, therefore, by **Einstein's famous equation** $E = mc^2$, does it bears an infinite amount of mass. If so, according to **general relativity**, the **infinite amount of mass** would have curved up the universe to infinitely small size. But which obviously has not happened. Virtual particles play a crucial role in many areas of modern physics, including particle physics, condensed matter physics, and cosmology. They are also used in the development of new technologies, such as quantum computing and nanotechnology. The word "**virtual particles**" literally mean that these particles cannot be observed directly, but their indirect effects can be measured to a remarkable degree of accuracy. Their properties and consequences are well established and well understood consequences of **quantum mechanics** (which states that the position of a particle is uncertain, and therefore that there is some possibility that a particle will be within an energy barrier rather than outside of it. The process of moving from outside to inside without traversing the distance between is known as **quantum tunneling**, and it is very important for the fusion reactions in stars like the Sun). However, they can be materialized into real particles by several ways. All that one require an **energy = energy required to tear the pair apart + energy required to boost the separated virtual particle-antiparticles into real particles** (i.e., to bring them from virtual state to the materialize state).

When **Einstein** was 26 years old, he calculated precisely how energy must change if the **relativity principle** was correct, and he discovered the relation $E= mc^2$ (which led to the Manhattan Project and ultimately to the bombs that exploded over **Hiroshima and Nagasaki** in 1945). This is now probably the only equation in physics that even people with no background in physics have at least heard of this and are aware of its prodigious influence on the world we live in. And since c is constant **(because the maximum distance a light can travel in one second is 3×10^8 meter)**, this equation tells us that mass and energy are interconvertible and are two different forms of the same thing and are in fact equivalent. Suppose a **mass** "m" is converted into **energy** "E", the resulting energy carries mass = "m" and moves at the speed of light "c". Hence, **energy** E is defined by $E= mc^2$.

As we know c squared **(the speed of light multiplied by itself)** is an astronomically large number: **9 ×10^{16} meters square per second square**. So if we convert a small amount of mass, we'll get a tremendous amount of energy. **For example,** if we convert 1kg of mass, we'll get energy of 9 × 10^{16} Joules (i.e., the energy more than 1 million times the energy released in a chemical explosion). **Perhaps since c is not just the constant namely the maximum distance a light can travel in one second but rather a fundamental feature of the way space and time are married to form space-time**. One can think that in the presence of **unified space and time**, mass and energy are equivalent and interchangeable. But WHY? The question lingers, **unanswered. Until now**. The equation **$E=mc^2$** is a well-established principle that has been verified through numerous experiments and observations, and its accuracy is not in doubt. If, hypothetically, the equation $E=mc^2$ were wrong, it would mean that our understanding of the relationship between energy and mass would be fundamentally flawed. This could have far-reaching consequences for a wide range of scientific fields, including nuclear physics, astrophysics, and cosmology. In practical terms, if **$E=mc^2$** were found to be wrong, it would likely require a complete rethinking of our current models of the universe, energy production, and the behavior of matter. However, given the wealth of experimental evidence that supports the equation, it is highly unlikely that it could be proven wrong without a significant paradigm shift in the scientific understanding of the universe. The equation $E=mc^2$ is important for our understanding of the origins of the universe. According to the **Big Bang theory**, the universe began as a hot, dense soup of particles that were in **thermal equilibrium**. As the universe cooled, particles began to combine to form atoms, releasing vast amounts of energy in the process. This energy was in the form of radiation, and it eventually became the **cosmic microwave background radiation** that we can observe today. The equation $E=mc^2$ helps us to understand the relationship between mass and energy in the early universe, and how they were converted from one to the other during the formation of the cosmos. However, the equation $E = mc^2$ (where E is energy, m is mass, and c is the speed of light. People often employ this equation to calculate how much energy would be produced if, say, and a bit of matter was converted into pure electromagnetic radiation. **Because the speed of light is a large number, the answer is a lot—the weight of matter converted to energy in the bomb that destroyed the city of Hiroshima was less than one ounce**. But the equation also tells us that if the energy of an object increases, so does its mass, that is, its resistance to acceleration, or change in speed) has some remarkable consequences **(e.g. conversion of less than 1% of 2 pounds of uranium into energy was used in the atomic bomb over Hiroshima and body at rest still contains energy. When a body is moving, it carries an additional energy of motion called kinetic energy. In chemical and nuclear interactions, kinetic energy can be converted into rest energy, which is equivalent to generating mass. Also, the rest energy can be converted into kinetic energy. In that way, chemical and nuclear interactions can generate kinetic energy, which then can be used to run engines or blow things up).** Because $E = mc^2$, the energy which a body possess due to its motion will add to its rest mass. This effect is only really significant for bodies moving at speeds close to the speed of light. **For example,** at **10 percent of the speed of light** a body's mass $\mathbf{m = m_0} / (1 - v^2/c^2)^{1/2}$ is only 0.5 percent more than its rest mass m_0, while at 90 percent of the speed of light it would be more than twice its rest mass. And as an body approaches the speed of light, its mass raise ever more quickly, it acquire infinite mass and since an **infinite mass** cannot be accelerated any faster by any force, the issue of infinite mass remains an intractable problem. **For this reason all the bodies are forever confined by relativity to move at speeds slower than the speed of light.** Only tiny packets or particles of light (dubbed "photons" by chemist **Gilbert Lewis**) that have no intrinsic mass can move at the speed of light. There is **little disagreement** on this point. Now, being more advanced, we do not just consider conclusions like photons have no intrinsic mass. We constantly test them, trying to prove or disprove. So far, relativity has withstood every test. And try as we might, we can measure **no mass for the photon**. We can just put upper limits on what mass it can have. These upper limits are determined by the sensitivity of the experiment we are using to try to weigh the photon. The last number we can see that a photon, if it has any mass at all, must be less than $\mathbf{4 \times 10^{-48}}$ **grams**. For comparison, the electron has a mass of $\mathbf{9 \times 10^{-28}}$ **grams**. Moreover, if the mass of the photon is not considered to zero, then quantum mechanics would be in trouble. And it also an uphill task to conduct an experiment which proves the photon mass to be exactly zero. **Tachyons** the putative class of **hypothetical particles** (with negative mass: $\mathbf{m < 0}$) is believed to travel faster than the **speed of**

light. But, the existence of **tachyons** is still in question and if they exist, how can they be detected is still a? However, on one thing most physicists agree: **Just because we haven't found anything yet that can go faster than light doesn't mean that we won't one day have to eat our words. We should be more open minded to other possibilities that just may not have occurred to us**. Moreover, in expanding space − recession velocity keeps increasing with distance. Beyond a certain distance, known as the **Hubble distance**, it exceeds the velocity greater than the speed of light in vacuum. But, this is not a violation of relativity, because **recession velocity** is caused not by motion through space but by the expansion of space.

The **Planck equation**, also known as **Planck's law**, is a fundamental equation in physics that was first formulated by German physicist **Max Planck** in 1900 and has been extensively tested and confirmed by experimental measurements. E= hυ **(**which implies the energy a photon can have is proportional to its frequency: larger frequency **(shorter wavelength)** implies larger photon energy and smaller frequency (longer wavelength) implies smaller photon energy) – because h is constant, energy and frequency of the photon are equivalent and are different forms of the same thing. And since h − which is one of the most fundamental numbers in physics, ranking alongside the speed of light c and confines most of these radical departures from life-as- usual to the microscopic realm − is incredibly small **(i.e.,** 6×10^{-34} — a decimal point followed by 33 zeros and a 6 — of a joule second**)**, the frequency of the photon is always greater than its energy, so it would not take many quanta to radiate even ten thousand megawatts. And some say the only thing that **quantum mechanics** (the great intellectual achievement of the first half of this century) has going for it, in fact, is that it is unquestionably correct. Since the **Planck's constant** is almost infinitesimally small, quantum mechanics is for little things. The **Planck constant** is a key parameter in quantum mechanics, the **branch of physics** that describes the behavior of particles at the atomic and subatomic level. It is used to describe the wave-particle duality of matter, which is a fundamental concept in quantum mechanics. The Planck constant plays a critical role in energy quantization, which refers to the fact that energy is not continuous, but comes in discrete units. The **Planck constant** determines the size of these discrete energy units, which are known as quanta. If the Planck constant were larger, the size of these energy quanta would also increase, which could affect the energy levels of atoms and molecules. It is important to remember that the Planck constant is a very small constant, and any variations in its value are likely to have very intense effects on the behavior of particles and radiation. The **Planck constant** is related to the scale at which quantum effects become important. A change in the **Planck constant** could affect the size of quantum effects, such as the uncertainty principle, and could have implications for the behavior of particles and radiation at the atomic and subatomic level. Yet, the Planck constant is a fundamental constant of nature, and even slight variations in its value could have significant effects on our comprehension of the fundamental behavior of matter and energy.

Neutrinos are subatomic particles that are known for their ability to pass through matter with little or no interaction. They are one of the fundamental particles of the **Standard Model of particle physics**, alongside quarks, leptons, and gauge bosons. **Neutrinos** are electrically neutral, have very low mass, and interact only weakly with other particles. There are three types of neutrinos, known as **electron neutrinos**, **muon neutrinos**, and **tau neutrinos**, which are associated with the three charged leptons of the **Standard Model**. Neutrinos are produced in a variety of astrophysical and terrestrial processes, including nuclear reactions in stars, nuclear reactors, and particle accelerators. **Neutrinos** were first postulated by Wolfgang Pauli in 1930 to explain the apparent violation of energy conservation in nuclear beta decay. The first experimental evidence for **neutrinos** was obtained in the 1950s, and since then, many experiments have been conducted to study their properties. The study of **neutrinos** is an active area of research, and many experiments are underway to study their properties and behavior. **Neutrinos** are important not only for our understanding of the fundamental particles and forces of nature but also for their potential applications in fields such as astrophysics, nuclear physics, and particle physics. **Are Neutrinos Massless?** If not they could contribute significantly to the mass of the universe? Evidence of neutrino oscillations prove that neutrinos are not massless but instead have a mass less than one hundred-thousandth that of an electron. The work on atomic science in the first thirty five years of this century took our understanding down to lengths of a millionth of a millimeter. Then we discovered that protons and neutrons are made of even smaller particles called **quarks** (which were named by the Caltech physicist Murray Gell-Mann, who won the **Nobel Prize** in 1969 for his work on them). We might indeed expect to find several new layers of structure more basic than the **quarks and leptons** that we now regard as elemental particles. Are there elementary particles that have not yet been observed, and, if so, which ones are they and what are their properties? **What lies beyond the quarks and the leptons?** If we find answers to them, then the entire picture of particle physics would be quite different.

Experimental evidence supporting the **Watson and Crick model** was published in a series of five articles in the same issue of Nature – caused an explosion in biochemistry and transformed the science. Of these, **Franklin and Gosling's paper** was the first publication of their own x-ray diffraction data and original analysis method that partially supported the Watson and Crick model; this issue also contained an article on DNA **(a main family of polynucleotides in living cells)** structure by Maurice Wilkins and two of his colleagues, whose analysis supported their double-helix molecular model of DNA. In 1962, after **Franklin's death**, Watson, Crick, and Wilkins jointly received the Nobel Prize in Physiology or Medicine. From each gene's point of view, the 'background' genes are those with which it shares bodies in its journey down the generations. DNA **(deoxyribonucleic acid)** – which is known to occur in the chromosomes of all cells (whose coded characters spell out specific instructions for building willow trees that will shed a new generation of downy seeds). Most forms of life including vertebrates, reptiles, Craniates or suckling pigs, chimps and dogs and crocodiles and bats and cockroaches and humans and worms and dandelions, carry the amazing complexity of the information within the some kind of replicator − molecules called **DNA** in each cell of their body, that a live reading of that code at a rate of one letter per second would take thirty-one years, even if reading continued day and night. Just as protein molecules are chains of amino acids, so DNA molecules are chains of nucleotides. Linking the two chains in the DNA, are pairs of **nucleic acids** (purines + pyrimidines). There are four types of nucleic acid, adenine "A", cytosine "C", guanine "G", and thiamine "T." An **adenine** (purine) on one chain is always matched with a **thiamine** (pyrimidine) on the other chain, and a **guanine** (purine) with a **cytosine** (pyrimidine). Thus DNA exhibits all the properties of genetic material, such as replication, mutation and recombination. Hence, it is called the molecule of life. We need DNA to create enzymes in the cell, but we need enzymes to unzip the DNA. **Which came first, proteins or protein synthesis?** If proteins are needed to make proteins, how did the whole thing get started? We need precision genetic experiments to know for sure.

A **theory** is a good theory if it satisfies one requirement. It must make definite predictions about the results of future observations. Basically, all scientific theories are scientific statements that predict, explain, and perhaps describe the basic features of reality. Despite having received some great deal, discrepancies frequently lead to doubt and discomfort. For example, the most precise estimate of sun's age is around 10 million years, based on linear density model. But geologists have the evidence that the formation of the rocks, and the fossils in them, would have taken hundreds or thousands of millions of years. This is far longer than the age of the Earth, predicted by linear density model. Hence the earth existed even before the birth of the sun! Which is absolutely has no sense. **The linear density model therefore fails to account for the age of the sun. Any physical theory is always provisional, in the sense that it is only a hypothesis: it can be disproved by finding even a single observation that disagrees with the predictions of the theory.** Towards the end of the nineteenth century, physicists thought they were close to a complete understanding of the universe. They believed that entire universe was filled by a hypothetical medium called the ether. As a material medium is required for the propagation of waves, it was believed that light waves propagate through ether as the pressure waves propagate through air. Soon, however, inconsistencies with the idea of ether begin to appear. Yet a series of experiments failed to support this idea. The most careful and accurate experiments were carried out by two Americans: **Albert Michelson** and **Edward Morley** (who showed that light always traveled at a speed of one hundred and eighty six thousand miles a second (no matter where it came from) and disproved **Michell** and **Laplace's idea** of light as consisting of particles, rather like cannon balls, that could be slowed down by gravity, and made to fall back on the star) at the Case School of Applied Science in Cleveland, Ohio, in 1887 − which proved to be a serve blow to the existence of ether. All the known subatomic particles in the universe belong to one of two groups, **Fermions** or **bosons**. Fermions are particles with integer spin 1/2 and they make up ordinary matter. Their ground state energies are negative. Bosons are particles (whose ground state energies are positive) with integer spin 0, 1, 2 and they act as the force carriers between **fermions** (For example: The electromagnetic force of attraction between electron and a proton is pictured as being caused by the exchange of large numbers of virtual massless bosons of spin 1, called **photons**).

Positive ground state energy of bosons plus
negative ground state energy of fermions = 0

But Why? May be because to eliminate the biggest infinity in supergravity theory (the theory which introduced a superpartner to the conjectured subatomic particle with spin 2 that is the quanta of gravity **"the graviton"** (called the gravitino, meaning "little graviton," with spin 3/2) – that even inspired one of the most brilliant theoretical physicists since Einstein

"Stephen Hawking" to speak of "the end of theoretical physics" being in sight when he gave his inaugural lecture upon taking the Lucasian Chair of Mathematics at Cambridge University, the same chair once held by **Isaac Newton** – a person who developed the theory of mechanics, which gave us the classical laws governing machines which in turn, greatly accelerated the Industrial Revolution, which unleashed political forces that eventually overthrew the feudal dynasties of Europe)?

There is strong evidence ... that the universe is permeated with dark matter approximately six times as much as normal visible matter (i.e. invisible matter became apparent in 1933 by Swiss astronomer Fritz Zwicky – which can be considered to have energy, too, because $E = mc^2$ – exist in a huge halo around galaxies and does not participate in the processes of nuclear fusion that powers stars, does not give off light and does not interact with light but bend starlight due to its gravity, somewhat similar to the way glass bends light). Although we live in a dark matter dominated universe (i.e., dark matter, according to the latest data, makes up 23 percent of the total matter or energy content of the universe) experiments to detect dark matter in the laboratory have been exceedingly difficult to perform because dark matter particles such as the neutralino, which represent higher vibrations of the superstring – interact so weakly with ordinary matter. Although dark matter was discovered almost a century ago, it is still a mystery shining on library shelves that everyone yearns to resolve.

Opening up the splendor of the **immense heavens** for the first time to serious scientific investigation. On the short time scale of our lives, not surprisingly, we underwent many transformations in our slow, painful evolution, an evolution often overshadowed by religious dogma and superstition to seek the answer to the question from the beginnings of our understanding. No progress was made in any scientific explanations because the experimental data were non-existent and there were no theoretical foundations that could be applied. In the latter half of the 20th century, there were several attempts such as quantum mechanics **(the theory of subatomic physics and is one of the most successful theories of all time which is based on three principles: (1) energy is found in discrete packets called quanta; (2) matter is based on point particles but the probability of finding them is given by a wave, which obeys the Schrödinger wave equation; (3) a measurement is necessary to collapse the wave and determine the final state of an object)**, the "big bang," probability theory, the **general relativity** (a theoretical framework of geometry which has been verified experimentally to better than **99.7** percent accuracy and predicts that the curvature of space-time gives the illusion that there is a force of attraction called **gravity**) to adjust to ensure agreement with experimental measurements and answer the questions that have so long occupied the mind of philosophers (from **Aristotle** to **Kant**) and scientists. However, we must admit that there is ignorance on some issues, for example, "we don't have a complete theory of universe which could form a framework for stitching these insights together into a seamless whole – **capable of describing all phenomena**…. We are not sure exactly how universe happened."

However, the generally **accepted history of the universe**, according to what is so-called the **big bang theory** (proposed by a Belgian priest, **Georges Lemaître**, who learned of **Einstein's theory** and was fascinated by the idea that the theory logically led to a universe that was expanding and therefore had a beginning) has completely changed the discussion of the origin of the universe from almost pure speculation to an observational subject. In such model one finds that our **universe** started with an explosion. This was not any ordinary explosion as might occur today, which would have a point of origin **(center)** and would spread out from that point. The explosion occurred simultaneously everywhere, filling all space with infinite heat and energy. At this time, order and structure were just beginning to emerge – the universe was hotter and denser than anything we can imagine (at such temperatures and densities **(of about a trillion trillion trillion trillion trillion trillion (1 with 72 zeros after it) tons per cubic inch)** gravity and quantum mechanics were no longer treated as two separate entities as they were in point-particle quantum field theory, the four known forces were unified as one unified super force) and was very rapidly expanding much faster than the speed of light (this did not violate Einstein's dictum that nothing can travel faster than light, because it was empty space that was expanding) and cooling in a way consistent with **Einstein field equations**. As the universe was expanding, the temperature was decreasing.

Since the temperature was decreasing, the universe was cooling and its curvature energy was converted into matter like a formless water vapor freezes into snowflakes whose unique patterns arise from a combination of symmetry and randomness. Approximately 10^{-37} seconds into the expansion, a **phase transition caused a cosmic inflation**, during which the universe underwent an incredible amount of superliminal expansion and grew exponentially by a factor e^{3Ht} **(where H was a constant called Hubble parameter and t was the time)** – just as the prices grew by a factor of ten million in a period of 18 months in Germany after the **First World War** and it doubled in size every tiny fraction of a second – just as prices double every year in certain countries. After inflation stopped, the universe was not in a **de Sitter phase** and its **rate of expansion** was no longer proportional to its volume since H was no longer constant. At that time, the entire universe had grown by an unimaginable factor of 10^{50} and consisted of a hot plasma "soup" of high energetic quarks as well as leptons **(a group of particles which interacted with each other by exchanging new particles called the W and Z bosons as well as photons)**. And quarks and gluons were "deconfined" and free to move over distances much larger than the hadron size (>>1 fm) in a soup called **quark gluon plasma** (QGP). There were a number of different varieties of quarks: there were six "flavors," which we now call up, down, strange, charmed, bottom, and top. And among the **leptons** the electron was a stable object and **muon** (that had mass 207 times larger than electron and now belongs to the second redundant generation of particles found in the **Standard Model**) and the

tauon (that had mass 3,490 times the mass of the electron) were allowed to decay into other particles. And associated to each charged lepton, there were three distinct kinds of ghostly particles called **neutrinos** (the most mysterious of subatomic particles, are difficult to detect because they rarely interact with other forms of matter. Although they can easily pass through a planet or solid walls, they seldom leave a trace of their existence. Evidence of neutrino oscillations prove that neutrinos are not massless but instead have a mass less than one- hundred-thousandth that of an electron):

The electron neutrino (which was predicted in the early 1930s by Wolfgang Pauli and discovered by Frederick Reines and Clyde Cowan in mid-1950s)
The muon neutrino (which was discovered by physicists when studying the cosmic rays in late 1930s)
The tauon neutrino (a heavier cousin of the electron neutrino)

Gluons → excitations of the strong field

Photons → excitations of the electromagnetic field

Temperatures were so high that these quarks and leptons were moving around so fast that they escaped any attraction toward each other due to nuclear or electromagnetic forces. However, they possessed so much energy that whenever they collided, particle – antiparticle pairs of all kinds were being continuously created and destroyed in collisions. And the uncertainty in the position of the particle times the uncertainty in its velocity times the mass of the particle was never smaller than a certain quantity, which was known as Planck's constant. Similarly, $\Delta E \times \Delta t$ was $\geq h / 4\pi$ (where h was a quantity called Planck's constant and $\pi = 3.14159...$ was the familiar ratio of the circumference of a circle to its diameter). Hence the Heisenberg's uncertainty principle (which captures the heart of quantum mechanics – i.e. features normally thought of as being so basic as to be beyond question **(e.g. that objects have definite positions and speeds and that they have definite energies at definite moments)** are now seen as mere artifacts of Planck's constant being so tiny on the scales of the everyday world) was a fundamental, inescapable property of the universe. At some point an unknown reaction led to a very small excess of quarks and leptons over antiquarks and antileptons − of the order of one part in 30 million. This resulted in the predominance of matter over antimatter in the universe. The universe continued to decrease in density and fall in temperature, hence the typical energy of each particle was decreased in inverse proportion to the size of the universe (since the average energy – or speed – of the particles was simply a measure of the temperature of the universe). The symmetry (a central part of the theory [and] its experimental confirmation would be a compelling, albeit circumstantial, piece of evidence for strings) however, was unstable and, as the universe cooled, a process called **spontaneous symmetry breaking phase transitions** placed the fundamental forces of physics and the parameters of elementary particles into their present form. After about 10^{-11} seconds, the picture becomes less speculative, since particle energies drop to values that can be attained in **particle physics** experiments. At about 10^{-6} seconds, there was a continuous exchange of smallest constituents of the strong force called gluons between the quarks and this resulted in a force that pulled the quarks to form little wisps of matter which obeys the strong interactions and makes up only a tiny fraction of the matter in the universe and is dwarfed by **dark matter** called the **baryons** (protons – a positively charged particles very similar to the neutrons, which accounts for roughly half the particles in the nucleus of most atoms − and neutrons – a neutral subatomic particles which, along with the protons, makes up the nuclei of atoms – belonged to the class baryons) as well as other particles. The small excess of quarks over antiquarks led to a small excess of baryons over antibaryons. The **proton** was composed of two up quarks and one down quark and the neutron was composed of two down quarks and one up quark. And other particles contained other quarks **(strange, charmed, bottom, and top),** but these all had a much greater mass and decayed very rapidly into protons and neutrons. The charge on the up quark was = + 2/3 e and the charge on the down quark was = – 1/3 e. The other quarks possessed charges of + 2/3 e or – 1/3 e. The charges of the quarks added up in the combination that composed the proton but cancelled out in the combination that composed the neutron i.e.,

Proton charge was = (2/3 e) + (2/3 e) + (– 1/3 e) = e

Neutron charge was = (2/3 e) + (– 1/3 e) + (– 1/3 e) = 0

And the force that confined the rest mass energy of the proton or the neutron to its radius was so strong that it is now proved very difficult if not impossible to obtain an isolated quark. As we try to pull them out of the proton or neutron it gets more and more difficult. Even stranger is the suggestion that the harder and harder if we could drag a quark out of a proton this force gets bigger and bigger – rather like the force in a spring as it is stretched causing the quark to snap back immediately to its original position. This **property of confinement** prevented one from observing an isolated quark **(and the question of whether it makes sense to say quarks really exist if we can never isolate one was a controversial issue in the years after the quark model was first proposed)**. However, now it has been revealed that experiments with large particle accelerators indicate that at high energies the strong force becomes much weaker, and one can observe an isolated quark. In fact, the **standard model** (one of the most successful physical theories of all time and since it fails to account for gravity **(and seems so ugly)**, theoretical physicists feel it cannot be the final theory) in its current form requires that the quarks not be free. The observation of a free quark would falsify that aspect of the standard model, although nicely confirm the quark idea itself and fits all the experimental data concerning particle physics without exception. Each quark possessed **baryon number** = 1/3: the total baryon number of the proton or the neutron was the sum of the baryon numbers of the quarks from which it was composed. And the electrons and neutrinos contained no quarks; they were themselves truly **fundamental particles**. And since there were no electrically charged particles lighter than an electron and a proton, the electrons and protons were prevented from decaying into lighter particles – such as photons **(that carried zero mass, zero charge, a definite energy E = pc and a momentum p = mc)** and less **massive neutrinos** (with very little mass, no electric charge, and no radius — and, adding insult to injury, no strong force acted on it). And a free neutron being heavier than the proton was not prevented from decaying into a proton **(plus an electron and an antineutrino)**. The temperature was now no longer high enough to create new proton– antiproton pairs, so a mass annihilation immediately followed, leaving just one in 10^{10} of the original protons and neutrons, and none of their antiparticles **i.e.,** antiparticle was sort of the reverse of matter particle. The counterparts of electrons were positrons **(positively charged)**, and the counterparts of protons were antiprotons **(negatively charged)**. Even neutrons had an antiparticle: antineutrons. A similar process happened at about 1 second for electrons and positrons **(positron: the antiparticle of an electron with exactly the same mass as an electron but its electric charge is +1e)**. After these annihilations, the remaining protons, neutrons and electrons were no longer moving relativistically and the energy density of the universe was dominated by photons − **(what are sometimes referred to as the messenger particles for the electromagnetic force)** − with a minor contribution from neutrinos. The density of the universe was about 4×10^9 times the density of water and much hotter than the **center of even the hottest star** – no ordinary components of matter as we know them – molecules, atoms, nuclei – could hold together at this temperature. And the total positive charge due to protons plus the total negative charge due to electrons in the universe was = 0 **(Just what it was if electromagnetism would not dominate over gravity and for the universe to remain electrically neutral)**.

And a few minutes into the expansion, when the temperature was about a billion **(one thousand million; 10^9)** Kelvin and the density was about that of air, protons and neutrons no longer had sufficient energy to escape the attraction of the strong nuclear force and they started to combine together to produce the universe's deuterium and helium nuclei in a process called **Big Bang nucleosynthesis**. And most of the protons remained uncombined as hydrogen nuclei. And inside the tiny core of an atom, consisting of protons and neutrons, which was roughly 10^{-13} cm across or roughly an angstrom, a proton was never permanently a proton and also a neutron was never permanently a neutron. They kept on changing into each other. A neutron emitted a π meson (a particle predicted by **Hideki Yukawa** **(for which he was awarded the Nobel Prize in physics in 1949)** – composed of a quark and antiquark, which is unstable because the quark and antiquark can annihilate each other, producing electrons and other particles) and became proton and a proton absorbed a **π meson** and became a neutron. That is, the exchange force resulted due to the absorption and emission of π mesons kept the protons and neutrons bound in the nucleus. And the time in which the absorption and emission of **π mesons** took place was so small that π mesons were not detected. And a property of the strong force called

asymptotic freedom caused it to become weaker at short distances. Hence, although quarks were bound in nuclei by the strong force, they moved within nuclei almost as if they felt no force at all.

Within only a few hours of the big bang, the **Big Bang nucleosynthesis** stopped. And after that, for the next million years or so, the universe just continued expanding, without anything much happening. Eventually, once the temperature had dropped to a few thousand degrees, there was a continuous exchange of virtual photons between the nuclei and the electrons. And the exchange was good enough to produce — what else? — A force **(proportional to a quantity called their charge and inversely proportional to the square of the distance between them)**. And that force pulled the electrons towards the nuclei to form neutral atoms (the basic unit of ordinary matter, made up of a tiny nucleus **(consisting of protons and neutrons)** surrounded by orbiting electrons). And these atoms reflected, absorbed, and scattered light and the resulted light was red shifted by the expansion of the universe towards the microwave region of the electromagnetic spectrum. And there was cosmic microwave background radiation **(which, through the last 15 billion years of cosmic expansion, has now cooled to a mere handful of degrees above absolute zero** (–273^{o}C − the lowest possible temperature, at which substances contain no heat energy and all vibrations stop − almost: the water molecules are as fixed in their equilibrium positions as quantum uncertainty allows) **and**

today, scientists measure tiny deviations within this background radiation to provide evidence for inflation or other theories).

The irregularities in the universe meant that some regions of the nearly uniformly distributed atoms had slightly higher density than others. The gravitational attraction of the extra density slowed the expansion of the region, and eventually caused the region to collapse to form galaxies and stars. And the nuclear reactions in the stars transformed hydrogen to helium (composed of two protons and two neutrons and **symbolized by $_2He^4$,** highly stable—as predicted by the rules of quantum mechanics) to carbon **(with their self- bonding properties, provide the immense variety for the complex cellular machinery — no other element offers a comparable range of possibilities)** with the release of an enormous amount of energy via **Einstein's equation** $E = mc^2$. This was the energy that lighted up the stars. And the process continued converting the carbon to oxygen to silicon to iron. And the **nuclear reaction** ceased at iron. And the star experienced several chemical changes in its innermost core and these changes required huge amount of energy which was supplied by the severe **gravitational contraction**. And as a result the central region of the star collapsed to form a **neutron star**. And the outer region of the star got blown off in a powerful and catastrophic explosion called a supernova, which outshone an entire galaxy of **100 billion stars**, spraying the manufactured elements into space. It was one of the most energetic events in the universe and released more energy in a few seconds than the sun would emit over its entire lifetime. And these elements provided some of the raw material for the generation of cloud of rotating gas which went to form the sun and a small amount of the heavier elements collected together to form the asteroids, stars, comets, and the bodies that now orbit the sun as planets like the Earth and their presence caused the fabric of space around them to warp **(more massive the bodies, the greater the distortion it caused in the surrounding space)**.

The earth was initially very hot and without an atmosphere. In the course of time the planet earth produced **volcanoes** and the volcanoes emitted water vapor, carbon dioxide and other gases. And there was an **atmosphere**. This early atmosphere contained no oxygen, but a lot of other gases and among them some were poisonous, such as hydrogen sulfide **(the gas that gives rotten eggs their smell)**. And the sunlight dissociated water vapor and there was oxygen. And carbon dioxide in excess heated the earth and balance was needed. So carbon dioxide dissolved to form carbonic acid and carbonic acid on rocks produced limestone and subducted limestone fed volcanoes that released more carbon dioxide. And there was high temperature and high temperature meant more evaporation and dissolved more carbon dioxide. And as the carbon dioxide turned into limestone, the temperature began to fall. And a consequence of this was that most of the water vapor condensed and formed the oceans. And the low temperature meant less evaporation and carbon dioxide began to build up in the atmosphere. And the cycle went on for **billions of years**. And after the few billion years, volcanoes ceased to exist. And the molten earth cooled, forming a hardened, outer crust. And the earth's atmosphere consisted of nitrogen, oxygen, carbon dioxide, plus other miscellaneous gases **(hydrogen sulfide, methane, water vapor, and ammonia)**. And then a continuous electric current through the atmosphere simulated lightning storms. And some of the gases came to be arranged in the form of more complex organic molecules such as simple **amino acids** (**the basic chemical subunit of proteins, when, when linked together, formed proteins**) and **carbohydrates** (**which were very simple sugars**). And the water vapor in the atmosphere probably caused millions of seconds of torrential rains, during which the organic molecules reached the earth. And it took two and a **half billion years** for an ooze of organic molecules to react and built earliest cells as a result of chance combinations of atoms into large structures called **macromolecules** and then advance to a wide variety of one – celled organisms, and another billion years to evolve through a highly sophisticated form of life to primitive mammals endowed with two elements: **genes (a set of instructions that tell them how to sustain and multiply themselves)**, and **metabolism (a mechanism to carry out the instructions)**. But then evolution seemed to have speeded up. It only took about a hundred million years to develop from the early mammals (the highest class of animals, including the ordinary hairy quadrupeds, the whales and Mammoths, and characterized by the production of living young which are nourished after birth by milk from the teats (**MAMMAE, MAMMARY GLANDS**) of the mother) to Homosapiens. This picture of a universe that started off very hot and cooled as it expanded **(like when things are compressed they heat up ... and, when things ... expand ... they cool down)** is in agreement with all the observational evidence which we have today (and it explains **Olbers' paradox:** The **paradox** that asks why the night sky is black. If the universe is infinite and uniform, then we must receive light from an infinite number of stars, and hence the sky must be white, which violates observation). Nevertheless, it leaves a number of important questions unanswered: Why the universe started off very hot i.e., **why it violently emerged from a state of infinite compression?** Why is the universe the same everywhere i.e., looks the same from every point **(homogeneous)** and looks the same in every direction **(isotropic)**? If the cosmic inflation made the universe flat, homogeneous and isotropic, then what is the hypothetical field that powered the inflation? **What are the details of this inflation?**

Much is explained by **protons and electrons**. But there remains the neutrino…

$\approx 10^9$ neutrinos / proton. What is their physical picture in the universe?

What is our physical place in the universe?

Present 13.8 billion years after the **Big Bang**, the universe has undergone a vast series of changes and transformations. In the first few minutes after the Big Bang, the universe was hot and dense plasma of subatomic particles, consisting mainly of protons, neutrons, and electrons. Over time, as the universe cooled and expanded, these particles combined to form atoms, which eventually led to the formation of stars and galaxies. Around 380,000 years after the Big Bang, the universe had cooled enough for atoms to form, and the cosmic microwave background radiation was released. This radiation is still visible today and is one of the key pieces of evidence supporting the Big Bang theory. Over the next several billion years, the universe continued to evolve, with the formation of stars, galaxies, and clusters of galaxies. Along the way, there were major events such as the formation of the first stars, the reionization of the universe, and the emergence of dark matter and dark energy. In more recent times, the universe has continued to expand at an accelerating rate, driven by the mysterious force of dark energy. Observations from telescopes and experiments such as the cosmic microwave background have provided us with a wealth of information about the history and composition of the universe, but there are still a lot of unanswered questions. Today, the universe is still expanding, and it is estimated to contain billions of galaxies, each consists of countless stars, dust, gas, planets, and other celestial bodies, many of which are still waiting to be discovered and explored.

The **big bang theory**, on its own, cannot explain these features or answer these questions because of its prediction that the universe started off with infinite density at the **big bang singularity**. At the **singularity (a state of infinite gravity)**, all the known **physical laws of cosmology** would break down: one couldn't predict what would come out of the infinitely dense Planck-sized nugget called the singularity. The search for the origin and fate of the universe (which is determined by whether the **Omega (Ω_0)** density parameter is less than, equal to or greater than 1) is a distinctly human drama, one that has stretched the mind and enriched the spirit. We **(a species ruled by all sorts of closer, warmer, ambitions and perceptions)** are all, each in our own way, seekers of an absolute limit of scientific explanation **(that may never be achieved)** and we each long for an answer to why we exist... as our future descendants marvels at our new view of the universe ... we are... contributing our wrong to the human letter reaching for the stars. In the millennia of Homo sapiens evolution, we have found it something quite . . . puzzling. Even that great Jewish scientist **Albert Einstein** (**who freed us from the superstition of the past and interpreted the constancy of the speed of light as a universal principle of nature that contradicted Newtonian theory**) sustained a mystical outlook on the universe that was, he said, constantly renewed from the wonder and humility that filled him when he gazed at the universe. I wonder, can our finite minds ever truly understand such things as mysticism and infinity?

Flatness problem: Why is the density in the Universe almost critical?

Horizon problem: Why is the large scale of the Universe so smooth?

The universe is a pretty big place seems like an awful waste of space.

Nearest star: 4.22 light years.

Nearest galaxy: 2.44 million light years.

Galaxies within our horizon are now 40 billion light years away.

Universe beyond horizon: 10 to the 10 to the 100 times bigger.

The Goldilocks Planet is not all that well suited for human life.

2/3 salt water unfit for drinking.

Humans are restricted only to surface.

Atmosphere does not block harmful ultraviolet radiation which causes skin cancer and other genetic disorders.

Natural calamities like floods, earthquakes, famine and droughts, diseases like cancer, AIDS, kill millions millions of people yearly.

Only two photons of every billion emitted by sun are used to warm the Earth surface, the rest radiating uselessly into space. And lack of oxygen and cosmic microwave background radiation (which is well characterized by a (2.728 ± 0.002) Kelvin black body spectrum over more than three decades in frequency) prevents humans from spending years in outer space.

The **fine-tuning coincidences** refer to the observation that certain fundamental constants and physical parameters of the universe appear to be finely tuned to allow for the existence of life as we know it. In other words, if these values were even slightly different, life may not have been able to exist in the universe. **For example,** if the strength of the strong nuclear force, which binds protons and neutrons together in the nucleus of an atom, were just slightly weaker or stronger, then elements essential for life, such as carbon and oxygen, may not be able to form. Similarly, if the **mass of the electron** were different, the stability of atoms and molecules could be affected, and life may not be able to exist. The fine tuning coincidences are updated and refurbished and have been somewhat misleadingly categorized under the designation anthropic principle, a term coined by astronomer **Brandon Carter** in 1974 – which states that the physical properties of the universe are as they are because they permit the emergence of life. This **teleological principle** tries to explain why some physical properties of matter seem so fine-tuned as to permit the existence of life − and are widely claimed to provide prima facie evidence for purposeful design − a design with life and perhaps humanity in mind. However, **fine tuning coincidences** are only needed to fill in the details of evidence for the existence of insulated interpositions of Divine power. If the universe were congenial to human life, then we would expect it to be easy for humanlike life to develop and survive throughout the vast stretches of the universe **(an intricately complex place)**. We must admit that much of what we believe, including our fundamental coincidences about the universe is a blind leap of faith. We, after all, **carbon-based biological systems** operating a billion times slower than computer chips made of silicon, can carry the implications of the illusion of intelligent design about as far as we can imagine we could go − classifying as an argument from design is the contemporary claim that the laws and constants of physics are **"fine-tuned"** so that the universe is able to contain life – which is commonly -- have been publicized in the popular print media, featured in television specials on **PBS and BBC**, and disseminated through a wide variety of popular and scholarly books, including entries from prestigious academic publishing houses such as **Oxford and Cambridge University Presses** -- but misleading. Furthermore, blind faith can justify anything and we have no reason to conclude that earthlike planets and sun-like stars and life itself are far too complex to have arisen by coincidence or could not have had a purely accidental origin because astrobiologists have now demonstrated that captured material from a comet - analyzed immediately after striking **Earth** so that effects of contamination by earthly matter are minimal- possessed lysine, an amino acid, in the sample, suggesting that the evolution of life on **Earth** had only begun after accidental jump-start from space i.e., the first ingredients of life accidently came from space after Earth formed. The fact that the universe seems to be fine-tuned for life has led some to propose the idea of a **"cosmic designer"** or a **"multiverse"** with countless other universes, each with different physical constants and laws, with ours just happening to be the one in which life is possible. However, these ideas are speculative and have not been conclusively proven. It is worth noting that some scientists argue that the fine-tuning coincidences may not be as surprising as they seem, as the universe may have gone through a process of natural selection, in which only the conditions that allow for life to exist could arise. Others suggest that the apparent fine-tuning may be an artifact of our limited understanding of the underlying physics of the universe. Overall, the **fine-tuning coincidences** remain a topic of debate and active research in cosmology and the philosophy of science.

LONG STANDING QUESTIONS

◆ ◆ ◆

Are there undiscovered principles of nature: new symmetries, new physical laws?

How can we solve the mystery of dark energy? Are dark energy and the Higgs field related?

What are neutrinos telling us? Is dark matter is made up of weakly interacting massive particles **(something like heavy versions of the neutrinos)**?

What is dark matter? How can we make it in the laboratory?

Why are there so many kinds of particles? **Why the Higgs exists and who its cosmological cousins are?**

Which particles are travelers in extra dimensions, and what are their locations within them? Is our Universe part of a Multiverse?

How did the universe come to be? What happened to the antimatter? What do we learn about the early Universe from experiments at the LHC? **Can precise measures of the distribution of galaxies and Dark Matter unveil the nature of Dark Matter or Dark Energy?**

Why there is missing energy from a weakly interacting heavy particle? Is the direct discovery of the effects of extra dimensions or a new source of matter- antimatter asymmetry possible? An all-embracing theory of physics that unifies quantum mechanics **(which applies to the very small: atoms, subatomic particles and the forces between them)** and general relativity **(which applies to the very large: stars, galaxies and gravity, the driving force of the cosmos)** would solve the problem of describing everything in the universe from the big bang to subatomic particles? Our leading candidate for a theory of everything is known as M-theory. It grew from a merger of the two seemingly different approaches: 11-dimensional supergravity and 10-dimensional superstring theory. **Could this be the final theory of everything?** What do observations of galaxies at early times tell us about how galaxies were made?

Mapping the dark universe

PROFILING THE INVISIBLE

Is Cosmology about to SNAP?

Or does it explain everything about the universe?

While there may be many **challenges and mysteries** that remain to be solved in our understanding of the universe, many people find great wonder and beauty in the cosmos and consider it a source of inspiration and awe. To answer the most challenging questions about the nature of the universe and led down open doors into new insights and findings, all the approaches must converge. Results from accelerator experiments at **LHC** must agree with most powerful and insightful **astrophysical observations and results** from sophisticated data. However, the experiments necessary to go beyond the existing knowledge of **standard physics** are rapidly becoming prohibitively expensive and time consuming and the macroscopic experiments are difficult to perform in the laboratory as subatomic reactions at the incredible energy scale of **10^9 GeV** − which is far beyond the range of our largest particle accelerators and it is the biggest embarrassment in all of modern physics and if you listen closely, you can almost hear the dreams of **physicists** everywhere being **shattered**. Physics is an essential tool for understanding the greatest questions in cosmology, and many cosmological questions have already been answered through the application of physical principles. For example, the discovery of the **cosmic microwave background radiation** provided strong evidence for the **Big Bang theory**, which is now the leading explanation for the origin and evolution of the universe. Other cosmological questions that physics has helped to answer include the nature of dark matter and the large-scale structure of the universe. However, there are still many unanswered questions in cosmology, and it is not yet clear whether physics alone will be able to solve all of them. **For example, the nature of dark energy, which is thought to be responsible for the accelerating expansion of the universe, remains a mystery, and physicists are currently working to develop new models and theories to explain it.** Moreover, some of the greatest questions in cosmology are philosophical or conceptual in nature, such as the nature of time or the existence of a **multiverse**. While physics can provide insights into these questions, they may ultimately require a more interdisciplinary approach that incorporates insights from philosophy, mathematics, and other fields. Overall, while **physics** has made great strides in understanding the cosmos, there is still much that we do not know, and the quest to answer the greatest questions in cosmology will likely require continued collaboration and innovation across multiple disciplines.

◆ ◆ ◆

CHAPTER 3

Our Mathematical Universe

"But the creative principle resides in mathematics. In a certain sense, therefore, I hold it true that pure thought can grasp reality, as the ancients dreamed."

— Albert Einstein

We Humans, a curious beings developed from the Darwin's principle of natural selection, are accustomed into an inquisition. The question is not 'do we know everything from the triumph of the **Higgs boson** to the underlying discomfort of ultimate question of life, the universe, and everything?' or it is 'do we know enough?' **But how the creative principle resides in mathematics?** There's something very mathematical about our gigantic Cosmos, and that the more carefully we look, the more equations are built into nature: From basic arithmetic to the calculation of **rocket trajectories**, math provides a good understanding of the equations that govern the world around us. Our universe isn't just described by math, but that universe is a **"grand book"** written in the language of mathematics. We find it very appropriate that mathematics has played a striking role in our growing understanding of the events around us, and of our own existence. The mathematical universe hypothesisis a philosophical and scientific theory that proposes that the universe is not just described by **mathematics**, but actually is mathematics. In other words, the hypothesis asserts that the universe is a mathematical structure, and that all physical phenomena can be described in terms of mathematical equations and formulas. The theory has its roots in the ancient Greek philosophical tradition, particularly in the work of **Pythagoras** and **Plato**, who believed that the universe was fundamentally mathematical in nature. In more recent times, the hypothesis has been developed and expanded upon by several modern thinkers, including the physicist **Max Tegmark**. According to the **mathematical universe hypothesis**, the universe is not just described by mathematical concepts and formulas, but is, in fact, a mathematical structure. This means that the physical world that we observe is simply one aspect of a much larger **mathematical structure** that exists beyond our perception. **Proponents of the hypothesis** argue that it provides a simple and elegant explanation for the apparent order and regularity that we observe in the universe. They also point out that mathematics is a powerful tool for predicting and describing **physical phenomena**, which suggests that there is a deep connection between mathematics and the physical world. However, critics of the hypothesis argue that it is more of a **philosophical idea** than a scientific theory, and that there is no evidence to support the claim that the universe is a **mathematical structure**. They also point out that the hypothesis raises many questions about the nature of mathematics and its relationship to the physical world. While the **mathematical universe** hypothesis remains controversial, it continues to be a topic of debate and discussion among philosophers, mathematicians, and physicists. Some argue that the hypothesis may have implications for our understanding of the nature of reality and the role of **human consciousness** in the universe. However, much more research and investigation will be needed before we can fully understand the implications of this intriguing idea.

Laws Of Universe:

> "You cannot get something for nothing because matter and energy are conserved.
>
> You cannot return to the same energy state because there is always an increase in entropy.
>
> Absolute zero is unattainable."

The **laws of the universe** are the fundamental physical principles that govern the behavior of matter and energy in the universe. These laws describe the behavior of everything from **subatomic particles** to **galaxies** and beyond. Here are some of the most important laws of the universe:

The law of conservation of energy: Energy can neither be created nor destroyed, but can only be transformed from one form to another.

The law of conservation of mass: Mass can neither be created nor destroyed, but can only be transformed from one form to another.

The laws of thermodynamics: These laws govern the behavior of energy in systems, and describe the relationships between temperature, heat, and work.

Newton's laws of motion: These laws describe the relationship between force, mass, and acceleration, and form the basis of classical mechanics.

The law of gravitation: This law describes the gravitational force between objects, and is fundamental to our understanding of the motion of planets, stars, and galaxies.

The laws of electromagnetism: These laws describe the behavior of electric and magnetic fields, and form the basis of our understanding of electronics, electromechanical devices, and the behavior of light.

The laws of quantum mechanics: These laws describe the behavior of matter and energy at the atomic and subatomic level, and are essential to our understanding of modern physics.

These are just a few of the many laws that govern the **behavior of the universe**. Understanding and applying these laws has allowed us to develop technologies and tools that have transformed our lives and our understanding of the world around us.

Equivalence Principle:

> "The laws of nature in an accelerating frame are equivalent to the laws in a gravitational field."

The **Equivalence Principle** is a fundamental principle in physics that states that the effects of gravity are indistinguishable from the effects of acceleration. In other words, if you are in a box that is being accelerated upward at a constant rate, it would be impossible for you to tell whether you are experiencing the effects of gravity or the effects of the acceleration. The Equivalence Principle was first proposed by Albert Einstein as part of his theory of General Relativity. According to this theory, gravity is not a force that acts between objects, as in **Newtonian physics**, but rather a curvature of spacetime caused by the presence of mass and energy. The **Equivalence Principle** has several important implications in physics. For example, it implies that the acceleration of an object due to gravity is independent of its mass or composition. This was demonstrated by **Galileo** in the 16th century, when he dropped objects of different masses from the Leaning Tower of Pisa and observed that they fell at the same rate. The **Equivalence Principle** also implies that light is affected by gravity in the same way as matter. This was confirmed by the observation of **gravitational lensing**, in which the path of light is bent by the curvature of spacetime near massive objects. Overall, the **Equivalence Principle** is a key principle in our understanding of gravity and the behavior of matter and energy in the universe.

Geometry → field theory → classical theory → quantum theory

Newton's Laws Of Motion:

Three fundamental laws, known as Newton's laws of motion, govern how moving objects behave. They were first formulated by **Sir Isaac Newton** in the 17th century, and they form the basis of classical mechanics. **Newton's laws of motion tie into almost everything we see in everyday life:**

> **Law 1 (the Law of Inertia):** An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted uponby an unbalanced force.
>
> **Law 2 (the Law of Force and Acceleration) :** Force equals mass times acceleration (F = ma).
>
> **Law 3 (the Law of Action and Reaction) :** For every action, there is an equal and opposite reaction.

These **three laws** provide a framework for understanding the behavior of objects in motion and the relationships between force, mass, and acceleration. They are used to describe everything from the motion of planets and stars to the behavior of everyday objects like cars and bicycles. **Newton's laws of motion** are still widely used today, and they have been expanded and refined by subsequent physicists and mathematicians. They form the foundation of **classical mechanics**, which is essential to our understanding of the physical world. While **Newton's laws of motion** are fundamental principles of classical mechanics that have been widely applied in physics, there are certain circumstances in which they may not hold true. Here are some examples of the **failures of Newton's laws of motion**:

High-speed motion: At very high speeds approaching the speed of light, the laws of motion fail to accurately describe the motion of objects. In this regime, Einstein's theory of relativity is required.

Very small particles: At the subatomic level, the behavior of particles is governed by quantum mechanics, which behaves differently than classical mechanics. Quantum mechanics provides more accurate predictions for the motion of these particles.

Non-inertial reference frames: Newton's laws of motion only hold true in inertial reference frames, where there are no external forces acting on the system. In non-inertial reference frames, such as a rotating reference frame, fictitious forces arise, which do not obey Newton's laws.

Strong gravitational fields: In strong gravitational fields, such as those near a black hole, the behavior of objects is governed by Einstein's theory of general relativity, which predicts the curvature of spacetime.

Electrodynamic forces: The behavior of charged particles, such as electrons and protons, is governed by electromagnetic forces. These forces are not described by Newton's laws of motion, but by the laws of electrodynamics.

Nuclear forces: The behavior of particles within the atomic nucleus is governed by the strong nuclear force, which is not described by Newton's laws of motion.

To sum up, while **Newton's laws of motion** are powerful tools for understanding the behavior of objects in many situations, they are not always applicable and may fail under certain circumstances.

Heisenberg's Uncertainty Principle:

The **Uncertainty Principle** was first proposed by **Werner Heisenberg** in 1927 as part of his work on the foundations of quantum mechanics. The

Uncertainty Principle is a fundamental principle of quantum mechanics that places limits on the precision with which certain physical properties can be measured simultaneously. It is an essential part of our understanding of the behavior of particles in the quantum world, and has important implications for a wide range of fields, from atomic and molecular physics to quantum computing and information theory. As a remarkable consequence of the **uncertainty principle of quantum mechanics** (which implies that certain pairs of quantities, such as the energy and time, cannot both be predicted with complete accuracy), the empty space is filled with what is called **vacuum energy**. Although the **Uncertainty Principle** is a fundamental principle of **quantum mechanics** with many successes in explaining the behavior of small particles, but it also has limitations and is the subject of ongoing debate and research in the field of physics. The **Uncertainty Principle** applies only to the measurements of small particles, such as electrons or photons. It is not applicable to everyday macroscopic objects.

The Grand Idea Of Einstein | $E=Mc^2$:

Mass-energy equivalence is a fundamental concept in physics that describes the relationship between mass and energy. It is best known through Einstein's famous equation, $E=Mc^2$, which relates the energy (E) of an object to its mass (M) and the speed of light (c). This concept was first proposed by Albert **Einstein** in 1905 as part of his theory of special relativity. The concept of mass-energy equivalence is a fundamental part of our understanding of the physical world and allows us to understand the behavior of subatomic particles, such as electrons and protons, in terms of their mass and energy. It provides a deep insight into the nature of mass and energy, and has led to many important discoveries in fields ranging from nuclear physics to cosmology.

Because $E=Mc^2$:

Mass is just energy in disguise.

A small amount of mass can equal a large amount of energy.

The equation $E=Mc^2$ has had profound impacts on our understanding of the universe, including the energy source of stars, nuclear energy, the development of nuclear weapons, and the relationship between mass and energy. It remains a **fundamental principle in physics** and continues to be a topic of research and exploration in the field of theoretical physics.

The Fundamental Constants Of Nature:

The Seven Most Important Of The Fundamental Constants Are:

Speed of Light:

The **speed of light** is a fundamental constant of the universe and is denoted by the symbol "c". Its value is approximately 299,792,458 meters per second in a vacuum, which means that it takes light about 299,792,458 meters (or about 186,282 miles) to travel in one second. The speed of light is not just a theoretical concept; it has been experimentally verified to a high degree of accuracy. This constant plays a crucial role in many areas of physics, such as Einstein's theory of relativity, which describes the relationship between space and time, and in the understanding of electromagnetic waves and the behavior of particles at high energies. A small change in the speed of light in a vacuum would have significant effects on our understanding of the fundamental laws of physics. This is because the speed of light is a fundamental constant of the universe and is used in many equations and theories in physics, such as Einstein's theory of relativity. If the speed of light were to increase or decrease slightly, it would affect many areas of physics, including:

Time dilation: According to Einstein's theory of relativity, time appears to slow down for an object in motion relative to an observer. This effect is directly related to the speed of light, and a change in its value would affect our understanding of how time passes in different reference frames.

Mass-energy equivalence: Einstein's famous equation $E=mc^2$ relates energy to mass and the speed of light. A change in the speed of light would affect the amount of energy released in nuclear reactions and the stability of atomic nuclei.

Electromagnetic radiation: The speed of light is a constant in the equations that describe the behavior of electromagnetic waves, such as light and radio waves. A change in the speed of light would affect the wavelength, frequency, and propagation of these waves.

Quantum mechanics: The behavior of subatomic particles, such as electrons and photons, is described by quantum mechanics, which relies on the speed of light as a fundamental constant. A change in the speed of light would affect the behavior and interactions of these particles.

It is important to note that the speed of light is a fundamental constant of the universe, and current scientific evidence suggests that it cannot be changed.

Gravitational Constant:

The **gravitational constant**, denoted by the symbol "G", is a fundamental physical constant that appears in Newton's law of gravitation. It represents the strength of the gravitational force between two objects with masses M and m that are separated by a distance r. The value of the gravitational constant is approximately 6.67430×10^{-11}N $(m/kg)^2$. This means that the **force of gravitational attraction** between two objects with a mass of 1 kilogram each, separated by a distance of 1 meter, is approximately 6.67430×10^{-11}Newtons. The gravitational constant plays a fundamental role in many areas of physics, including:

Classical mechanics: The gravitational constant appears in Newton's law of gravitation, which describes the force of attraction between two masses. This law is used to calculate the gravitational force between objects in our everyday experience, such as the force that keeps us on the surface of the Earth.

Astrophysics: The gravitational constant is used in the study of celestial bodies, such as planets, stars, and galaxies. It is used to calculate the gravitational force between these objects and to predict their motions.

General relativity: The gravitational constant appears in Einstein's theory of general relativity, which describes the curvature of space and time due to the presence of mass and energy. The theory predicts the existence of phenomena such as black holes and gravitational waves.

Cosmology: The gravitational constant is used in the study of the large-scale structure of the universe, including the formation and evolution of galaxies and the distribution of dark matter.

The value of the gravitational constant is known to a high degree of accuracy, but its exact value is still subject to ongoing research and measurement. A small change in the value of the **gravitational constant** "G" would have significant effects on our understanding of the fundamental laws of physics. This is because the gravitational constant is a fundamental constant of the universe that appears in many equations and theories in physics, including **Newton's law of gravitation** and **Einstein's theory of general relativity**. If the value of the gravitational constant were to increase or decrease slightly, it would affect many areas of physics, including:

Planetary motion: A change in the gravitational constant would affect the force of gravity between celestial bodies, such as planets and stars, and would alter their motion and orbits.

Tidal forces: Tidal forces are caused by the gravitational pull of celestial bodies, such as the Moon and the Sun, on the Earth's oceans. A change in the gravitational constant would affect the magnitude of these forces and could have significant effects on the Earth's climate and geology.

Black holes: The properties of black holes, such as their event horizons and Hawking radiation, are determined by the laws of gravity, which depend on the value of the gravitational constant. A change in the gravitational constant could alter the properties of black holes and affect our understanding of these enigmatic objects.

Cosmology: The gravitational constant is used in the study of the large-scale structure of the universe and the formation of galaxies. A change in the gravitational constant could alter the evolution of the universe and affect our understanding of its origins and future.

It is important to note that the value of the **gravitational constant** is known to a high degree of accuracy and is considered a fundamental constant of the universe. While small variations in the value of G have been observed in some experiments, these are still subject to ongoing research and scrutiny.

Boltzmann Constant:

The Boltzmann constant (symbol: k or k_B) is a fundamental physical constant that relates the average kinetic energy of particles in a gas to the temperature of the gas. It is named after the Austrian physicist **Ludwig Boltzmann**. The **Boltzmann constant** has a value of approximately 1.380649×10^{-23} joules per kelvin (J/K). This means that for every degree Kelvin (or Celsius), a particle in a gas has an average kinetic energy of approximately 1.380649×10^{-23} joules. A small change in the value of the **Boltzmann constant** would have significant effects on many areas of physics, particularly in the study of **thermodynamics** and **statistical mechanics**. The **Boltzmann constant** is a fundamental constant that relates the average kinetic energy of particles in a gas to the temperature of the gas.

If the value of the Boltzmann constant were to change, it would affect many areas of physics, including:

- **Thermodynamics:** The Boltzmann constant is used in the laws of thermodynamics, which describe the behavior of heat and energy in systems. A change in the Boltzmann constant would alter the relationships between temperature, energy, and entropy, and could affect our understanding of thermodynamic systems, such as engines and refrigerators.
- **Statistical mechanics:** The Boltzmann constant is used in the equations that describe the behavior of large numbers of particles, such as those in a gas. A change in the Boltzmann constant would alter the equations that describe the behavior of these systems, and could affect our understanding of the behavior of gases, liquids, and solids.
- **Astrophysics:** The Boltzmann constant is used in the study of celestial bodies, such as stars and planets. A change in the Boltzmann constant would affect the temperature and pressure calculations for these objects, and could affect our understanding of their behavior and evolution.
- **Materials science:** The Boltzmann constant is used to calculate the behavior of materials at different temperatures. A change in the Boltzmann constant could affect our understanding of the behavior of materials, such as their thermal conductivity and specific heat.

It is important to note that the value of the **Boltzmann constant** is known to a very high degree of accuracy and is considered a fundamental constant of the universe. While small variations in the value of the **Boltzmann constant** have been observed in some experiments, these are still subject to ongoing research and scrutiny.

Planck's Constant:

The **Planck constant**, denoted as "h", is a fundamental physical constant that plays a central role in quantum mechanics. It is named after the German physicist **Max Planck**, who first introduced the concept in 1900 as a fundamental unit of energy in the quantization of light. The **Planck constant** has units of joule-seconds (J·s) or equivalently, energy multiplied by time. The Planck constant is a fundamental constant of nature and is one of the most precisely measured physical constants. Its value is approximately 6.626×10^{-34}J·s. The Planck constant relates the energy of a photon, or a particle of light, to its frequency. It is also related to the **wave-particle duality of matter**, where particles, such as electrons, can exhibit wave-like behavior. The **Planck constant** is used extensively in many areas of physics, particularly in quantum mechanics. It is used to calculate the energy of individual photons, the energy levels of atoms and molecules, and the behavior of particles on a quantum level. The **Planck constant** also plays a role in understanding the behavior of **black holes** and the **evolution of the universe**. A small change in the value of the **Planck constant** would have significant effects on various areas of physics, particularly in **quantum mechanics**. Firstly, the energy of individual photons would change proportionally to the change in the **Planck constant**. This would have consequences for the absorption and emission of light by atoms and molecules, as well as the behavior of light in optical systems. Secondly, the value of the **Planck constant** affects the allowed energy levels of atoms and molecules. A small change in the **Planck constant** would lead to changes in the spectral lines observed in atomic and molecular spectra, which are critical for determining the composition and properties of various celestial objects. Thirdly, the **Planck constant** plays a crucial role in the behavior of subatomic particles, such as electrons. A small change in the **Planck constant** would affect the energy levels of electrons in atoms and molecules, which would in turn impact the chemical properties of these systems. Finally, the **Planck constant** is used in the calculation of the Hubble constant, which is a measure of the rate of expansion of the universe. Any change in the Planck constant would therefore have implications for our understanding of the evolution and structure of the universe.To sum up, a small change in the **Planck constant** would have significant effects on various areas of physics, including the behavior of light, the energy levels of atoms and molecules, the behavior of subatomic particles, and our understanding of the universe.

The Strong Coupling Constant:

The **strong coupling constan**t, denoted by $\alpha_{s,}$ is a fundamental constant in physics that describes the strength of the **strong nuclear force**, which is one of the four fundamental forces of nature. The **strong nuclear force** binds quarks together to form protons and neutrons, which are the building blocks of atomic nuclei. In **particle physics**, the strong coupling constant is a measure of the strength of the interaction between quarks and **gluons**, the particles that mediate the strong force. It is also known as the strong interaction coupling constant. The value of α_s depends on the energy scale at which the interaction is measured, due to the phenomenon of **asymptotic freedom**. At high energies, α_s becomes smaller, which means that the interaction between quarks and gluons becomes weaker. This effect is described by the theory of **quantum chromodynamics** (QCD), which is the fundamental theory of the strong nuclear force.

The Cosmological Constant:

The **cosmological constant** is a term in Einstein's field equations of general relativity that represents a form of energy that permeates all of space and exerts a negative pressure. This term was introduced by **Einstein** in 1917 to account for the apparent stability of the universe, as it was thought at the time that the universe was static and unchanging. The **cosmological constant** is denoted by the Greek letter lambda (Λ) and has units of inverse length squared. It is related to the energy density of the vacuum of space and is often called **dark energy**, as it is not associated with any known **particle or physical phenomenon**. Observations in the late 1990s showed that the expansion of the universe is accelerating, which is consistent with the presence of a cosmological constant. The current best estimate of the value of the **cosmological constant** is $\Lambda = 10^{-52}\ m^{-2}$, which is an extremely small value, but it has a significant effect on the large-scale structure of the universe. The **cosmological constant** is an important parameter in **modern cosmology**, as it influences the expansion rate of the universe and the formation of galaxies and other large-scale structures. Its precise value is difficult to determine, as it depends on the details of the universe's evolution and on the properties of the vacuum energy. The **cosmological constant** remains an active area of research in both cosmology and fundamental physics.

The Mass of an Electron:

The **mass of an electron** is a fundamental constant in physics, and a small change in its value can have significant effects on a wide range of physical phenomena. The electron mass is one of the most precisely measured constants, with a current best estimate of $9.10938356(11) \times 10^{-31}$ kg. A small change in the **electron mass** can have effects on the energy levels of atoms, the properties of materials, and the behavior of subatomic particles. For example:

Atomic spectra: The energy levels of atoms are determined by the interactions between electrons and the atomic nucleus. A change in the electron mass can alter the energy levels, causing shifts in atomic spectra. This effect is used in precision spectroscopy and can be used to test fundamental physics theories.

Chemical reactions: The electron mass affects the electronic structure of atoms and molecules, which in turn affects chemical reactions. A change in the electron mass can alter reaction rates and product distributions, potentially leading to new chemical properties.

Solid-state physics: The properties of materials are determined by the electronic structure of their constituent atoms. A change in the electron mass can alter the band structure of solids, affecting properties such as conductivity, magnetism, and optical properties.

Particle physics: The electron is one of the most common particles in the universe, and a small change in its mass can affect a wide range of particle interactions. For example, a change in the electron mass can affect the stability of atomic nuclei and the properties of neutrinos.

In general, a small change in the electron mass can have subtle effects on physical phenomena, and its precise value is an important input parameter for many areas of physics. The **electron mass** is also related to other fundamental constants, such as the **fine structure constant**, and a change in its value can have broader implications for our understanding of the universe.

Stars | The Most Basic Components that Make up Galaxies:

Stars are large, luminous objects that are made up of hot gases and are held together by their own gravity. They are one of the most important objects in the universe, as they are the engines that power the universe through the process of **nuclear fusion**. **Stars** are classified based on their spectral type, which is determined by the temperature of their outer atmosphere. The classification system, known as the **Morgan-Keenan spectral classification** system, uses letters from O to M, with O stars being the hottest and M stars being the coolest. A nebula, which is a cloud of gas and dust, is where a star's life cycle starts. The **nebula** begins to collapse under its own gravity, which causes it to heat up and spin faster. Eventually, the gas and dust in the center of the nebula become dense enough and hot enough to ignite nuclear fusion, which creates a protostar. Once **nuclear fusion** begins, the **protostar** begins to emit light and heat, and becomes a fully-fledged star. The energy created by nuclear fusion keeps the star from collapsing under its own gravity, and creates a balance between the inward force of gravity and the outward force of radiation pressure. Stars spend the majority of their lives in a phase known as the **main sequence**, during which they fuse hydrogen into helium in their cores. This process releases an enormous amount of energy in the form of light and heat, which is what makes stars shine. As the star ages and runs out of hydrogen fuel in its core, it begins to undergo changes that depend on its mass. Smaller stars, such as **red dwarfs**, simply burn out and become white dwarfs. Larger stars, such as red giants, expand and cool, and eventually explode in a supernova. After a **supernova**, the remnant of the star can become a neutron star or a black hole, depending on the mass of the original star. **Neutron stars** are incredibly dense objects that are made up entirely of neutrons, while **black holes** are regions of space where the gravitational force is so strong that nothing can escape. Overall, stars are fascinating objects that play a crucial role in the universe. They are responsible for the creation of all the elements in the universe beyond **hydrogen** and **helium**, and their energy powers the cosmos. Studying **stars** can help us to understand the origins and evolution of the universe as a whole.

If the mass of the star < 1.4 solar masses:

Electrons prevent further collapse.

The core will thus continue to collapse and form a white dwarf.

If the mass of the star > 1.4 solar masses but mass < 3 solar masses:

Electrons + protons combine to form neutrons.

Neutrons prevent further collapse.

The core will thus continue to collapse and form a neutron star.

If the mass of the star > 3 solar masses:

Gravity wins! Nothing prevents collapse.

The core will thus continue to collapse and form a black hole.

Any object with a physical radius smaller than its Schwarzschild radius will be a black hole.

The **Schwarzschild radius** is a critical parameter used in astrophysics to describe the size of the event horizon surrounding a non-rotating black hole. It is named after the German physicist **Karl Schwarzschild**, who derived its mathematical expression in 1916 as part of his solution to Einstein's field equations of general relativity. The **Schwarzschild radius** represents the distance from the center of a **black hole** at which the escape velocity is equal to the **speed of light**. Anything that comes within this distance is said to have entered the event horizon and can no longer escape the gravitational pull of the black hole. The **Schwarzschild radius** depends only on the mass of the black hole and is given by the formula: $R_S = 2GM/c^2$ where R_S is the Schwarzschild radius, G is the gravitational constant, M is the mass of the black hole, and c is the speed of light. The **Schwarzschild radius** is an important parameter for understanding the properties and behavior of black holes. **For example**, the radius sets an upper limit on the size of a black hole, beyond which it would no longer be able to exist. It also provides a way to estimate the mass of a black hole based on observations of its surrounding environment. To sum up, the **Schwarzschild radius** is a critical parameter used to describe the size of the **event horizon** surrounding a non-rotating black hole, and it depends only on the mass of the black hole.

All the laws of physics that we know, breaks down –

Below this time: (Planck Time)

Below this length: (Planck Length)

Above this temperature: (Planck Temperature)

Density Parameter and Curvature :

Density parameter (Ω): The ratio of the total amount of matter in the universe divided by the minimum amount of matter needed to cause the big crunch.

Ω < 1: The Universe will continue to expand forever.

Ω > 1: The Universe will eventually halt its expansion and recollapse.

Ω = 1: The Universe contains enough matter to halt the expansion but not enough to recollapse it.

If Ω = 1, the universe is considered to be flat. If Ω < 1, the universe is considered to be "open," meaning that it will continue to expand indefinitely. If Ω > 1, the universe is considered to be "closed," meaning that it will eventually collapse back in on itself due to the gravitational attraction of its matter and energy. The value of the density parameter depends on the total density of matter and energy in the universe, including both visible matter and dark matter. Observations of the **cosmic microwave background radiation**, the large-scale structure of the universe, and the distribution of galaxies and galaxy clusters suggest that the universe is very close to being flat, with a density parameter of Ω ≈ 1. The **density parameter** is an important parameter in cosmology because it affects the expansion rate of the universe, which in turn affects the evolution and structure of the universe. In particular, the value of the **density parameter** determines the ultimate fate of the universe, whether it will continue to expand indefinitely or eventually collapse in on itself. Overall, the density parameter is a dimensionless quantity used in cosmology to describe the ratio of the actual density of the universe to the critical density required for the universe to be flat. Its value determines the ultimate fate of the universe and affects the expansion rate and structure of the universe.

If a black hole has a mass less than the **Planck mass**, its quantum mechanical size could be outside its event horizon. This wouldn't make sense, **Planck mass** is the smallest possible black hole.

When 2 similar waves are added, the resultant wave is bigger → constructive interference
When 2 dissimilar waves are added, they cancel each other out → destructive interference

Proton charge + Electron charge = 0

Just what it is if electromagnetism would not dominate over gravity and for the universe to remain electrically neutral.

It's not their energy; it's their zero rest mass that makes photons to travel at the speed of light.

Just like a dozen is 12 things, a mole is simply Avogadro's number of particles.

What is GRAVITY?

Newtonian view: Force tells mass how to accelerate. Accelerated mass tells what gravity is.
Einsteinian view: Mass tells space how to curve. Curved space tells what gravity is.

Gravity is a fundamental force of nature that exists between all objects with mass or energy. It is the force that causes two or more objects to be attracted to each other. The mass of the objects and the separation separating them determine the gravitational force's strength. **Sir Isaac Newton** was the person who originally put forth the idea of gravity in the 17th century. According to **Newton's law of gravitation**, the force of gravity between two objects is proportional to the product of their masses and inversely proportional to the square of the distance between them. In the 20th century, **Albert Einstein** proposed a new theory of gravity known as general relativity. **General relativity** describes gravity as the curvature of spacetime caused by the presence of mass and energy. According to this **theory**, objects with mass or energy warp the fabric of spacetime, and other objects move along the curved paths created by this warping. **Gravity** is one of the four fundamental forces of nature, along with electromagnetism, the strong nuclear force, and the weak nuclear force. It is responsible for many **phenomena in the universe**, including the motion of planets and stars, the structure of galaxies, and the behavior of black holes.

What is electromagnetic radiation?

Electromagnetic radiation, also known as **electromagnetic waves**, is a type of energy that travels through space at the speed of light. It consists of oscillating electric and magnetic fields that are perpendicular to each other and to the direction of the wave's motion. **Electromagnetic radiation** can have different wavelengths and frequencies, which determine its properties and the ways in which it interacts with matter. The entire range of **electromagnetic radiation** is called the **electromagnetic spectrum**, which includes radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays. **Electromagnetic radiation** is produced by the acceleration of electric charges, such as electrons, and can be emitted by a variety of sources, including the sun, light bulbs, and electronic devices. It can be absorbed, reflected, or transmitted by matter, depending on the properties of the material and the wavelength of the radiation. **Electromagnetic radiation** has many applications in science and technology, including communication, imaging, and energy production. For example, radio waves are used for wireless communication, microwaves are used in microwave ovens, X-rays are used in medical imaging, and solar radiation is used for renewable energy.

All objects emit electromagnetic radiation according to their temperature. Colder objects emit waves with very low frequency (such as radio or microwaves), while hot objects emit waves with very high frequency (such as infrared or ultraviolet).

Longer half-life of nucleus → **Slow Radioactive Decay**

Shorter half-life of nucleus → **Fast Radioactive Decay**

".. Physics at the atomic and subatomic level ..."

… Weird things are possible:

Energy is quantized ($E = nh\upsilon$).

Momentum is quantized ($L = n\hbar$).

Charge is quantized ($Q = ne$).

Physics at the subatomic level is the study of the behavior and properties of matter and energy at the smallest scales, typically involving particles such as electrons, protons, neutrons, and other subatomic particles. This field of physics is known as **quantum mechanics** or **quantum physics**, and it describes the fundamental behavior of nature at the microscopic level. At the subatomic level, particles do not behave like classical objects with well-defined positions and velocities, but instead exhibit **wave-particle duality**. This means that they can behave like particles, with definite positions and momenta, or like waves, with characteristic wavelengths and frequencies. **Quantum mechanics** also predicts the existence of phenomena such as superposition, where a particle can be in multiple states simultaneously, and entanglement, where two particles can become correlated in such a way that the state of one particle is instantaneously affected by the state of the other, regardless of the distance between them. **Subatomic physics** has many practical applications, such as in the development of electronic devices, such as transistors and microchips, and in medical imaging technologies, such as **positron emission tomography** (PET) and **magnetic resonance imaging** (MRI). It is also important in the study of nuclear energy, particle physics, and astrophysics.

Dual Nature of Matter:

Because:

$$E = h\upsilon,\ c = \lambda\upsilon,\ E = hc/\lambda = pc$$

$$\lambda = h / p$$

Every particle or quantum entity may be partly described in terms not only of particles, but also of waves.

The **dual nature of matter** is a fundamental concept in **quantum mechanics** that is closely related to the wave-particle duality. It refers to the fact that matter, including subatomic particles such as electrons and protons, can exhibit both **wave-like** and **particle-like** behavior. As waves, matter exhibits interference patterns and diffraction, which can be observed in experiments such as the **double-slit experiment**. As particles, matter has a well-defined position and momentum, and can be localized in space. The concept of the **dual nature of matter** was first proposed by **Louis de Broglie** in the early 20th century, who suggested that just as light has both wave and particle properties, matter also has both wave and particle properties. This was later experimentally confirmed by the famous **Davisson-Germer experiment**, in which electrons were diffracted by a crystal lattice, demonstrating their wave-like nature. The **dual nature of matter** has important implications for our understanding of the nature of matter and energy. It helps explain many phenomena in the subatomic world, including the behavior of electrons in atoms and the formation of chemical bonds. It is also the foundation for the development of technologies such as **electron microscopy** and the **scanning tunneling microscope**. Overall, the dual nature of matter is a fundamental concept in **quantum mechanics** that has transformed our understanding of the physical world and has led to numerous advances in science and technology.

The Laws of Thermodynamics:

The **Thermodynamic Laws** think big: they dictate energy behavior…

1 Law: Energy is conserved; its form can be converted.

2 Law: Energies can flow, equilibrate.

3 Law: "Driving force" for equilibration uniquely defined.

0 Law: Thermal equilibrium is transitive.

The **thermodynamic laws** are a set of fundamental principles that govern the behavior of energy and matter in physical systems. They have significant implications and applications across many fields of science and engineering, including chemistry, physics, materials science, and mechanical engineering. Energy cannot be generated or destroyed; rather, it can only be changed from one form to another, according to the **first law of thermodynamics**, sometimes referred to as the **law of conservation of energy**. This law is essential to our understanding of energy conservation and the transfer of energy in various physical and chemical processes. It has important applications in the design of energy-efficient systems and technologies, including renewable energy systems and energy storage devices. The **second law of thermodynamics** states that the entropy, or disorder, of an isolated system always increases over time. This law is crucial for our understanding of energy conversion and efficiency, and it has important implications for the design of energy-efficient engines and devices. It also explains why some processes, such as the conversion of heat to work, are inherently less efficient than others. The **third law of thermodynamics** states that as a system approaches absolute zero temperature, its entropy approaches a minimum value. This law is important for our understanding of the behavior of matter at very low temperatures and has applications in fields such as materials science and condensed matter physics. Overall, the **thermodynamic laws** are fundamental principles that govern the **behavior of energy and matter in physical systems**. They are essential to our understanding of energy conservation and efficiency, and they have significant applications across many fields of science and engineering.

The Life of a Star:

"More mass
More pressure and temperature
Faster Fusion
Shorter life"

"Less mass
Less pressure and temperature
Slower Fusion
Longer life"

MATTER UNDER EXTREME CONDITIONS:

Nuclei + heat + pressure → quark-gluon plasma

Hydrogen atom: Diameter about a Billionth of an inch.

Electron: Diameter at least 1000 times smaller than that of proton.

Proton: Diameter about 60,000 times smaller than Hydrogen atom.

Probability distribution is the only way to locate an electron in an atom.

Gas Laws :

The **Gas laws** deal with how gases behave with respect to pressure, volume, temperature …

Boyle's law:

Volume and pressure are inversely proportional.

Charles' law:

Volume is proportional to temperature.

Pressure law:

Pressure is proportional to temperature.

The combination of these three laws is known as the **ideal gas law**, which can be expressed as:

$$PV / T = \text{constant}$$

Gas laws have many practical applications in science and engineering, such as in the design and operation of engines, refrigeration systems, and gas storage facilities. They are also important in the study of the Earth's atmosphere and the behavior of gases in space.

Weak nuclear forces + Maxwell equations →Electro weak theory

Electro weak theory + Quantum Chromodynamics (QCD) →Standard Model of particle physics

Standard Model of particle physics→ explains everything except gravity.

Quantum Numbers:

Quantum numbers are a set of values used to describe the energy, position, and orientation of an atomic particle, such as an electron, within an atom. There are four main quantum numbers:

- **Principal quantum number:** A number that describes the average distance of the orbital from the nucleus and the energy of the electron in an atom.
- **Angular momentum quantum number:** A number that describes the shape of the orbital.
- **Magnetic quantum number:** A number that describes how the various orbitals are oriented in space.
- **Spin quantum number:** A number that describes the direction the electron is spinning in a magnetic field — either clockwise or counterclockwise.

Quantum numbers are important in the study of atomic and molecular structure, as they help to explain the arrangement and behavior of electrons within an atom. They are used in the development of quantum mechanics and the interpretation of spectroscopic data.

Kepler's Third Law of Planetary Motion:

The square of the periods of the planets (the times for them to complete one orbit) is proportional to the cubes of their average distance from the Sun. A consequence of this isthat the inner planets move rapidly in their orbits. Venus, Earth and Mars move progressively less rapidly about the Sun. And the outer planets, such as Jupiter and Saturn, move stately and slow.

Kepler's Third Law of Planetary Motion, also known as the **law of harmonies**, relates the orbital period of a planet to its distance from the Sun. This law was first formulated by the German astronomer **Johannes Kepler** in the early 17th century, based on his observations of the motion of the planets. It is a mathematical expression of the fact that the force of gravity between two objects decreases with the square of the distance between them, as described by **Newton's law of universal gravitation**. **Kepler's Third Law** has important implications for the study of the solar system and other planetary systems. By measuring the orbital period and distance of a planet, astronomers can calculate its mass and the mass of the star it orbits, and use this information to study the structure and evolution of the system. The law also helps to explain why some planets, such as the gas giants, have much longer orbital periods than others, such as the terrestrial planets.

Wavelength of UV radiation < Wavelength of IR radiation < Wavelength of microwave radiation

Molecule dissociates (when it absorbs UV radiation).
Molecule vibrates (when it absorbs IR radiation).
Molecule rotates (when it absorbs microwave radiation).

"If the **expansion of space** had overwhelmed the pull of gravity in the beginning − stars, galaxies and humanswould never have been able to form. If, on the other hand, gravity had been 5% stronger−

stars and galaxies might have formed, but they would have quickly collapsed in on themselves and each other to form a sphere of roughly infinite density."

Neutrons have a mass of 939.56 MeV:

If the mass of a **neutron** was a seventh of a percent more than it is, stars like most of those we can see would not have existed. If the **neutron mass** was 0.085% less than it is, the Universe would have been full of neutrons and nothing else.

> "A **neutron** is a subatomic particle that is found in the nucleus of an atom along with protons. It has no electrical charge, and its mass is slightly greater than that of a proton. The British physicist **James Chadwick** made the neutron's discovery in 1932. In terms of structure, a neutron is composed of three quarks: two down quarks and one up quark. The down quarks have a negative charge, while the up quark has a positive charge, and together they give the neutron its neutral charge. **Neutrons** play a crucial role in nuclear reactions, such as **nuclear fission** and **nuclear fusion**, because they can be absorbed by atomic nuclei, causing them to become unstable and split apart or merge together. They are also used in many scientific applications, such as in neutron scattering experiments to study the properties of materials and in **neutron imaging techniques** to study the structure of biological and engineering samples. In addition to their scientific applications, neutrons have important practical uses, such as in the production of **nuclear power** and in cancer treatment through neutron therapy. However, they can also be a byproduct of nuclear reactions and can be harmful to living organisms due to their ability to ionize atoms and cause damage to DNA."

If we cut the surface of a sphere up into faces, edges and vertices, and let F be the number of faces, E the number of edges and V the number of vertices, we will always get: V – E + F = 2.

Fibonacci Numbers:

"From pinecones to the Hurricane Sandy, **Fibonacci** reflects various patterns found in nature."

Fibonacci numbers are a sequence of numbers in which each number is the sum of the two preceding numbers, starting with 0 and 1. The sequence's initial few numbers are:

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, ...

The sequence is named after the Italian mathematician **Leonardo Fibonacci**, who introduced it to the Western world in his book **Liber Abaci**, published in 1202. However, the sequence had been previously described in Indian mathematics. The **Fibonacci sequence** has many interesting properties and applications in mathematics and science. For example, the ratio of two adjacent Fibonacci numbers approaches the **golden ratio**, which is approximately 1.618. The **golden ratio** is a mathematical constant that appears in many natural phenomena, such as the spiral patterns in seashells and the proportions of the human body. The **Fibonacci sequence** also appears in various areas of mathematics, such as in the solution of the Fibonacci recurrence relation, the calculation of determinants of certain matrices, and the analysis of the dynamics of chaotic systems. In addition, the **Fibonacci sequence** has practical applications in computer science, such as in algorithms for sorting and searching data. Interestingly, the **Fibonacci sequence** can be observed in nature in a variety of ways. Here are a few examples:

Flower petals: Many flowers have a number of petals that is a Fibonacci number. For example, lilies have three petals, buttercups have five, and delphiniums have eight.

Pinecones: The scales on a pinecone are arranged in a spiral pattern, and the number of scales in each spiral is often a Fibonacci number.

Nautilus shells: The chambered nautilus is a marine animal that has a spiral shell with a distinctive pattern of chambers. The shape of the shell follows a logarithmic spiral, which is related to the Fibonacci sequence.

Leaf arrangements: The way leaves are arranged on a stem can follow a pattern related to the Fibonacci sequence. For example, many plants have leaves that are arranged in a spiral pattern, and the number of turns in the spiral is often a Fibonacci number.

Human body: Some proportions of the human body follow the Fibonacci sequence. For example, the ratio of the length of the forearm to the length of the hand is close to the golden ratio, which is derived from the Fibonacci sequence.

These are just a few examples of the many ways in which the **Fibonacci sequence** can be observed in nature.

The paths of anything you throw have the same shape, called an **upside-down parabola**.

When we observe how objects move around in gravitationally curved trajectories in space, we discover another recurring shape: **the ellipse**.

All material particles have properties such as charge and spin.

Space itself has properties such as dimensions.

These properties are purely mathematical.

Equations aren't the only hints of mathematics that are built into nature: there are also numbers involving not only motion and gravity, but also areas as disparate as classical physics, quantum mechanics, and astronomy. **Equations** are important because they provide a concise and precise way of expressing relationships between variables and making predictions about how those variables will behave under different conditions. **Equations** are used extensively in fields such as mathematics, physics, chemistry, engineering, economics, and many others. They allow scientists and engineers to model complex systems, analyze data, and make predictions about how those systems will behave. **Equations** are also important in everyday life. For example, the formulas used to calculate interest on a loan, determine the amount of medication to take based on body weight, or predict the outcome of a sports game are all based on equations. Equations allow us to make sense of the world around us and to make informed decisions based on data and analysis. They are a **fundamental tool** in problem-solving and decision-making, and they play a crucial role in advancing our understanding of the natural world and the technologies we use. **Equations play a crucial role in understanding the behavior of**

natural systems and phenomena. Here are a few examples of equations in nature:

Newton's laws of motion: Newton's laws of motion are a set of equations that describe how objects move and interact with each other. These laws are fundamental to our understanding of mechanics and the behavior of objects in the natural world.

Maxwell's equations: Maxwell's equations describe the behavior of electric and magnetic fields and how they interact with each other. These equations are fundamental to our understanding of electromagnetism and are used extensively in the study of light, radio waves, and other electromagnetic phenomena.

The Navier-Stokes equations: The Navier-Stokes equations describe the motion of fluids, such as water and air. These equations are important for understanding weather patterns, ocean currents, and many other natural phenomena.

The Schrödinger equation: The Schrödinger equation is a fundamental equation in quantum mechanics, describing how particles behave at the microscopic level. This equation is used to understand the behavior of atoms, molecules, and other small particles.

The Logistic equation: The logistic equation is used to model population growth in ecology. It describes how populations grow and reach a carrying capacity over time, taking into account factors such as birth rates, death rates, and available resources.

These are just a few examples of the many equations that are used to model and understand natural phenomena. **Equations** allow us to make predictions about the behavior of natural systems and to design technologies that harness these systems for our benefit.

Strong force→ Force that is responsible for binding together the fundamental particles of matter to form larger particles.

If stronger: No hydrogen would have formed; atomicnuclei for most life-essential elements would have been unstable; thus, there would have been no life chemistry.

If weaker: No elements heavier than hydrogen would have formed− again, no life chemistry.

*"One of the four fundamental forces of nature, along with electromagnetic, gravity, and the weak force, is the **strong force**. It is the force that holds the nucleus of an atom together, binding protons and neutrons together to form the nucleus. The strong force is the strongest of the fundamental forces, but it has a very short range, acting only within the nucleus of an atom. It is mediated by particles called gluons, which are exchanged between quarks, the particles that make up protons and neutrons. The strong force is essential for the stability of matter. Without it, the positively charged protons in the nucleus would repel each other and cause the nucleus to break apart, releasing huge amounts of energy in the process. In addition to its role in nuclear physics, the strong force also plays a crucial role in the behavior of high-energy particles. It is responsible for the production of particles such as mesons and baryons in particle accelerators and is also involved in the process of quark confinement, which prevents quarks from existing as free particles. Overall, the strong force is a fundamental force of nature that plays a crucial role in the behavior of matter at the atomic and subatomic level."*

Weak force→Force that is responsible for the radioactive decay of atoms

If stronger: Too much hydrogen would have been converted to helium in the big bang; hence, stars would have converted too much matter into heavy elements making life chemistry impossible.

If weaker: Too little helium would have been produced from big bang; hence, stars would have converted too little matter into heavy elements making life chemistry impossible.

"*The weak force, also known as the weak nuclear force, is one of the four fundamental forces in the universe. It is responsible for a number of phenomena related to particle physics, including radioactive decay, nuclear fusion, and some types of particle interactions. The weak force is carried by three particles called the W^+, W^-, and Z bosons. These bosons are heavy, and their masses give the weak force a relatively short range, meaning it operates only over very short distances. One of the unique features of the weak force is that it violates parity symmetry, which means that it behaves differently when viewed in a mirror. This was first observed in experiments with the decay of **cobalt-60 nuclei**, where the emitted electrons were found to be preferentially* *oriented in one direction relative to the nucleus. The weak force also violates CP symmetry, which is the combination of parity symmetry and charge conjugation symmetry. This means that the force behaves differently when particles and their corresponding antiparticles interact. This violation of* ***CP symmetry*** *is believed to be one of the reasons why there is more matter than antimatter in the universe. In addition to its role in nuclear physics, the weak force is also important in astrophysics. It is responsible for the process of stellar nucleosynthesis, where heavier elements are created through nuclear fusion in the cores of stars. The weak force is also involved in the process of neutrino oscillation, where neutrinos change between different flavors as they travel through space. Overall, the weak force is a fundamental force of nature that plays a crucial role in a variety of physical phenomena, from radioactive decay to the behavior of stars."*

Electromagnetic force→ Force that is responsible for most of the interactions we see in our environment today.

If stronger: Chemical bonding would have been disrupted; elements more massive than boron would have been unstable to fission.

If weaker: Chemical bonding would have been insufficient for life chemistry.

"The electromagnetic force is one of the four fundamental forces of nature, along with gravity, the strong nuclear force, and the weak nuclear force. It is responsible for the interaction between electrically charged particles, and is the force behind many everyday phenomena, such as electricity, magnetism, and light. The electromagnetic force is carried by particles called photons, which are massless and travel at the speed of light. Electrically charged particles interact by exchanging photons, and the strength of the interaction depends on the magnitude and separation of the charges. One of the most important properties of the electromagnetic force is that it obeys the inverse-square law, which means that the force between two charged particles decreases as the distance between them increases. This property is responsible for many of the behaviors we observe in electric and magnetic fields, such as the way that the strength of an electric field decreases with distance from a charged object. The electromagnetic force also has a number of important applications in modern technology, including telecommunications, electronics, and power generation. It is the force behind the operation of electric motors, generators, and transformers, and is the basis for many

technologies such as wireless communication, radar, and medical imaging. Overall, the electromagnetic force is a fundamental force of nature that plays a central role in many of the phenomena we observe in the world around us. Its properties and behaviors have been studied extensively by physicists, and continue to be the subject of ongoing research and discovery."

c = 299,792,458 meters per second− serves as the single limiting velocity in the universe, being an upper bound to the propagation speed of signals and to the speeds of all material particles.

Ratio of electromagnetic force to gravitational force:

If larger: All stars would have been at least 40% more massive than the sun; hence, stellar burning would have been too brief and too uneven for life support.

If smaller: All stars would have been at least 20% less massive than the sun, thus incapable of producing heavier elements.

Ratio of electron to proton mass:

If larger or smaller: Chemical bonding would have been insufficient for life chemistry.

Mass of the neutrino:

If smaller: Galaxy clusters, galaxies, and stars would have not formed.

If greater: Galaxy clusters and galaxies would have been too dense.

Ratio of exotic matter to ordinary matter:

If larger: The universe would have collapsed before the formation of solar-type stars.

If smaller: No galaxies would have formed.

Number of effective dimensions in the early universe:

If larger or smaller: Quantum mechanics, gravity, and relativity could not have coexisted; thus, life would have been impossible.

Entropy level of the universe:

If larger: Stars would have not formed within proto-galaxies.

If smaller: No proto-galaxies would have formed.

Polarity of the water molecule:

If greater: Heat of fusion and vaporization would have been too high for life.

If smaller: Heat of fusion and vaporization would have been too low for life; liquid water would not have worked as a solvent for life chemistry; ice would not have floated, and a runaway freeze-up would have resulted.

$$F_E = Qq/4\pi\varepsilon_0 r^2$$

The electrical force decreases with increasing distance between the charged particles; when the distance is doubled, the force falls by a factor of 4.

Hubble's law:

The greater the distance "d" to the galaxy, the higher the velocity "v" with which it receded from us, according to the formula:

v = Hubble parameter × d

*"**Hubble's law** is a fundamental principle in astrophysics that describes the relationship between the distance to a galaxy and its radial velocity, or speed of motion away from us. The law is named after **Edwin Hubble**, the American astronomer who first proposed it in 1929 based on his observations of distant galaxies. **Hubble's law** states that the velocity of recession of a galaxy is directly proportional to its distance from us. The law implies that the universe is expanding uniformly in all directions, with galaxies moving away from each other at a rate proportional to*

their distance. This expansion is thought to have begun with the Big Bang, which occurred approximately 13.8 billion years ago. Hubble's law has been confirmed by many subsequent observations and is considered one of the most important discoveries in cosmology. It provides a key tool for measuring distances to distant galaxies and for studying the large-scale structure and evolution of the universe."

Photoelectric Effect:

The **photoelectric effect** is a phenomenon in which electrons are emitted from a material when light of a certain frequency or higher is shone on it. The effect was first observed by **Heinrich Hertz** in 1887 and later explained by **Albert Einstein** in 1905. In the photoelectric effect, photons (particles of light) collide with electrons in the material, transferring energy to the electrons and causing them to be emitted from the surface. The energy of the emitted electrons is proportional to the frequency of the incident light, and there is a threshold frequency below which no electrons are emitted, regardless of the intensity of the light. The photoelectric effect has many practical applications, including in photovoltaic cells (solar cells) and in electronic devices such as photomultiplier tubes and image sensors. It also played a key role in the development of **quantum mechanics**, as it provided strong evidence for the particle nature of light. The photoelectric equation, also known as the **Einstein's photoelectric equation**, is an equation that describes the relationship between the energy of a photon and the energy of an emitted electron in the photoelectric effect. The equation is given as:

Energy of the photon = Work Function of the metal surface + Kinetic energy of the emitted electron

$$h\upsilon = W + m_0 v^2/2$$

If $h\upsilon < W$:

No photoelectric emission.

The **Lorentz factor** is a term used in special relativity to describe the relationship between time, space, and energy or momentum for objects moving at relativistic speeds (i.e., speeds that approach the speed of light). The Lorentz factor is given by the equation:

$$\beta = v/c$$

$$\gamma = 1 / (1 - \beta^2)$$

where γ is the Lorentz factor, v is the velocity of the object, and c is the speed of light. As an object's velocity approaches the speed of light, the denominator of this equation approaches zero, making the **Lorentz factor** infinitely large. This means that **time dilation** and **length contraction** become more and more pronounced as an object approaches the speed of light. Additionally, the increase in the **Lorentz factor** also leads to an increase in the object's momentum and energy. The **Lorentz factor** is a fundamental concept in special relativity and has important implications for our understanding of time, space, and the behavior of objects at high speeds.

Relativistic mass = Lorentz factor × Rest mass

Contracted length = Proper length / Lorentz factor

Dilated time = Lorentz factor × Stationary time

If v = c:

Relativistic mass → ∞

Contracted length → 0

Dilated time → ∞

Neutron ↔ proton + electron + antineutrino (beta decay)

Proton + electron ↔ neutrino + neutron (electron capture)

Proton + antineutrino ↔ positron + neutron (inverse beta decay)

Closed Universe → positively curved

Open Universe → negatively curved

Flat Universe → uncurved

$$\Delta x \, \Delta p \geq h/4\pi$$

The momentum and the position of a particle cannot be simultaneously measured with unlimited precision.

$$dA/dt = L/2m = \text{constant}$$

The areal velocity of a planet revolving around the sun in elliptical orbit remains constant which implies one-half its angular momentum divided by its mass remains constant. A consequence of this is that the Planet sweeps out equal areas in equal times.

Black hole temperature:

$$T = \hbar c^3/8\pi G M k_B$$

Thus, a smaller black hole is hotter, and consequently radiates more.

Technically, **black holes** don't "evaporate" in the classic sense. Nonetheless, black holes do emit particles over time and lose mass, according to **Stephen Hawking's hypothesis of Hawking radiation**. Black hole evaporation is the name given to this process. The evaporation time of a black hole depends on its mass. **Black holes** with smaller sizes evaporate more quickly than those with larger sizes. Specifically, the evaporation time is given by the formula:

$$t_{ev} = 5120\pi G^2 M^3/\hbar c^4$$

For a **black hole** with the mass of the Sun (about 2×10^{30} kg), the evaporation time is extremely long, about 2×10^{67} years. For a supermassive black hole with a mass of 10 billion Suns, the

evaporation time is about 2×10^{100} years, which is much longer than the current age of the universe.

Stefan Boltzmann law:

$$L = \sigma T^4 A$$

L= luminosity

σ = Stefan-Boltzmann constant

A = surface area

T = temperature in Kelvin

A consequence of this is that:

The larger a star is, the more energy it puts out, and the more luminous it is.

The star with a higher temperature will be more luminous than the star with lower temperatures.

Astrobiophysics → astrophysics + biophysics

Astrostatistics → astrophysics + statistical analysis + data mining

Black hole entropy is a measure of the disorder or randomness of a black hole's internal state. It is a concept in theoretical physics that is closely related to the **second law of thermodynamics**, which states that the total entropy of a closed system never decreases over time. The concept of black hole entropy was first proposed by physicist **Jacob Bekenstein** in the early 1970s, and was later refined by Stephen Hawking. According to **Hawking's theory of Hawking radiation**, black holes emit particles over time and eventually evaporate. If A stands for the surface area of a black hole (area of the event horizon), then the black hole entropy is given by:

$$S_B = k_B A / 4L_{Planck}^2$$

This formula implies that the **entropy of a black hole** is proportional to the area of its **event horizon**. The larger the black hole, the greater its surface area and hence its entropy. This relationship between black hole entropy and surface area is known as the **Bekenstein-Hawking entropy formula**. Black hole entropy is an important concept in modern physics, as it provides a link between **gravity** and **thermodynamics**, two seemingly unrelated areas of physics. It also plays a role in the ongoing effort to reconcile the laws of **quantum mechanics** and **general relativity**, known as the problem of quantum gravity.

Wien's Law: The wavelength of peak emission is inversely proportional to the temperature of the emitting object.

$$\lambda_{max} = b / T$$

b is a constant of proportionality called **Wien's displacement constant**, equal to $2.897771955... \times 10^{-3}$ mK

Thus, hotter objects emit most of their radiation at shorter wavelengths; hence they will appear to be bluer.

> *"**Wien's Law** is a principle in physics that describes the relationship between the wavelength of the peak emission of a blackbody radiation spectrum and its temperature. This law applies to any object that emits thermal radiation, regardless of its composition or shape. A blackbody is an idealized object that absorbs all radiation incident upon it and emits radiation at all wavelengths. The spectrum of radiation emitted by a blackbody is continuous, and the peak of the spectrum shifts to shorter wavelengths (i.e., higher frequencies) as the temperature increases. Wien's Law has many practical applications, including in the design of incandescent light bulbs, the study of astrophysics, and the analysis of thermal imaging data."*

Stellar Radiation Pressure:

$$P_{radiation} = 4\sigma T^4/3c$$

Thus, a doubling of temperature means an increase of radiation pressure by a factor of 16.

The **nuclear radius** R can be approximated by the following formula:

$$R = r_0\ A^{2/3}$$

A = Atomic mass number (the number of protons "Z" plus the number of neutrons "N") and r_0= 1.25 fm = 1.25 × 10^{-15} m.

Thus, size of nucleus depends on the mass number of nucleus.

"If electrons were bosons, rather than fermions, then
they would not obey the Pauli Exclusion Principle.
There would be no life chemistry."

$$F_G = GMm/r^2$$

G represents the gravitational constant, which has a value of $6.674 \times 10^{-11} N\,(m/kg)^2$. Because G is small, gravitational force is very small unless large masses are involved. **Newton's law of gravitation** is a fundamental principle in physics that describes the force of gravity between two objects with mass. However, the law is unable to explain the anomalous precession of the orbit of Mercury, which was observed to deviate slightly from what would be predicted by Newton's law. This deviation was later explained by **Einstein's theory of general relativity**.

The Eddington Limit:

The **Eddington limit** is a critical luminosity beyond which a star or other astronomical object would become unstable and unable to maintain its current size and shape. It is named after the British astrophysicist **Arthur Eddington**, who first derived this limit in 1926. The **Eddington limit** is based on the balance between the inward gravitational force and the outward radiation pressure exerted by a star. At the **Eddington limit**, the radiation pressure becomes so strong that it overcomes the gravitational force, causing the star to expand and become unstable. Specifically, the **Eddington luminosity limit** is given by:

$$L_{Edd} = 4\pi G M m_p c / \sigma_T$$

where L_{Edd} is the Eddington luminosity, G is the gravitational constant, M is the mass of the star, c is the speed of light, σ_T is the Thomson scattering cross-section for the electron, and m_p is the mass of a proton.

For a star that exceeds the **Eddington limit**, the radiation pressure can cause the outer layers of the star to be blown away, resulting in a massive stellar wind or even a complete explosion known as a **supernova**.

Virial Theorem for star:

Thermal energy + gravitational potential energy = 1/2 × gravitational potential energy

Thermal energy = − 1/2 × gravitational potential energy

$$K = -U/2$$

As a consequence of this is that: The thermal energy increases if the gravitational potential energy becomes more negative.

Wavelength of light << size of particle : **Geometrical scattering**

Wavelength of light ≈ size of particle : **Mie scattering**

Wavelength of light >> size of particle : **Rayleigh scattering**

$k_B T \ll KE_{Fermi}$: the electron gas is fully degenerate

$k_B T \approx KE_{Fermi}$: the electron gas is partially degenerate

$k_B T \gg KE_{Fermi}$: the electron gas is non-degenerate

The spin of the **neutron**, **proton** and **electron** are all 1/2. If beta decay involves just a neutron becoming a proton and an electron, spin is not conserved.

Neutron → proton + electron

1/2 → 1/2 + 1/2

Half integral → integral

Hence, the **above reaction** cannot take place since spin is not conserved.

The electrostatic repulsion between two protons is $e^2/ 4\pi\varepsilon_0 r^2$ while the gravitational attraction between them is Gm_p^2/r^2. The ratio of these two forces is $e^2/ 4\pi\varepsilon_0 Gm_p^2$. This expression is independent of distance between them, so the relative strength of the forces is the same throughout all space.

$$\text{If } mv^2/2 > GMm/r :$$

Object of mass "m" will escape the gravitational field of mass "M".

In classical physics, it is possible to exactly specify both position and momentum simultaneously.

In Quantum mechanics: if we try to localize a particle spatially, we lose information about its momentum.

A light year is the distance traveled by light in a year:

$$1 \text{ light year} = (\text{speed of light}) \times (1 \text{ year}) = 3\times10^{10}\text{cms}^{-1}\times 3 \times 10^{7}\text{s} = 9\times10^{17}\text{cm}.$$

Water freezes at 273 K (≡ 0^{o}C)

Water boils at 373 K (≡ 100^{o}C)

Hubble's law→ Consequence of the expansion of the space through which light is travelling.

$m_p c^2/k_B$ → Temperature below which proton is effectively removed from the universe

The angles in a triangle when added together sum up to 180^{o}.

The circumference of a circle divided by its diameter is a fixed number called π.

In a right angled triangle the lengths of the sides are related by $c^2 = a^2 + b^2$ where c is the length of the side opposite to the right angle.

$1\ \text{eV} = 1.6 \times 10^{-19}\ \text{J}$

1 keV is a thousand eV

1 MeV is a million eV

1 GeV is a thousand million eV

1 TeV is a million million eV

Particles can only spin at a rate that is a multiple of h/2π

Fermions (quarks and leptons) spin at 1/2 × h/2π

Bosons (photons and gluons) spin at 1 × h/2π or 2 × h/2π.

Euler's formula:

$$e^{\pi i} + 1 = 0$$

Connects the five fundamental constants of mathematics (e, π, i, 0, 1). [Imaginary number $i = (-1)^{1/2}$]

Euler's formula shows that even though e, π, and i are seemingly unrelated constants, they are connected in a fundamental way through this equation. It has important applications in various branches of mathematics, including complex analysis, number theory, and signal processing.

Maxwell equations → electromagnetism

Schrödinger equation → quantum mechanics

Balmer equation→ Interpretation of atomic spectra

Yang-Mills equation → SU(2) gauge symmetry of isospin

Dirac equation→ relativistic quantum mechanics

Higgs field equation → symmetry breaking

Einstein equations→ relativity

The logistic map → chaotic dynamics

Noether's Theorem (1918): "For every continuous symmetry there is a corresponding conserved quantity [such as electric charge] and vice versa."

$$(i\gamma_{\mu}d^{\mu} - m)\,\psi = 0$$

The Dirac Equation that predicts the existence of antimatter

where:

- i = imaginary number
- γ_{μ} = Pauli matrices
- d^{μ} = derivative in 4 dimensions
- m = fermion mass
- ψ = wave function

Bayes' Theorem:

$$P(H \mid E) = P(E \mid H) \times P(H) / P(E)$$

H represents a hypothesis and E the evidence.

P (H | E) – the probability of H given E is true

P (E | H) – the probability of E given H is true

P (E) – the probability of E

P (H) – the probability of H

Bayes' Theorem is a fundamental concept in probability theory that provides a way to update our beliefs about the probability of an event occurring based on new evidence or information. It is named after the English statistician **Thomas Bayes** who first formulated it in the 18th century. Bayes' Theorem is widely used in fields such as statistics, data science, and machine learning, where it is used to update probabilities based on new evidence or data. It has numerous practical applications, such as in medical diagnosis, spam filtering, and image recognition.

The number 0 is the neutral element of addition:

1 + 0 = 1

23 + 0 = 23

Adding 0

Nothing happens

Zero (0) is a number that represents the absence of quantity or value. It is an important concept in mathematics and plays a critical role in many mathematical operations. **Zero** is the additive identity, meaning that when it is added to any number, the result is that number itself. It is also the multiplicative identity, meaning that when it is multiplied by any number, the result is zero. **Zero** was not recognized as a number in early civilizations, and it was not until the Indian mathematician **Brahmagupta** introduced the concept of zero as a number in the 7th century that it became widely accepted. Today, zero is an essential part of the number system and is used in a wide range of mathematical applications, including algebra, calculus, and number theory. **Zero** also has many practical applications in fields such as physics, computer science, and engineering, where it is used to represent empty spaces, null values, or starting points of measurements.

$$F_G = GMm/r^2$$

G → Constant that controls the strength of gravity

H_2O → Consisting of one oxygen atom and two hydrogen atoms, water molecule plays a special role in the chemistry of life.

General relativity→ Tell us about the geometry of spacetime, but not the topology.

The **Planck mass** is a fundamental constant of nature that has important significance in **theoretical physics**, particularly in the field of **quantum gravity.** It is defined as:

$$m_{Planck} = (\hbar c/G)^{1/2}$$

whichis roughly 24,000,000,000,000,000,000,000 (2.4 × 1022) times the mass of the electron.The **Planck mass** is the mass that would be required to create a black hole with a **Schwarzschild radius** equal to the **Planck**

length. The **Planck mass** is significant because it corresponds to the mass scale where quantum gravitational effects are expected to become significant. This is due to the prediction that the curvature of spacetime will become very nonlinear and that quantum effects of gravity will become significant at energies and masses close to the Planck scale, demanding the development of a **theory of quantum gravity**. The **Planck mass** is also relevant in cosmology, where it is used to define the **Planck density**, which is the maximum possible energy density of the universe. The **Planck mass** therefore represents a fundamental limit on the amount of mass that can be concentrated in a given volume of space.

Planck's law is accurate at all wavelengths.

Wien's Law is a good approximation at short wavelengths.

The **Rayleigh-Jeans Law** is a good approximation at large wavelength.

$$\alpha = e^2/4\pi\varepsilon_0\hbar c$$

Fine structure constant → Constant characterizing the strength of interaction between charged particles.

The **fine structure constant**, also known as **Sommerfeld's constant**, is a dimensionless physical constant that characterizes the strength of the electromagnetic interaction between charged particles. It is denoted by the symbol α and is approximately equal to 1/137. The fine structure constant is a **fundamental constant of nature** that appears in many areas of physics, including atomic and molecular physics, condensed matter physics, particle physics, and cosmology. It is related to the fundamental constants of nature, such as the speed of light, Planck's constant, and the elementary charge. The fine structure constant is derived from a combination of physical constants, including the elementary charge, the vacuum permittivity, and the reduced Planck constant. It is a unitless, dimensionless quantity. One of the most notable features of the fine structure constant is its apparent "unexplained" value. Despite decades of experimental and theoretical efforts, there is currently no accepted explanation for why α has the value it does. Some theories suggest that the value of α might be evidence of the existence of extra dimensions or other fundamental physics beyond the standard model. The fine structure constant is also important in the study of atomic and molecular spectra. It determines the spacing between energy levels in atoms and molecules, and can be used to predict the wavelengths of spectral lines with high precision. The fine structure constant also plays a role in the calculation of the rate of spontaneous emission of light by excited atoms, and in the calculation of the anomalous magnetic moment of the electron.

Observations

↓

Hypothesis

↓

Experiment

↓

Laws

↓

Theory

Five Equations That Changed the World:

$F = GMm/r^2$ (Newton's Law of Universal Gravitation)

$P + \rho \times v^2/2 = \text{constant}$ (Bernoulli's Law of Hydrodynamic Pressure)

$\nabla \times E = -\,\partial B / \partial t$ (Faraday's Law of Induction)

$E = mc^2$ (Albert Einstein's mass–energy equivalence)

$S_{universe} > 0$ (Clausius's Law of Thermodynamics)

$$c^2 = 1 / (\text{vacuum permittivity} \times \text{vacuum permeability})$$

$$c = 1 / (\varepsilon_0 \times \mu_0)^{1/2}$$

c → Determined by the electromagnetic properties of free space – μ_0 and ε_0

Quantum mechanics + General theory of relativity → Quantum theory of gravity

The **quantum theory of gravity** is a theoretical framework that seeks to describe the nature of gravity within the framework of quantum mechanics. Gravity is one of the four fundamental forces of nature, responsible for the attraction between masses. However, our current understanding of gravity, which is described by Einstein's theory of general relativity, is incompatible with **quantum mechanics**, the theory that describes the behavior of matter and energy at a microscopic level. The **quantum theory of gravity** is an active area of research in theoretical physics, and several competing theories have been proposed, including **string theory**, **loop quantum gravity**, and **causal dynamical triangulation**. These theories attempt to reconcile the apparent incompatibility between general relativity and quantum mechanics by describing **gravity** as a quantum field or a quantum property of spacetime. One of the main challenges in developing a quantum theory of gravity is the problem of infinities that arise in the calculations. This is known as the **problem of non-renormalizability**, and it requires the development of new mathematical techniques and conceptual frameworks. Despite the challenges, the quantum theory of gravity is an important area of research, as it may lead to a deeper understanding of the fundamental nature of the universe and the unification of all fundamental forces into a single theory.

If the density perturbations were much weaker, then galaxies may never have coalesced. Without galaxies there would be no buildup of heavy elements, and it is unlikely that planets, and life, would have emerged.

In the presence of gravity, time slows down — the stronger the effect of gravity the more that time slows down

Entropy of Universe = entropy of visible Universe + entropy of dark matter + entropy of black holes

The total energy of the star = internal energy due to thermal motion and radiation + gravitational potential energy

Stars with mass> 0.08 M_{sun} burn hydrogen.

Stars with mass> 0.5 M_{sun} burn hydrogen and helium.

Stars with massin the range of 1 to 8 M_{sun} continue nucleosynthesis up till the production of carbon.

Stars with mass > 10 M_{sun} synthesize all the elements up to iron and nickel.

Rate of energy production in the **pp-processof hydrogen burning** $\propto$ (Temperature) ^{4}

Rate of energy production in the CNO-processof hydrogen burning $\propto$ (Temperature) ^{18}

Superstrings → Supersymmetry + Quantum Gravity + Grand Unified Theories

Size of our universe $\approx 10^{26}$ m

The distance Earth–Sun is $\approx 1.5 \times 10^{11}$ m

The radius of the Sun is $\approx 7 \times 10^{8}$ m

The radius of the Earth is $\approx 6.4 \times 10^{6}$ m

Rocks, Humans, . . . ≈ 1 m

Grains of sand $\approx 10^{-3}$ m

Viruses $\approx 10^{-7}$ m

Simple molecules $\approx 10^{-9}$ m

Atoms $\approx 10^{-10}$ m

What can astronomers learn from redshifts?

$$\text{Redshift} = (\lambda_{observed} / \lambda_{emitted}) - 1$$

is always positive, i.e. observed radiation is redder than the emitted one − **which implies:** Universe is in expansion.

Redshift is a phenomenon in **astronomy** that occurs when the light emitted from an object, such as a star or a galaxy, appears to shift towards longer wavelengths, or towards the red end of the electromagnetic spectrum. Redshift is caused by the **Doppler Effect**, which is a change in the frequency of waves emitted by a moving source relative to an observer. When an object is moving away from an observer, the wavelengths of light emitted by the object are stretched out, making them appear longer and redder. This is known as **redshift**. The amount of redshift is proportional to the velocity of the object and the distance between the observer and the object. The more distant an object is, the greater its **redshift** will be. **Redshift** is an important tool in astronomy, as it can be used to measure the velocity and distance of celestial objects. By studying the redshift of galaxies, **astronomers** have been able to determine that the universe is expanding, as the observed redshift of distant galaxies is proportional to their distance from Earth. There are two types of redshift: gravitational redshift and cosmological redshift. **Gravitational redshift** occurs when light is emitted from an object that is located in a strong gravitational field, such as a black hole or a neutron star. The gravitational field causes the wavelength of the light to stretch, resulting in redshift. **Cosmological redshift** results from the universe's expansion. As the universe expands, the distance between objects in space increases, causing the wavelengths of light to stretch out and resulting in redshift. The amount of **cosmological redshift** is proportional to the distance between the observer and the object and is used to measure the distance and velocity of galaxies and other celestial objects.

Principle of equivalence:

m in $(m \times a)$ and the **m** in GMm/r^2 are identical.

Inertial mass and gravitational mass are identical.

Gravity will affect anything carrying energy

↓

Root of the construction of Einstein's equations

which describe gravity

Light intensity drops as $1 / (\text{distance})^2$

In an open universe (negative curvature): the angles in a triangle add up to less than 180°.

In a closed universe (positive curvature): the angles in a triangle add up to more than 180°.

In a flat universe (zero curvature): the angles in a triangle add up to 180°.

The energy of the universe is constant.

The entropy of the universe tends to a maximum.

External Reality Theory (ERT) → External reality exists completely independent of human beings.

Mathematical Universe Theory (MUT) → External physical reality is a mathematical structure.

G when associated with c and with the reduced Planck's constant ħ, it leads to the definition of the Planck's time: $t_{Planck}=(\hbar G/c^5)^{1/2}= 5.4 \times 10^{-44}$ seconds **(The shortest possible time interval that can be measured)**.

The nuclear charge Q can be approximated by the following formula:

$$Q = Ze$$

Z = Atomic number (the number of protons).

Thus, charge of nucleus depends on the number of protons.

The strong coupling constant defines the strength of the force that holds protons and neutrons together.

The Universe is made up of three things:

Vacuum

Matter

Photons

Total energy density of the universe:

$$\rho = \rho_{vacuum} + \rho_{matter} + \rho_{radiation}$$

$\rho_{vacuum} = \Lambda c^2 / 8\pi G$ is constant and independent of time. The **cosmological constant** "Λ" has negative pressure equal and opposite to its energy density and so causes the expansion of the universe to accelerate.

"**Vacuum energy density** refers to the energy that is thought to be present in the vacuum of space, even in the absence of matter or radiation. This energy is believed to be responsible for the accelerating expansion of the universe, and is closely related to the concept of **dark energy**. The idea of **vacuum energy density** arises from quantum field theory, which describes the behavior of subatomic particles and their interactions with each other. According to this theory, the vacuum of space is not empty, but instead contains fluctuations of **quantum fields** that can give rise to particles and antiparticles, which are constantly popping into and out of existence. These fluctuations are known as **virtual particles**, and they have measurable effects on the properties of particles and fields. The **vacuum energy density** is calculated by adding up the contributions of all the quantum fields in the universe, and then subtracting out any contributions from matter or radiation. However, the calculated value of vacuum energy density is many orders of magnitude larger than what is observed in the universe. This is known as the **vacuum energy catastrophe**, and it remains one of the biggest unsolved problems in physics. One possible explanation for the observed value of vacuum energy density is that it is due to a type of **dark energy** that permeates all of space and drives the accelerating expansion of the universe. This dark energy is thought to have a negative pressure, which counteracts the gravitational attraction of matter and causes the expansion of the universe to accelerate. However, the nature of this **dark energy** remains a mystery, and further observations and experiments are needed to better understand it."

$$m_{proton} / m_{electron} = 1836.15267245$$

↓

Changing their values changes the physical phenomena

The **proton to electron mass ratio** is a dimensionless constant that represents the mass ratio between a proton and an electron. The value of the **proton to electron mass ratio** is approximately 1836.15267245, meaning that a proton is approximately 1836 times more massive than an electron. This **ratio** is an important fundamental constant in physics and is used in many calculations involving subatomic particles. It is also used in the study of atomic and subatomic particles, including in the calculation of atomic spectra and the determination of the masses of other subatomic particles.

When the Universe was at the Planck temperature $(\hbar c^5/Gk_B{}^2)^{1/2}$ and the mean energy of photons was close to the Planck energy $(\hbar c^5/G)^{1/2}$

Solar mass = 2×10^{30} kg − of which about 70% is hydrogen, 28% helium, and 2% consists of other elements. Only about a seventh part of that hydrogen mass is available at any time for hydrogen fusion in the core of the Sun.

At Planck length $(\hbar G/c^3)^{1/2}$, the gravitational force is as strong as the other forces and space-time is "foamy" − filled with tiny bubbles and wormholes appearing and disappearing into the vacuum.

Rayleigh scattering law: The amount of scattering of light is inversely proportional to the fourth power of the wavelength.

$$I \propto 1/\lambda^4$$

Thus, **Rayleigh scattering** is more intense at shorter wavelengths.

Rayleigh scattering is the scattering of light by particles much smaller than the wavelength of the light. It was first described by **Lord Rayleigh** in the late 19th century. The **Rayleigh scattering law** explains why the sky appears blue during the day. The Earth's atmosphere contains tiny particles such as molecules of nitrogen and oxygen that scatter sunlight in all directions. Blue light has a shorter wavelength than red light, so it is scattered more in the atmosphere. As a result, the blue light is scattered in all directions, making the sky appear blue to an observer on the ground.

Supersymmetry →The positive zero point energy of the boson field exactly cancels the negative zero point energy of the fermion field.

$$h \rightarrow 6.62607004 \times 10^{-34} m^2 kg/s$$

Because h is too small: Quantum mechanics is for little things.

Gravity pulls everything in, but a mysterious force called dark energy tries to push it all back together again. Our fate relies on which force will win the desire to succeed.

> *"Because of **CP violation** (violation of charge conjugation parity symmetry) there was more matter than antimatter right after the Big Bang."*

CP violation, also known as **charge-parity violation**, is a phenomenon in particle physics where the symmetry of charge conjugation (C) and parity (P) is violated in certain processes. **Charge conjugation** is the operation of changing all particles to their corresponding antiparticles, while parity is the operation of changing the direction of space coordinates. In other words, **CP violation** occurs when the laws of physics do not behave the same way under the combined operation of charge conjugation and parity as they do under the separate operations of charge conjugation or parity alone. **CP violation** was first observed in 1964 in the decay of neutral kaons, which are particles composed of a quark and an anti-quark. The observation of **CP violation** was a significant discovery because it implies that the laws of physics are not symmetric under all possible transformations, and it opened up new areas of research in **particle physics**. One of the most important consequences of **CP violation** is that it may provide an explanation for the observed imbalance of matter and antimatter in the universe. According to the laws of physics, matter and antimatter should have been created in equal amounts in the Big Bang, but our universe is predominantly made up of matter. **CP violation** may be responsible for this asymmetry by allowing some particles to decay into matter more frequently than into antimatter. However, the exact mechanism for this is still an active area of research.

General theory of relativity describes gravity, ignoring quantum mechanics.

$$\mathbf{m} = m_0 / (1 - v^2/c^2)^{1/2}$$

Tachyons (if they exist) have $v > c$. This means that m is imaginary!

Tachyons are hypothetical particles that are postulated to travel faster than the speed of light in vacuum. The concept of tachyons was first introduced by the physicist **Gerald Feinberg** in 1967, and the name **"tachyon"** comes from the Greek word **"tachus,"** which means **"fast."** According to **special relativity**, particles with mass can never reach or exceed the speed of light, because the closer a massive object gets to the speed of light, the more its mass increases, making it harder to accelerate further. However, **tachyons** are postulated to have imaginary mass, meaning that their mass squared is negative, which leads to some unusual properties, including the ability to travel faster than light without violating the laws of relativity. One of the most striking consequences of the existence of **tachyons** is that they would violate the principle of causality, which states that an effect cannot occur before its cause. This is because a **tachyon** could potentially travel backwards in time, allowing it to arrive at its destination before it was even sent. However, there is currently no experimental evidence for the existence of tachyons, and they remain purely hypothetical. While **tachyons** are not currently considered to be a viable possibility in our universe, they have been the subject of much theoretical and philosophical speculation, and continue to be studied in the context of some exotic theories of physics, such as string theory and other models of quantum gravity.

Math in Nature:

Hexagon→ Bee Hive.

Concentric Circles→ Ripples of a pond when a stone hits the surface of the water.

Mathematics is present in many aspects of nature, from the shapes and patterns of plants and animals to the laws that govern the behavior of the universe. One example of math in nature is the Fibonacci sequence, which appears in the spiral patterns of many plants, such as pinecones, sunflowers, and nautilus shells. The Fibonacci sequence is a series of numbers where each number is the sum of the two preceding numbers (0, 1, 1, 2, 3, 5, 8, 13, 21, 34, etc.), and the ratio between adjacent numbers approaches the **golden ratio**, approximately 1.618. This ratio is also seen in the proportions of many natural forms, such as the human body and the Mona Lisa. Another example is fractals, which are self-similar geometric patterns that repeat at different scales. **Fractal patterns** can be found in many natural phenomena, such as the branching patterns of trees, the shapes of clouds and mountains, and the distribution of galaxies in the universe. The mathematics of fractals has led to many applications in computer graphics and visualization. Mathematics is also fundamental to our understanding of the **laws of physics** that govern the behavior of the universe, from the motion of objects under gravity to the behavior of subatomic particles. The **language of mathematics** provides a precise and universal way to describe and quantify these phenomena, and has led to many technological advances in fields such as astronomy, physics, and engineering. Overall, **mathematics** is a powerful tool for understanding the natural world, and has led to many insights and discoveries in fields ranging from biology and ecology to cosmology and quantum mechanics.

In more than three space dimensions, planetary orbits would be unstable and planets would either fall into the sun or escape its attraction altogether.

What goes up must get down →Newton's law of gravity

What goes up need not descend− if it is shot upward

faster than the escape velocity $(2GM/R)^{1/2}$

Because: $2\pi r = n\lambda$

Only orbits with circumferences corresponding to a whole number of electron wavelengths could survive without destructive interference.

Because: $r = 3GM/c^2$

The photon spheres can only exist in the space surrounding an extremely compact object (a black hole or possibly an "ultracompact" neutron star).

A **photon orbit** is a trajectory that a photon can follow when moving around a massive object under the influence of gravity. The photon orbit is also known as the **"photon sphere."** The concept of the photon orbit was first introduced by the physicist **Johann Georg Rosen** in 1913, and later developed further by other scientists, including **Albert Einstein**. According to general relativity, the path of light is curved by the gravitational field of a massive object, and the curvature increases as the object becomes more massive and compact. For a **black hole**, the photon orbit is located at a distance of 1.5 times the **Schwarzschild radius**, which is the distance from the center of the black hole where the speed of light seems to be the escape velocity. The **photon orbit** is of interest to astronomers, as it can be used to study the properties of black holes and test the predictions of **general relativity**. Overall, the concept of the **photon orbit** is an important application of **general relativity**, and has contributed to our understanding of the nature of gravity and the behavior of light in the presence of massive objects.

In phase → wave crests and troughs reinforce each other.

Out of phase → wave crests and troughs cancel out.

The energy above which (Grand unification energy ≈ 10^{16} GeV), the electro-magnetic force, weak force, and strong force become indistinguishable from each other.

Since the graviton has no mass of its own, the gravitational force of attraction between the sun and every planet is long range.

The proton and neutron masses are so similar; they differ only by the replacement of an up quark with a down quark.

Because: $E/B = c$

Electric and magnetic fields turn into each other in a wavelike motion, creating an electromagnetic field that travels at the speed of light.

When two black holes collide, they merge, and the area of the final black hole is greater than the sum of the areas of the original holes.

Inside the **nucleus of an atom**, a proton is never permanent a proton and a neutron is never permanently a neutron. They keep on changing into each other. A **neutron** emits a **pi meson** and become proton and a proton absorbs a **pi meson** and become a neutron.

$$\text{Neutron} \rightarrow \text{proton} + \pi^{-}$$

$$\text{Proton} + \pi^{-} \rightarrow \text{neutron}$$

There is no escape from a black hole in **classical theory**, but quantum theory enables energy and information to escape.

Accelerated massive bodies give off gravitational waves just as bound electrons in an atom emit electromagnetic radiation.

A rotating **neutron star** (a tiny, burnt out star) generates regular pulses of radio waves.

Quantum mechanics says that the position of a particle is uncertain, and therefore that there is some possibility that a particle will be within an energy barrier rather than outside of it. The process of moving from outside to inside without traversing the distance between is known as **quantum tunneling**, and it is very important for the fusion reactions in stars like the Sun. A successful application of **quantum tunneling** is in the field of quantum computing. In a **quantum computer**, information is stored and processed using quantum bits **(qubits)** that can exist in multiple states at once. **Quantum tunneling** is one of the key mechanisms used to manipulate and control the quantum states of qubits, and is essential for many quantum computing algorithms.

Because:

$$dM = (k/8\pi G)\, dA + \Omega dJ + \Phi dQ$$

M stands for mass, k for surface gravity, A for area of the event Horizon, J for angular momentum, Ω for angular velocity, Q for charge and Φ for the electrostatic potential

the size and shape of the **black hole** depends only on its mass, charge and rate of rotation, and not on the nature of the star that had collapsed to form it.

Hund's rule: Every orbital in a subshell is singly occupied with one electron before any one orbital is doubly occupied, and all electrons in singly occupied orbitals have the same spin.

Because:

Photon energy = 13.6 eV + Kinetic energy of the emitted electron

Photons need an energy > 13.6 eV to ionize hydrogen atom.

Palindrome number: A number that reads the same forwards or backwards.

$$11 \times 11 \rightarrow 121$$

$$111,111,111 \times 111,111,111 \rightarrow 12,345,678,987,654,321$$

If particle A enters the ergosphere of a **Kerr black hole,** then it splits into particles B and C.

$$E_A = E_B + E_C$$

Particle C with Energy $E_C < 0$ **(negative energy)**→ **falls into the black hole**. **Particle B** with Energy $E_B > E_A$ → **escapes**. The added negative energy particle will slow down the spinning of the **Kerr black hole** and reduce its energy and therefore its mass.

Black holes are incredibly dense objects in space that have such strong gravitational fields that nothing, not even light, can escape once it gets too close. While it is not currently possible to directly extract energy from a **black hole**, there are several theoretical processes that could be used to indirectly extract energy from these powerful cosmic phenomena. Here are some of the most promising methods:

Accretion disks: When matter falls into a black hole, it forms an accretion disk around the black hole. This disk can become incredibly hot and emit high-energy radiation, including X-rays and gamma rays. By capturing this radiation and converting it into usable energy, it may be possible to extract energy from the black hole.

Hawking radiation: According to Stephen Hawking's theory, black holes are not completely black, but instead emit a form of radiation called Hawking radiation. This radiation is extremely weak for large black holes, but for smaller black holes, it can be significant. By capturing and converting this radiation, it may be possible to extract energy from the black hole.

Penrose process: The Penrose process is a theoretical method for extracting energy from a rotating black hole. It involves sending an object into the black hole's ergosphere (a region just outside the event horizon where the black hole's rotation drags spacetime around it), and then allowing it to split into two parts, with one part falling into the black hole and the other escaping with increased energy. This process can extract energy from the black hole's rotation.

Black hole mergers: When two black holes merge, they release a tremendous amount of energy in the form of gravitational waves. While this energy is not directly extractable, it could be captured by gravitational wave detectors and converted into usable energy.

It's worth noting that these methods are all highly theoretical and would require significant advances in technology before they could be used to extract energy from black holes.

Because: $\nabla \times E = -\partial B / \partial t$

Electricity and magnetism are related

Tycho's model → Planets orbit around the Sun and the Sun orbit around the Earth at the center of the Universe.

Electromagnetic wave →The undulating strength of the electric and magnetic disturbance − propagating through space − carrying electromagnetic radiant energy.

The expansion of the Universe can be compared to the expanding surface of a balloon that is being inflated. As more air is blown into it, we would see the surface area of the balloon expanding and every point on its surface getting further and further away from one other.

In a **bound atom of hydrogen** the negatively charged electron moves round the positively charged nuclei. In **high temperature plasma** the nuclei and electrons are no longer bound.

Motion of stars in galaxies reveals the existence of hypothetical form of mass thought to account for approximately 85% of the mass in the universe and about 27% of its total mass–energy density, or "dark matter," whose nature remains unknown.

Three Hydrogen nuclei →Nuclear Fusion→ Helium nuclei + Energy

Large nucleus →Nuclear Fission+ Two Smaller nucleus + Energy

Atomism: The world view that everything is built up from two fundamental principles: **atom** (fundamental indivisible component) and **void**.

The sum of multiple waves → superposition

(The resulting wave form is stable in time and space)

Complementarity Principle: Wave and particle or position and momentum cannot be observed at the same time.

Ontology: What the underlying structure of reality is?

Paradigm → Framework for thinking about the nature of reality

Aristotle (384−322 B.C)→The earth is spherical in shape.

Aristarchus (312-230 B.C)→The Universe is Sun-centered.

Johannes Kepler (1571−1630)→ Planets more around the Sun in Orbits which are not circular but elliptical.

Nicolaus Copernicus (1473−1543)→ The Sun is at the centre of the Solar System.

Galileo Galilei (1564−1642)→ The Sun has both hot high temperature and dark low temperature spots.

When two numbers are added, their order is not important

$$1 + 2 = 2 + 1$$

Arithmetic and number theory→ patterns of number and counting

Geometry→ patterns of shape

Calculus→ patterns of motion

Logic→ patterns of reasoning

Probability theory→patterns of chance

Topology→ patterns of closeness and position

Gravity and Distance:

$$F_1 = GMm/r^2$$

If the distance between the masses triples, the gravitational force decreases by three squared, or nine:

$$F_3\text{(force at thrice the distance)} = GMm/(3r)^2$$

$$F_3 = GMm/9r^2 = F_1/9$$

Increasing the distance by twenty times would decrease the gravitational attraction by four hundred times:

$$F_{20}\text{(force at twenty times the distance)} = GMm/(20r)^2$$

$$F_{20} = GMm/400r^2 = F_1/400$$

Since the Moon's mass is 7.35×10^{22}kg i.e., about 1.2 percent of Earth's mass, it has a much weaker gravitational pull on us. This means our weight would be less on the Moon than on Earth. In fact, we would weigh about one-sixth what we weigh on Earth.

Spontaneous generation theory

↓

Different kinds of nonliving matter give rise to different kinds of living creatures

(Rotting meat gives rise to flies while old rags give rise to mice)

Albert Einstein's theory: The entire universe can expand or contract − just like the overall stretching or shrinking of an elastic sheet.

Max Tegmark's 4 distinct types of parallel universes:

Parallel universes with the same laws of physics but different initial conditions.

Parallel universes with the same equations of physics but perhaps different constants of nature.

Parallel universes superimposed in the same physical space but mutually isolated and evolving independently.

Parallel universes with different mathematical structures.

*"**Parallel universes**, also known as the **multiverse theory**, is a hypothetical concept in which there may exist multiple universes or realities, each with its own set of physical laws and properties. This idea has been explored in various fields such as physics, cosmology, philosophy, and science fiction. The concept of parallel universes is often associated with the idea that there may be alternate versions of us and events that we experience in our own universe. There are several versions of the multiverse theory, including the many-worlds interpretation of quantum mechanics, which suggests that every possible outcome of a quantum measurement exists in its own separate universe, and the inflationary multiverse theory, which suggests that our universe is just one of many bubble-like universes that emerged from an earlier period of inflation. While the concept of parallel universes remains speculative and has yet to be definitively proven, it is a fascinating topic that continues to inspire research and exploration into the nature of the universe and our place within it."*

Object moves at constant velocity in an inertial frame ↔ Object experiences zero net force

In string theory:

(Laws of physics + Particle spectrum+ Nature of forces) is Dictated by (shape + size (geometry) of dimensions)

String theory is a theoretical framework that attempts to reconcile two pillars of modern physics: **general relativity** and **quantum mechanics**. It posits that at the most fundamental level, everything in the universe is made up of tiny, one-dimensional strings that vibrate at different frequencies to produce the various particles and forces that we observe. In this theory, there are ten dimensions of space and one dimension of time, and the extra dimensions are thought to be curled up or compactified at very small scales beyond our current ability to observe. **String theory** has the potential to unify all fundamental forces of nature, including gravity, and it has inspired a wide range of mathematical and theoretical research. However, it has yet to be conclusively proven, and there remain significant challenges in testing its predictions and confirming its validity through experiments.

$(\hbar G/c^3)^{1/2} \rightarrow$ Planck length and $(\hbar G/c^5)^{1/2} \rightarrow$ Planck time are the smallest possible units. $(\hbar c^5/Gk_B^2)^{1/2} \rightarrow$ Planck temperature is the hottest possible temperature. $(\hbar c\ /\ G)^{1/2} \rightarrow$ Planck mass, however, is not the smallest possible mass. Many things weigh less, like, for example, an electron or a proton. The Planck mass is big because $G = 6.67408 \times 10^{-11} m^3 kg^{-1} s^{-2}$ (relatively very weak).

Spatial dimensions ≥ 4: Electrons fall on the nuclei and therefore the atomic structure of matter does not exist. The atomic matter and therefore life are possible only in 3-dimensional space.

If the electron charge were increased by a factor ~3 no nuclei with atomic number > 5 would exist and no living organisms would be possible.

Entropy change ≥ 0

Entropy change = 0 **(reversible process)**

Entropy change > 0 **(irreversible process)**

Principle of flotation

↓

Since boat displaces a weight of water equal to its own weight: **It floats in water**

Temperature > Curie temperature

Ferromagnetic → Paramagnetic

(Magnetic materials lose their ferromagnetic properties)

Temperature > Néel temperature

Antiferromagnetic → Paramagnetic

(Magnetic materials lose their antiferromagnetic properties)

Electron + proton → neutrino + neutron **(inverse beta decay)**

(Takes place in stars of extremely high density)

Jeans mass:

$$M_J = 3k_BTR / 2Gm$$

k_B= Boltzmann constant, T = temperature in Kelvin, R = radius of gas cloud, m = mass of gas particle and G = gravitational constant

Mass of gas cloud > M_J

Gravity wins

↓

Thermal pressure cannot support the gas cloud against its self gravity

↓

Gas cloud collapses!

The **Jeans mass** is a concept in astrophysics that determines the minimum mass required for a cloud of gas to collapse under its own gravitational attraction and form a stable object, such as a planet or star. It is named after the British physicist **James Jeans**, who first derived the equation for calculating the **Jeans mass** in 1902. In general, if the mass of a gas cloud is less than the Jeans mass, the cloud will not collapse and will remain in a stable state. However, if the mass is greater than the Jeans mass, the cloud will collapse and form a dense core, leading to the formation of a star or planet. The **Jeans mass** is an important concept in understanding the formation and evolution of objects in the universe, and it plays a key role in the study of astrophysics, cosmology, and planetary science.

Virial Theorem: $2K + U = 0$

If $2K > U$: the gas pressure will dominate over gravity.

If $2K < U$: the gas cloud will collapse.

The **Virial Theorem** is a fundamental principle in physics that relates the average kinetic energy and the average potential energy of a stable system in equilibrium. It was first developed in the mid-19th century by the German physicist **Rudolf Clausius** and later extended by other scientists, including **James Clerk Maxwell** and **Willard Gibbs**. The **Virial Theorem** is important in many areas of physics, such as astrophysics, molecular physics, and statistical mechanics, where it is used to calculate the properties of complex systems and understand the dynamics of gases and other materials. For example, the **Virial Theorem** can be used to estimate the mass of a galaxy from its observed motions or to study the properties of interstellar clouds and their role in star formation.

Low mass star → cooler, fainter, long lifetime.

High mass star → hotter, brighter, short lifetime.

Planck mass = 1.2×10^{19}GeV → about 22μ gram − much heavier than any mass of existing elementary particles.

Binary Stars – A pair of stars in orbit around their common center of gravity.

Binary stars are two stars that are gravitationally bound to each other and orbit around a common center of mass. They are relatively common in the universe, and are formed when two stars are formed from the same gas cloud or when a passing star gravitationally captures another star into orbit. **Binary stars** can have different characteristics and orbital configurations. They can be close or wide, with distances between them ranging from a few astronomical units (AU) to several thousand AU. They can also have different masses, sizes, temperatures, and luminosities, and can be composed of different types of stars, such as main-sequence stars, red giants, white dwarfs, or neutron stars. **Binary stars** play an important role in many areas of astronomy and astrophysics. They are used to study the properties of stars, such as their masses, radii, temperatures, and compositions, as well as their evolution and dynamics. They can also be used to test theories of gravity and to search for exoplanets through the detection of their gravitational influence on the motion of the stars. Overall, **binary stars** are fascinating objects that offer insights into the formation, evolution, and structure of stars and the universe as a whole.

Apparent Magnitude – A star's brightness as it appears to Earth.

Absolute Magnitude – How bright a star actually is.

Because: $T = \hbar c^3/8\pi G M k_B$

Tiny Black Hole is hot

Big Black Hole is cold

Objects moving away from observer→ Frequency decreases → wavelength increases **(red shift)**

Objects moving towards observer→ Frequency increases → wavelength decreases **(blue shift)**

Einstein Theory → 4 dimensions (length, width, depth, and time)

String theory → 4 dimensions + 7 other dimensions

(11th dimension holds the universe together)

The black hole no hair theorem: Mass, charge, and angular momentum are the only properties a black hole can possess.

The **"no hair theorem"** is a principle in physics that states that black holes can be described by only three parameters: their mass, electric charge, and angular momentum. This means that all other information about the matter that formed the black hole, such as its density, temperature, and chemical composition, is lost and cannot be observed from outside the event horizon. The no hair theorem was first proposed in the 1970s by physicist **John Wheeler** and later developed by other scientists, including **Stephen Hawking**. It is based on the idea that black holes are completely characterized by their macroscopic properties and that their internal structure is hidden from observers. The **no hair theorem** has important implications for the study of black holes and the universe as a whole. It suggests that black holes are among the simplest objects in the universe, and that they have a universal nature that is independent of their initial conditions. It also implies that black holes are predictable and stable objects, and that their properties can be determined by measuring their mass, charge, and angular momentum. Overall, the **no hair theorem** is a powerful concept in physics that has greatly advanced our understanding of black holes and their role in the universe.

The Sky is Dark at Night→ There must be some limit to the observable Universe.

Thomson Scattering ($h\upsilon << m_0c^2$): The photon and electron just both bounce off each other, changing their direction, but there is no exchange of energy.

Compton scattering ($h\upsilon > m_0c^2$): A photon of high energy collides with a stationary electron and transfers part of its energy and momentum to the electron, decreasing its frequency in the process.

Brown dwarf

Too big to be a planet

Too small to be a star

Pulsars→ Rotating neutron stars emitting beams of particles and electromagnetic radiation.

Special Relativity→The speed of light is the same for any observer.

At scale $L \sim (G\hbar / c^3)^{1/2}$, energy fluctuations become so large that even spacetime geometry is no longer smooth at all.

3 types of geometries for our universe:

Hyperbolic (negative curvature)

Elliptic (positive curvature)

Euclidean (zero curvature)

Photon + Hydrogen atom → proton + electron

(photodissociation)

Proton + electron → Photon + Hydrogen atom

(radiative recombination)

Newton Theory:

Weight is proportional to Mass

Einstein Theory:

Energy is proportional to Mass

Neither explained origin of Mass

"**Electroweak theory** predicted a heavy version of the photon called the Z^0 which was discovered in 1983."

The **electroweak theory** is a theoretical framework that describes the electromagnetic and weak nuclear interactions between elementary particles. It unifies two of the four fundamental forces of nature, the electromagnetic force and the weak force, into a single force that is mediated by four particles: the W^+, W^-, Z bosons, and the photon. The theory was developed in the 1970s by **Sheldon Glashow**, **Abdus Salam**, and **Steven Weinberg**, and it is an essential part of the Standard Model of particle physics. The **electroweak theory** postulates that the electromagnetic force and the weak force are different manifestations of the same underlying force. At high energies, the two forces are indistinguishable, but at lower energies, the weak force becomes dominant, and the electromagnetic force is weakened. The theory predicts the existence of the **Higgs boson**, which is responsible for giving mass to elementary particles. One of the key predictions of the electroweak theory is the existence of the W^+, W^-, and Z bosons, which were discovered in 1983 by the UA1 and UA2 experiments at **CERN**. The discovery of these particles provided strong evidence for the electroweak theory and helped to confirm the Standard Model of particle physics.

Quantum field theory which postulates that matter is composed out of elementary particles bound together by forces, mediated by exchange of other elementary particles.

Hawking 1975: Black hole background + Quantum Field theory → Black hole emits radiation!!

Hawking 1976: Black hole as a quantum pure state + Hawking radiation → Unitarily of Quantum Mechanics is broken!!

Computable Universe Theory: Our external physical reality is defined by computable functions.

Computable functions: The functions that can be calculated using a mechanical calculation device given unlimited amounts of time and storage space.

Theories of Origin of Life:

Life formation on the earth may have been taken place due to supernatural entity.

Life formation did not take place on earth. It took place somewhere else in the space or on any other planet and carried to the earth.

Life formation on the earth could have arisen through a series of organic chemical reactions that produced ever more complex biochemical structures.

Life may have evolved from non-living matter as association with prebiotic molecules under primitive earth conditions.

Frame dragging is the idea that spacetime is elastic and particles in it will exchange energy. That means spacetime will absorb some of the energy of a spinning particle. Research studies have shown that Earth is dragging spacetime around it as it rotates.

Zero-energy universe hypothesis: The total amount of energy in the universe is exactly zero: its amount of positive energy in the form of matter is exactly canceled out by its negative energy in the form of gravity. According to this hypothesis, the universe could have originated from a **quantum fluctuation** in which equal amounts of positive and negative energy were created. As the universe expanded, the positive energy took the form of matter, while the negative energy took the form of gravitational potential energy. The zero-energy universe hypothesis has some compelling theoretical and observational support. For example, the large-scale structure of the universe appears to be consistent with a universe that has zero total energy. Additionally, the **cosmic microwave background radiation**, which is thought to be the leftover heat from the Big Bang, appears to have a total energy of zero. However, the **zero-energy universe hypothesis** is still a subject of ongoing debate and research in cosmology. While some scientists believe that the hypothesis could be a fundamental principle of the universe, others argue that it may be inconsistent with certain observations or theoretical models.

Lambda-CDM model: Big-Bang cosmological model with a cosmological constant and cold dark matter.

Eternal inflation: New universes pop into existence at an unknown rate − creating a complex web of bubble universes within a vast multiverse.

Loop quantum gravity: The universe is a network of intersecting quantum threads − each of which carries quantum information about the size and shape of nearby space.

Graviphoton: A hypothetical particle whose physical properties are virtually indistinguishable from a photon − which emerges as an excitation of the gravitational field in spacetime dimensions higher than four − as described in **Kaluza–Klein theory** (classical unified field theory of gravitation and electromagnetism).

Ekpyrotic model of the universe: Our current universe arose from the collision of two three-dimensional universes traveling in a hidden fourth spatial dimension. This model does not require a singularity at the moment of the Big Bang.

Hartle-Hawking model : Universe has no initial boundaries in time or space.

Fermions (= matter): quarks and leptons

Bosons (= interactions): gauge fields + Higgs boson (God's particle)

Venus and Uranus are the only planets that rotate clockwise. The other six planets in the solar system rotate counterclockwise.

Weak Anthropic Principle:

If the world were any different we would not be here.

(The emergence of life is possible)

Strong Anthropic Principle:

The world had to be as it is in order for us to be here.

(The emergence of life is inevitable)

Absurd universe: Our universe just happens to be the way it is.

Unique universe: There is a deep underlying unity in the laws of physics that make it necessary for the Universe being the way it is.

Multiverse: The idea of multiple universes. Each of which comprise everything that exists: the entirety of space, time, matter, energy, information, and the physical laws and constants that describe them.

Intelligent design: Life on earth is so complex that it cannot be explained by the scientific theory of evolution and therefore must have been designed by a supernatural entity.

Self-explaining universe: No phenomenon can be said to exist until it is observed.

Fake universe: We are living in a simulated universe.

N → number of spatial dimensions

T → number of time dimensions

If N > 3 and T =1: the orbit of a planet about its Sun cannot remain stable.

If T > 1: the high energetic protons and electrons would be unstable and could decay into particles having greater mass than themselves.

A proton can decay into a neutron, a positron and a neutrino

An electron can decay into a neutron, an antiproton and a neutrino

If N = 1 and T = 3: all particles are tachyons with imaginary rest mass.

Only a **(N + T)** = (3 + 1) dimensional universe can contain dynamic observers who are complex and stable enough to be able to understand and predict all of space and time and their contents (including planets, stars, galaxies and all other forms of matter and energy) to any extent at all.

T > 1 or T < 1: insufficient predictability

N > 3: insufficient stability

N< 3: insufficient complexity

1 dimensional universe→ made up of only 1 dimension (width).

2 dimensional universe→ made up of 2 dimensions (width and breadth).

3 dimensional universe→ made up of 3 dimensions (width, breadth and height).

4 dimensional universe→ made up of 4 dimensions (width, breadth, height and time).

5 dimensional universe→ more challenging to visualize because we ourselves cannot perceive dimensions > 4 around us.

Causality Principle: All real events necessarily have a cause.

Dark matter could warm certain planets in the place of a sun, allowing life to arise on a sunless planet.

The only thing that can make a bigger atom than hydrogen is a star. The entire periodic table, every element you have ever heard of was processed inside the body of a star. The star then unraveled or exploded… and here we are. **We are dead stars**.

Black hole cosmology: The Hubble radius of the observable universe is equal to its Schwarzschild radius.

Conformal cyclic cosmology: The universe goes through infinite endless cycles from creation to destruction over and over again.

Loop quantum cosmology: Application of loop quantum gravity to eliminate singularities - such as the big bang and big crunch singularity.

Eternal recurrence: The idea that all events in the world repeat themselves in the same sequence through an eternal series of cycles.

Quantum emergence: Space and time develop out of a primeval state described by a quantum theory of gravity.

Isenthalpic process: $\Delta H = 0$ (Enthalpy constant)

Isentropic process: $\Delta S = 0$ (Entropy constant)

Steady state process: $\Delta U = 0$ (Internal energy constant)

Weakless universe: A hypothetical universe that contains no weak interactions.

Avogadro's hypothesis states that equal volumes of gases at the same temperature and pressure contain the same number of particles. At Standard Temperature and Pressure, one mole (6.02×10^{23} particles) of any gas occupies a volume of 22.4 liters.

Bernoulli's principle: As speed of the fluid increases, pressure within the fluid decreases.

Isothermal process: $\Delta T = 0$ (Temperature constant)

Isobaric process: $\Delta P = 0$ (Pressure constant)

Isochoric process: $\Delta V = 0$ (Volume constant)

Adiabatic process: $\Delta Q = 0$ (No heat flow between the system and the surroundings)

$$\Delta G = \Delta H - T\,\Delta S$$

If ΔG is negative (< 0), the process is spontaneous (exergonic).

If ΔG is positive (> 0), the process is non spontaneous (endergonic).

Hypervelocity stars are stars that have been ejected from the center of a galaxy due to interaction with a massive central **black hole** and sent rocketing through intergalactic space at speeds up to 2 million miles per hour. Most of the **hypervelocity stars** that have been identified so far are of similar size and mass as the Sun, but theoretically could be bigger.

The color and size of a star tells astronomers its age.

Yellow dwarfs and blue giants are young.

Red giants and red supergiants are older.

White dwarfs and black dwarfs are the oldest.

Quantum physics says reality changes with observation.

Quantum Bayesianism says reality is observation.

Quark matter is an extremely dense phase of matter made up of subatomic particles called quarks. This theoretical phase would occur at extremely high temperatures and densities. It may exist at the heart of neutron stars. It can also be created for brief moments in particle colliders on Earth, such as CERN's Large Hadron Collider.

Theory of relativity:

Removes inconsistencies in the classical theory.

Describes the behavior of matter at high energies and high speeds.

Quantum mechanics:

Removes disagreements between theory and experiments.

Describes the behavior of microscopic particles.

Like a black hole, a white hole is a prediction of Albert Einstein's theory of general relativity. It is essentially a black hole in reverse: if nothing can escape from a black hole's event horizon, then nothing can enter a white hole's event horizon.

special relativity + quantum mechanics

↓

Relativistic quantum electrodynamics

(very precise and highly successful)

quantum mechanics + gravity

↓

Theories of quantum gravity

(no data to test them)

1 Second to Get the Moon

8 Minutes to Get the Sun

2000 years to get out of Milky Way

46.5 Billion Years to Get the Edge of the Observable Universe

The **evolution of mathematics** reflects humankind's quest for cosmic understanding. From the properties of smallest atomic particles and the realm of intergalactic physics to the formation of a giant mathematical object (universe), math proves unquestionably effective in describing and predicting their physical reality. In an effort to resolve the basic conundrum of why our universe appears to be so mathematical, most accomplished scientists of our timeput out a revolutionary assumption: that our material existence is not only characterized by mathematics, but is itself mathematics. **Mathematics** may offer answers to our most fundamental questions: **How big is reality?** What is the composition of everything? Why our universe is structured the way it is? **Math** stand as mankind's greatest invention and gives us the definitive measurement of not only our universe but also all other conceivable universes. However, a question that lies at the intersection of philosophy and science arises: **Is Math the Language of the Universe?** The idea that the universe is made of math is a philosophical and theoretical concept that has been explored by many scientists and thinkers throughout history. The concept is based on the idea that mathematical principles and structures can be found in many aspects of the natural world, from the patterns of leaves on a tree to the movements of celestial bodies. In some ways, the idea that the universe is made of **math** is supported by the success of mathematics in describing and predicting the behavior of the natural world. **Mathematics** has proven to be an incredibly powerful tool for understanding everything from the behavior of subatomic particles to the structure of the universe on its largest scales. However, while **mathematics** is undeniably a fundamental tool for describing the natural world, it is also important to recognize that **mathematics** is a human creation. While the patterns and structures that we observe in the natural world can be described using mathematical language, it's not necessarily the case that the universe is inherently mathematical in nature. Ultimately, whether or not the universe is **"made of math"** is a matter of philosophical debate and one that is unlikely to be fully resolved anytime soon. Regardless of the answer, mathematics remains a powerful tool for understanding and exploring the natural world.

Gravitational waves are ripples in the fabric of spacetime that propagate outward from accelerating masses. They were first predicted by **Albert Einstein's theory of general relativity**, and were detected for the first time in 2015 by the Laser Interferometer Gravitational-Wave Observatory (LIGO). The gravitational wave signal was observed by LIGO detectors in Hanford and in Livingston on 14 September 2015. An exact analysis of the gravitational wave signal based on the **Albert Einsteinian theory of general relativity** showed that it came from two merging stellar black holes with 29 and 36 solar masses, which merged 1.3 billion light years from Earth. Before the merger, the total mass of both black holes was 36 + 29 solar masses = 65 solar masses. After the merger, the mass of resultant black hole was 62 solar masses.

What happened to three solar masses?

It was turned into the energy transported by the emitted gravitational waves. Using Albert Einstein's equation $E = mc^2$, where E is the energy transported by the emitted gravitational waves, m is the missing mass (3 solar masses) and c is the speed of light, we can estimate the energy released as gravitational waves:

$$E = (3 \times 2 \times 10^{30}\text{kg}) \times (3 \times 10^{8}\text{m/s})^{2}$$

$$E = 5.4 \times 10^{47}\text{J}$$

This is roughly 10^{21} more energy than the complete electromagnetic radiation emitted by our sun.

◆ ◆ ◆

CHAPTER 4

Amazing Facts About Space and the Universe

A lot of prizes have been awarded for showing the universe is not as simple as we might have thought.

− Stephen Hawking

◆ ◆ ◆

Universe: The LARGE Book of Incredible Facts and Intriguing Stuff

The **universe** is a vast expanse of space that includes everything that exists, from the smallest particles to the largest structures such as galaxies and galaxy clusters. The size and scale of the universe are almost impossible to comprehend, but scientists have developed models and measurements to help us understand its properties and evolution. The universe is thought to have begun with the **Big Bang**, a cataclysmic event that occurred approximately 13.8 billion years ago. At this moment, the universe was incredibly hot and dense, and it rapidly expanded and cooled over time. As it expanded, matter began to clump together under the force of gravity, eventually forming stars, galaxies, and other structures. The observable universe, or the part of the universe that we can see, is thought to have a diameter of about 93 billion light-years. This means that the light from the most distant objects we can observe has taken approximately **13.8 billion years** to reach us. The universe is made up of various types of matter and energy, including visible matter (such as stars and planets), dark matter, and dark energy. Visible matter makes up only a small fraction of the universe, while dark matter and dark energy are believed to make up the majority. **Dark matter** is a type of matter that does not interact with light or other forms of electromagnetic radiation, and its existence is inferred from its gravitational effects on visible matter. The accelerated expansion of the universe is supposed to be caused by **dark energy**, a hypothetical form of energy. The energy source of stars is nuclear fusion, a process that involves the combining of atomic nuclei to form heavier elements. The exact details of the fusion process in stars are still not fully understood, and researchers are still trying to unlock the mysteries of this process. The universe is also subject to a variety of **physical laws**, including gravity, electromagnetism, and the strong and weak nuclear forces. These laws govern the behavior of matter and energy in the universe and allow for the formation of structures such as galaxies and stars. **Scientists** study the universe using a variety of tools and methods, including telescopes, satellites, and computer simulations. By studying the universe, scientists hope to gain a better understanding of the **fundamental laws of nature** and the origins of the universe and life itself. Our **universe** is incredible. This universe's sheer size, together with its trillions of things, millions of stunning constellations, zillions of stars, and planetary systems, is really fascinating. Mystery, wonder, and a wealth of fascinating information are all woven into this realm. We have outlined several astounding and unbelievable facts about the universe in this chapter. If you want to discover more about the entirety of space, time, and existence —including planets, stars, galaxies, and all other types of matter and energy — this chapter is for you.

Mercury and **Venus** are the only two planets in our solar system that orbit closest to the Sun and have no moons.

The hottest planet in our solar system is **Venus** and is named after the Roman goddess of love and beauty.

A **light-year** is the unit of length used to express astronomical distances and is the distance covered by light in a single year and is equal to 9.46×10^{12} km.

The **Sun** accounts for 99.86% of the mass in the solar system and weighs about 330,000 times more than Earth.

Our **solar system** is 4.568 billion years old formed from the gravitational collapse of a giant interstellar molecular cloud.

The highest mountain discovered is the **Olympus Mons**, which is an enormous shield volcano on the planet Mars.

Because of lower gravity, a person who weighs 100 kg on Earth would only weigh 38 kg on the surface of Mars.

The **Sun** has a north and south pole, just as the **Earth** does, and makes a full rotation once every 25 – 35 days.

Earth is the third planet from the Sun and the only planet not named after a God.

On average, **13.8 billion years** have passed since the universe's beginning. Scientists arrived at this number by studying the cosmic microwave background radiation, which is the residual heat left over from the Big Bang.

The surface of **Venus** is dominated by volcanic features and has more volcanoes than any other planet in the Solar System.

Uranus' blue glow is due to the cold methane gas in its atmosphere.

In our solar system that are **4 planets** which don't have hard surfaces and instead have swirling gases above a solid core − known as **gas giants**: Jupiter, Saturn, Uranus and Neptune.

Uranus is an **Ice Giant planet** and nearly four times larger than Earth and has 27 moons that have been discovered so far.

The largest known structure in the universe is the **Hercules-Corona Borealis Great Wall**, a colossal collection of galaxies that stretches over 10 billion light-years across. To put that in perspective, the diameter of the Milky Way is estimated to be around 100,000 light-years.

A **photon** of energy $h\upsilon = mc^2$ generated at the center of the star makes its way to the surface. It may take up to several million years to get to the surface.

Because of its unique tilt, each season on **Uranus** lasts 21 earthly years and makes a huge difference between winter-summer and autumn-spring.

Triton is the largest of **Neptune's 13 moons** and orbits the planet backwards.

There are more stars in space than there are grains of sand in the world and there exist roughly 10,000 stars for each grain of sand on Earth.

As photon travel near the **event horizon** of a black hole they can still escape being pulled in by gravity of a black hole by traveling at a vertical direction known as **exit cone**. A photon on the boundary of this cone will not completely escape the gravity of the black hole. Instead it orbits the **black hole**.

The **cosmos** is expanding, and it is expanding faster. Two separate teams of astronomers were researching far-off **supernovae** when they made this discovery in 1998.

Tachyons are theoretically postulated hypothetical particles that always travel faster than light and have 'imaginary' masses.

Neptune is 17 times the mass of Earth and takes nearly 165 Earth years to make one orbit of the Sun.

Pluto's largest moon, **Charon** − also known as **Pluto I**, is half the size of the dwarf planet Pluto.

A day on **Pluto** is 6.4 Earth days or 153.3 hours long.

Saturn is the second largest planet in our solar system and a gas giant with an average radius of about nine times that of **Earth**.

The **inner planets** or **rocky** and **terrestrial planets** − Mercury, Venus, Earth and Mars are the four planets that orbit closest to the Sun.

Only 5% of the universe is visible from Earth.

The **heaviest elements**, such as gold, silver, and platinum, are formed in the **violent explosions of supernovae**. These explosions occur when a massive star runs out of fuel and collapses in on itself, releasing an enormous amount of energy.

It takes sunlight an average of 8 minutes and 20 seconds to travel from the Sun to the Earth.

There are **three main types of galaxies**: elliptical, spiral and irregular.

There are about 100 thousand million stars in the Milky Way alone.

The **Andromeda Galaxy** is a barred spiral galaxy approximately 2.5 million light-years from Earth and the nearest major galaxy to the Milky Way.

The warp and twist of space-time near the earth. The Moon follows this **warp of spacetime** as it orbits Earth.

The universe is thought to be flat, meaning that parallel lines will never meet, and the sum of the angles of a triangle adds up to 180 degrees. This conclusion was drawn from **observations of the cosmic microwave background radiation** and the **large-scale structure of the universe**.

Light exhibits **wave-particle duality**, which means that it can act as both a wave and a particle. In some experiments, light behaves like a wave, while in others, it behaves like a particle.

The **astronomical unit** is a unit of length, roughly the distance from Earth to the Sun and equal to about 150 million kilometers (93 million miles) or ~8 light minutes.

Astronauts can grow approximately two inches (5 cm) in height when in space.

Exoplanets or extrasolar planets are planets that orbit around other stars.

The **Enormous dust cloud** at the center of the Milky Way smells like rum and tastes like raspberries.

Our only proper natural satellite moon is being pushed away from Earth by 1.6 inches (4 centimeters) per year.

Saturn is the only planet that is lighter than water.

Asteroids are the rocky planetoids revolving around the sun and the byproducts of formations in the solar system − more than 4 billion years ago.

The **Earth** weighs about 81 times more than the Moon.

Light can bend and refract when it passes through different mediums, such as air, water, or glass. This is because light travels at different speeds in different mediums, causing it to change direction.

The **moon's density** is 3.34 grams per cubic centimeter. That is about 60 percent of **Earth's density**.

Mercury is the hottest planet in our solar system and has no atmosphere − which means there is no wind or weather.

There are **88 recognized star constellations** in our night sky.

Due to the Sun and Moon's gravitational pull, we have tides.

The **five best known dwarf planets** in our Solar System are: Ceres, Pluto, Makemake, Haumea and Eris.

Light can be polarized, which means that the electric field vector of the light waves oscillates in a specific direction. This is used in many technologies, including **Liquid Crystal Display** (LCD) screens and polarized sunglasses.

Mars is the second-smallest planet in the Solar System and the most likely planet (which carries the name of the **Roman god of war**) in our solar system to be hospitable to life.

Pluto is smaller than Earth's moon and is only half as wide as the United States.

Astronaut's footprint can last a million years on the surface of the moon as there is no wind.

There are 79 known moons orbiting Jupiter.

Most part of the atom is empty.

Temperature greater than **Planck temperature** cannot exist only for the reason that the **quantum mechanics** breaks down at temperature greater than 10^{32}K.

Gravity waves are vibrations in the 4 dimensional fabric of space-time. Gravitons are their quanta.

Exposure to light can affect our sleep patterns. **Blue light**, which is emitted by electronic devices such as smartphones and tablets, can disrupt the body's production of **melatonin**, a hormone that regulates sleep.

DNA carries information but cannot put that information to use, or even copy itself without the help of **RNA** and protein.

There is no escape from a **black hole** in classical theory, but quantum theory enables energy and information to escape.

The more massive a star, the more luminous it will be. This rule is called the **mass luminosity law**.

The objects of different masses are accelerated towards the earth at the same rate, but with different forces.

When we place two long parallel uncharged plates close to each other, virtual particles outside the plates exerts more pressure than the virtual particles inside the plates, and hence the plates are attracted to each other, which we call the **"Casimir effect."**

Newton rings is a phenomenon in which an interference pattern is created by the reflection of light between two surfaces — a spherical surface and an adjacent flat surface. It is named after **Isaac Newton**, who first studied them in 1717.

Electric and magnetic forces are far stronger than gravity, but remain unnoticeable because every macroscopic body contain almost equal numbers of positive and negative electrical charges (i.e., the electric and magnetic forces nearly cancel each other out).

By analyzing the **stellar spectrum**, one can determine both the temperature of a star and the composition of its atmosphere.

If the **leptons** would have felt the strong force, then they would have combined to form different particles. The entire picture of Particle Physics would have been quite different.

As **mercury** repeatedly orbits the sun, the long axis of its elliptical path slowly rotates, coming full circle roughly every 360,000 years.

Energy budget of the universe:

13.7 Billion Years ago (when the Universe was 380,000 years old):

Dark Matter: 63%

Neutrinos: 10%

Photons: 15%

Ordinary Matter: 12%

Today:

Dark Matter: 23 %

Dark Energy: 73%

Ordinary Matter: 4%

Out of 4% we only make up 0.03% of the ordinary matter.

Neither of these extremes would have allowed for the existence of stars and life: A **slightly stronger weak force**, all the neutrons in the early universe would have decayed, leaving about 100 percent hydrogen, with no deuterium for later use in the synthesizing elements in stars. A **slightly weaker weak force**, few neutrons would have decayed, leaving about 100 percent helium, with no hydrogen to fuel the fusion processes in stars.

Matter bends the fabric of space and time. The distortion of the **space-time** affects the path of light.

"Matter tells space how to curve, and curved space tells matter how to move."

Matter → curvature of space-time

The **two neutron stars** that are orbiting each other continually emit **gravitational waves**. These waves carries energy at the speed of light and are now considered as fossils from the very instant of creation . . . . since no other signal have survived from that era.

The **quarks** are much smaller than the wavelength of visible light and so they do not possess any color in the normal sense.

Surface gravity $g = GM/R^2$ is the same at all points on the event horizon of a black hole, just as the **temperature** is the same everywhere in a body at thermal equilibrium.

Every **living cell** of cyanobacteria, and eventually higher plants (including flowering angiosperms, orchids, conifers and other cone bearing gymnosperms, ferns, club mosses, hornworts, mosses and the **multicellular eukaryotes** of the kingdom Plantae)possess tiny molecular factories, called **chloroplasts**, which are in charge of a dye sensitized photochemical redox process - the conversion of sunlight, water and carbon dioxide into carbohydrates and oxygen.

$$6CO_2 + 6H_2O + \text{Sunlight} \rightarrow C_6H_{12}O_6 + 6O_2$$

Ordinary matter is made of atoms; atoms are made of nuclei, nuclei made of quarks.

Gravitational force $F_G = GMm/r^2$ is a purely attractive force which keeps the planets in orbit around the sun and the moon in orbit around the Earth.

Sun and other stars all emits approximately a **black body radiation** filling up the universe giving a concrete evidence for the **Stefan- Boltzmann law** i.e., power radiated per unit area is proportional to the fourth power of their temperature and the proportionality constant is **Stefan's constant**.

In any closed system like universe: randomness or entropy never decreases with time.

Neutrinos only feel the weak force.

Black hole is a region of space-time. According to the **theory of relativity**, nothing can travel faster than light. Thus if light cannot escape, neither can anything else; everything is dragged back by the gravitational field.

Energy can neither be created nor destroyed; it can only be transferred from one form to another.

Chandrasekhar limit (≈1.4 times the mass of the sun) is the maximum possible mass of a stable cold star, above which it collapses into a cosmic body of extremely intense gravity from which nothing, not even light, can escape.

The energy above which **(Grand unification energy)**, the electro-magnetic force, weak force, and strong force become indistinguishable from each other.

The distance — and the path — that a body travels, looks different to different observers.

The **wavelength of a wave** is the distance between successive peaks or troughs. Faint light means fewer photons.

Wormholes provides shortcuts between distant points in space.

In more than **three spatial dimensions**, planetary orbits would be unstable and planets would either fall into the sun or escape its attraction altogether.

Neutron stars are the fastest spinning objects known in the universe.

The decrease in frequency of light from distant galaxies due to the **Doppler effect**, indicate that they are moving away from us.

The **universe** was in perfect symmetry before the **big bang**. Since then, the universe has cooled and expanded, and hence the four fundamental forces of nature and their symmetries have broken down. Today, the **universe** is horribly broken, with all the forces split off from each other.

Electric and magnetic fields turn into each other in a wavelike motion, creating an electromagnetic field that travels at the speed of light.

The **gravitational force of attraction** between the sun and every planet is due to the exchange of a particle of spin 2 called the **graviton** between the particles that make up these two bodies. And this exchange makes the planets orbit the sun with a velocity = $(2GM / r)^{1/2}$.

Accelerated massive bodies give off **gravitational waves** just as bound electrons in an atom emit electromagnetic radiation.

The **laws of physics** remain unchanged under the combination of operations known s C, P, and T (C → changing particles for antiparticles. P → taking the mirror image so left and right is swapped for each other. T → reversing the direction of motion of all particles — in effect, running the motion backward).

Speed of light is the limiting velocity in the universe, unaffected by the movement of its source and independent of all observers.

Solids, liquids, and gases frame up the three familiar states of matter, but **plasma** (a gas of ionized atoms) form the fourth state of matter.

Mercury does not have any moons or rings.

Venus is named after the **Roman goddess of love and beauty** and rotates in the opposite direction to most other planets.

The proton is composed of two up quarks and one down quark. The neutron is composed of two down quarks and one up quark.

Friction takes place when one object tries to slide over the surface of another.

Quarks feel the strong force, leptons do not.

All **antiquarks** have baryon number = − 1/3

All reactions must conserve energy, momentum and electrical charge.

For each particle species there is a threshold temperature: $T = m_0c^2/ k_B$. Once the universe drops below that temperature the species is effectively removed from the universe.

The first object considered to be a black hole is **Cygnus X-1**.

Little **black holes** may have formed immediately after the cosmic explosion that marked the beginning of the universe. Quickly growing space may have crushed some regions into tiny, dense black holes less massive than the sun.

If a star moves too close in proximity to a supermassive black hole, the star can be torn apart.

Because a **black hole** is a region of space having a gravitational field so intense that no matter or radiation can escape — it's impossible for us to see them with the naked eye or sense the hole directly through our instruments.

Black holes distort time and space around them.

There is a **supermassive black hole** at the heart of the **Milky Way** (the galaxy that contains our Solar System) — it is four million times more massive than the sun.

Nothing can travel faster than light, but that doesn't apply to the stretching of space. During the universe's inflationary phase, space expanded much faster than light.

Both space and time were created at the Big Bang. Before that, neither time nor space existed.

It is believed that all the **4 basic forces of nature** (gravity, strong nuclear, weak nuclear and electromagnetic) were combined into a single **"super"** force prior to 10^{-43}s after the Big Bang.

At the Planck time $(\hbar G / c^5)^{1/2}$, gravity is thought to have separated from the other forces.

The lowest mass atom is the hydrogen atom, with one electron and a nucleus consisting of just one proton.

The **electron-Volt** is a very small energy unit:

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ joule}$$

The **neutron** has a mass of 939.57 MeV and it decays into a proton, an electron and an antineutrino:

neutron → proton + electron + antineutrino

Antineutrinos colliding with a proton may produce a neutron and a positron:

antineutrino + proton → neutron + positron

Free antineutron decays into an antiproton, a positron and a neutrino:

antineutron → antiproton + positron + electron–neutrino

The more **inertia** that a body has, the more mass that it has.

Because $F_G = GMm / r^2$: the force of gravitational attraction decreases as we move away from the earth by distance squared.

Gravitational potential energy (PE = mgh) increases as height increases.

Light slows down, bends toward the normal and has a shorter wavelength when it enters a medium with a higher **index of refraction**.

White light is actually made up of all the colors of the rainbow. When light passes through a prism, it is refracted and separated into its component colors, creating a **rainbow-like effect**. A prism produces a rainbow from white light by dispersion.

The period of a wave is the inverse of its frequency. So waves with higher frequencies have shorter periods.

Only waves show diffraction, interference and the polarization.

Whenever charged particles are accelerated, electromagnetic waves are produced.

Named after the Greek word for the sun, **Helios**, Helium is the second most common element in the universe. Long before it was discovered on Earth, **Helium** was first discovered in the sun's spectral lines. A completely unreactive, colorless, and odorless gas.

Quarks were first predicted by physicists **Murray Gell-Mann** and **George Zweig** in the 1960s. At the time, there was no experimental evidence for the existence of quarks, but their existence was later confirmed by experiments. Quarks are some of the smallest known particles in the universe. They are much smaller than the protons and neutrons they make up. Quarks are constantly exchanging particles called gluons, which mediate the strong nuclear force that binds them together. They are always found in groups of two or three, never alone. This is due to a property called **color confinement**, which means that quarks are always bound together by the strong nuclear force.

It takes 225 million years for our Sun to travel round the galaxy.

Only one two-billionth of the Sun's energy hits the Earth.

Earth is the only known planet with plate tectonics.

The planet with the hottest surface temperature is not **Mercury**, but **Venus**, because of the Greenhouse Effect of its atmosphere.

You could fit 1.3 million Earths in the Sun.

It takes 8 minutes for the Sun's light to reach Earth.

The Sun is about 4.5 billion years old and is 92,960,000 miles away from Earth.

The Sun can appear blue when viewed at a wavelength of about 475 nm.

The **gravity of the Sun** is 28 times larger than Earths and there are thousands of colder patches on the Sun − they are called 'Sunspots'. These sunspots form in areas of strong magnetic activity that inhibit heat transfer.

The Suns magnetic polarity reverses every eleven years.

The atmosphere of the Sun is composed of three layers:

The **photosphere** (layer at which the Sun becomes opaque to radiation)
The **chromosphere** (emits a reddish glow as super-heated hydrogen burns off)
The **corona** (the Sun's outermost layer that merges with the solar wind)

To match the energy of the Sun, it would take 100 billion tons of dynamite exploding every second.

The Sun rotates in the opposite direction to Earth with the Sun rotating from west to east instead of east to west like Earth.

Helium is the only element that was not first discovered on Earth. Instead, it was discovered in 1868 in the form of previously unknown spectral lines in the light of the sun.

Going as fast as the **Earth** we could reach the reach the moon in 3.5 hours.

The **Earth** Isn't a Perfect Sphere − It Has a 27 Mile Tall Bulge at Its Belly.

If you leave at Age of 15 in a Spaceship at Speed of Light and Spends 5 Years in Space, when you get back on Earth you will 20 Years old. But all of your Friends who were 15 when you Left, will be 65 Years Old at that Time.

There's a highway in Space, called the **Interplanetary Superhighway**. It is used to send spacecraft around the solar system with least resistance using gravity.

Time slows down at high speeds and around massive objects. It completely stops at the speed of light and at the event horizon of a black hole and does not exist at the center of a **black hole**.

Without the discovery of wormholes, there is no scope for interstellar travel.

Even if we travel at the speed of light, it would take millions of years to get to the nearest galaxy.

Because of time dilation:

Your head is older than your feet.

The earth's surface is 2.5 years older than its core.

Clocks placed at higher altitudes run faster than the clocks at lower altitudes.

Three physicists flew around the world twice in 1971 with synced atomic clocks to test out thetime dilation theory. Upon meeting up, they found that all 3 of the clocks disagreed with each other.

YOU CANNOT CRY ON SPACE BECAUSE

YOUR TEARS WON'T EVER FALL.

Sunspots are regions on the Sun's surface where the magnetic field's lines of force are bent and ripped. As a result, strong plasma discharges known as solar flares happen in these regions.

The speed of a **meteoroid** traveling through the earth's atmosphere has speed at least 5 times of that of sound. Their mere passing by a building can lead to broken windows due to shock waves.

According to astronauts, space smells like seared steak, hot metal and welding fumes.

Astronauts on the international space station witness around 15 sunrises and 15 sunsets every day.

99% of matter is empty space. If you removed all the space within our atoms, then humanity (7 billion people) would fit into one sugar cube.

Light is used for long-distance communication through **fiber optic cables**, which transmit data using pulses of light. This technology is used for internet and telephone communication, as well as many other applications.

The coldest temperature ever recorded in the known universe was in **Massachusetts**, MIT, where scientists attained temperatures 810 trillionths of a degree Fahrenheit above the absolute zero (-459.67°F).

Plasma is actually the most common phase of matter in the universe (consists of a gas of ions – atoms or molecules which have one or more orbital electrons stripped, and free electrons), despite being rare on Earth. The Sun, the stars, and most of the interstellar matter in the universe are comprised of plasma.

If **astronauts** traveled in a spaceship at a constant "1g"of acceleration, they could travel the entire universe in their own lifetime, while billions of years would have passed by on earth.

Luminosity→ how much energy the Sun releases each second

Nuclear fission→ Splitting of an atomic nucleus

Nuclear fusion→ Fusion of two atomic nuclei

If an astronaut in Earth's orbit fired a bullet at the Sun at 1500ft/sec it would take roughly 10.4 years to hit its target.

YOU ARE THE SAME AGE AS THE UNIVERSE BECAUSE
MATTER CAN NEVER BE CREATED OR DESTROYED.

Because the period of a **planet's orbit** increases with increasing distance from the sun:
Mercury (the innermost planet) takes only 88 days to orbit the Sun.
The **earth** takes 365 days, while Saturn requires 10,759 days to do the same.

period→ The time a planet takes to complete one orbit around the sun.
semimajor axis→ size of orbit.
eccentricity→ how elongated the orbit is.

perihelion (position of smallest distance to sun): The point in the orbit of a planet that is nearest to the sun.

aphelion (position of greatest distance to sun): The point in the orbit of a planet most distant from the sun.

Light can be used to create energy through **solar panels**, which convert sunlight into electricity. This technology is becoming increasingly popular as a renewable energy source.

Half the atoms in our galaxy − including the atoms in our body − likely came from outside the **Milky Way** (i.e., came from across the universe).

The **largest galaxy** in the observable universe is an elliptical galaxy, **IC 1101**. It has 100 trillion stars and is 6 million light years across. By comparison, the Milky Way has a mere 100 billion stars and is 120,000 light years across.

When a ball is dropped to the ground, it experiences Earth's gravitational force. According to **Isaac Newton's third law of motion**, the ball exerts equal and opposite force on the ground. Even though both the ball and ground experience the same force, their acceleration is different. The mass of ground is enormous compared to that of a ball. So a ball experiences larger acceleration and the ground experiences almost negligible acceleration. Due to the **negligible acceleration**, ground appears to be stationary when a ball is dropped to the ground.

Only Earth has oxygen in its atmosphere and liquid water on its surface.

Conservation of angular momentum:

$$\text{radius} \times \text{rotation rate} = \text{constant}$$

Large radius → slow rotation
Small radius → rapid rotation

There are a **trillion stars** in the known universe for every human on Earth.

Astronauts in space need to sleep near fans so that when they exhale, there isn't a CO_2 cloud in front of their face causing them to potentially suffocate.

Giant stars→ radius between 10 and 100 times the Sun's
Dwarf stars→radius equal to or less than the Sun's
Supergiant stars→radius more than 100 times the Sun's

Carbon-detonation supernova→ If the mass of white dwarf exceeds 1.4 solar masses, electron degeneracy can no longer keep the core from collapsing. Carbon fusion begins throughout the star almost simultaneously, resulting in acarbon explosion.

We cannot see 80% of stars in the universe. If we could, the sky would look extremely cluttered. The reason why we can't see **80% of the stars** is that 80% of the stars in the universe are **Red**

Dwarfs. Red Dwarfs are dim and give off red light. Their luminosity is only 0.1% of that of the sun.

Every star in the night sky is larger than the sun.

There are 200 billion to 400 billion stars in our galaxy, but the **naked eye** can't spot more than a few thousand of them.

One of the strange properties of **dark energy** is that it has a constant energy density, regardless of the expansion of the universe. This means that as the universe expands, the **amount of dark energy per unit volume** remains constant.

The **twinkling of stars** (stellar scintillation) is caused by the refraction of light as it passes through the Earth's atmosphere.

Cool objects radiate at long wavelengths, hot objects at short wavelengths.

Photons can pass around objects which are much smaller than their wavelength.

As the earth rotates more slowly around the sun from year to year, 2016 was one second longer than 2015.

Cosmic rays are high-energy particles that originate from sources outside of the solar system. They are constantly bombarding the Earth from all directions, with an estimated 100,000 particles passing through every square meter of the Earth's atmosphere every second. **Cosmic rays** can pose a risk to human health, particularly for astronauts on long space missions, who are exposed to high levels of cosmic radiation outside of the protective shielding of the Earth's atmosphere.

The planet **Uranus** was discovered in 1781, while the Antarctica was not discovered until 1820.

The classification of **dwarf planets** is still a topic of debate among astronomers. For example, Pluto was once considered a planet but was later reclassified as a dwarf planet, raising questions about what exactly constitutes a planet.

Each year the **moon** moves 3.8 cm further from the **Earth**.

Every minute, you travel over 12,000 miles in space. That's just while standing still.

The reason why space is cold even if there is sun at the center is simply because there is no matter to absorb that heat.

Unprotected exposure to outer space can kill us in less than 30 seconds.

A **cosmic year** is the amount of time it takes the Sun to revolve around the center of the Milky Way... about 225 million years.

The Outer Space Treaty, signed by all major space faring nations, prohibits claiming territory in space or on celestial bodies. Space is considered **"the shared heritage of mankind"**.

If the Sun was scaled down to the size of a white blood cell, the Milky Way would be the size of the continental United States.

There is a mass reservoir of water floating in space that is 100,000 times bigger than our sun and holds 140 trillion times more water than all of our oceans.

Due to the highly elliptical orbit of **Pluto**, it sometimes gets closer to the Sun than **Neptune**. In fact during the years 1979 to 1999, **Neptune** was the 9th Planet and **Pluto** was the 8th Planet from the Sun.

Dark energy and **dark matter** are often confused or used interchangeably, but they are actually two separate phenomena. Dark matter is thought to be a form of matter that we cannot directly detect, while dark energy is a form of energy.

Mass and weight are not the same thing.

mass→ amount of matter.

weight → force with which gravity acts on matter.

On average a **meteor** the size of a car enters the Earth's atmosphere about once per year. Most burn up before hitting the ground.

The core of a star reaches 16 million degrees Celsius. A grain of sand this hot would kill someone from 150 kilometers away.

Continuous spectrum arise from hot, high pressure gas or solid.

Bright emission lines arise from hot, low pressure gas which radiate heat.

Dark absorption lines arise from cool, low pressure gas.

In 1954, Man arrived from Tokyo Airport. He had Passport issued by a Country named as **"Taured"** which did not exist. He had Visa of all Countries and said his Country is 1000 Years Old. Police locked him in a High Secure Room and he vanished. Experts said, he came from **Parallel Universe**.

The term **"astronaut"** comes from Greek words that mean "star" and "sailor."

Neutron stars are incredibly dense celestial objects that are created when a massive star undergoes a **supernova explosion**. These stars are composed almost entirely of neutrons and have a density of approximately 10^{17} kg/m^3.

The concept of dark energy is closely related to **Einstein's cosmological constant**. Einstein first introduced the **cosmological constant** in 1917 as a way to balance out the force of gravity and create a static universe. However, the discovery of the accelerating expansion of the universe has led to the idea that the cosmological constant may actually be a form of **dark energy**.

Astronauts in space lose on average 1% of their bone mass a month. Most of which is excreted in their urine. They literally pee their skeleton out.

Earth has a powerful magnetic field − this phenomenon is caused by nickel-iron core of the planet.

Earth doesn't take 24 hours to rotate on its axis − it's actually 23 hours, 56 minutes and 4 seconds.

There's a 30,000 kilometer hexagonal cloud at **Saturn's North Pole**.

Conduction → Heat is transmitted by electrons moving in a medium.
Radiation → Heat is transmitted by photons.
Convection → Heat is transmitted by bulk motion of a gas or liquid.

There is a weird star that appears to be shooting giant balls of plasma into space. Scientists found the bloated red giant while using the **Hubble telescope** and described the blobs as **"cannon balls"** that are twice the size of Mars and two times hotter than the sun.

Animals can sense when a solar eclipse is happening. Researchers found that when the moon passes between the Earth and Sun, cicadas stop singing, bees get restless, and squirrels run around non-stop during and for 2 hours after the eclipse.

Solar eclipse → Occur when the Moon passes between Earth and the Sun − leaving a moving region of shadow on Earth's surface.
Lunar eclipse → Occur when Earth passes between the Sun and the Moon − casting a shadow on the Moon.

Lunar eclipse can only occur at full moon and solar eclipse can occur only at new moon.

Because the Earth's orbit around the sun is not in the same plane as the Moon's orbit around the Earth − eclipses don't occur every month.

The size of the **nucleus** is typically around 10^{-14} meters, making it around 100,000 times smaller than the entire atom. The study of the nucleus and its properties is known as **nuclear physics**, which has applications in fields such as energy production, medicine, and materials science.

Polar orbit is the orbit where satellite goes over the Earth's pole.

The waves on the **Electromagnetic spectrum** are different than sound waves because they do not require a medium to travel through.

If a **"moon"** gets closer to the **"planet earth"** than this, it will get broken apart by the so-called "tidal forces".

A **crater** is an approximately circular depression in the surface of a planet − produced by the impact of a meteorite.

The **Sun** is a nearly perfect sphere, with a diameter of about 1.39 million kilometers (864,938 miles). The temperature at the core of the Sun is around 15 million degrees Celsius **(27 million degrees Fahrenheit)**, where nuclear fusion reactions take place. The Sun plays a crucial role in the **Earth's climate** and weather, and also affects space weather and the Earth's magnetic field.

Earth's atmosphere is composed of about 78% N_2, 21% O_2, 0.9% argon, and 0.1% other gases. Trace amounts of CO_2, methane, water vapor, and neon are some of the other gases that make up the remaining 0.1%.

Leptons are elementary particles that belong to the family of fundamental particles, along with quarks and bosons. Leptons are mysterious because they do not interact strongly with other particles, which mean they are not affected by the strong nuclear force that holds protons and neutrons together in the nucleus. Instead, they only interact through the weak nuclear force and electromagnetism.

Chemical analysis of **lunar rocks** revealed that these rocks are extremely similar in composition to Earth rocks.

Many planets have **magnetic fields,** but the mechanisms that produce and maintain these fields are not fully understood. For example, the magnetic field of Mars is much weaker than that of Earth, and scientists are still trying to understand why.

The fate of the universe is closely tied to the nature of **dark energy**. If dark energy continues to accelerate the expansion of the universe, it could eventually lead to a **"Big Rip"** where the universe is torn apart. However, if the amount of dark energy changes or the repulsive force weakens, the universe could eventually collapse in on itself in a **"Big Crunch."**

Protons are stable in the nucleus of an atom and do not decay over time. They can be accelerated to very high speeds using particle accelerators, such as the Large Hadron Collider. This technology is used in research to study the properties of subatomic particles. Protons are important in **nuclear physics**, as they are involved in nuclear fusion and fission reactions. These reactions are used to generate energy in nuclear power plants and to create nuclear weapons. Protons have a property known as a **magnetic moment**, which means that they behave like tiny magnets. This property is used in **magnetic resonance imaging** (MRI) to create images of the inside of the human body.

According to the **NASA**, the speed of Earth rotation is gradually slowing and it's happening at a rate of 1.4 milliseconds per 100 years. We may think it's not a big deal. But if we add up that small discrepancy every day for years and years, it can make a very big difference indeed. At this speed, the day may become 25 hours after 140 million years.

Planet Earth is 93,225,926 miles from the sun. We could go from the Earth to the moon and back 195 times in that distance.

The **Compton effect** was discovered by American physicist Arthur Compton in 1923, and earned him the Nobel Prize in Physics in 1927. It is a key process in the interaction of high-energy photons with matter, and is used in a variety of applications such as medical imaging, X-ray diffraction, and nuclear physics research.

Water covers 70% of the Earth's surface. Freshwater is about 2.5% of that total.

As Earth spins, gravity pushes inward and the centrifugal force pushes outward. However, due to the Earth's tilt, the forces are not exactly opposed, creating an imbalance at the equator and a **"spare tire"** around the planet.

The **Earth's orbit** lasts approximately 365.2 days, and it is for this reason that every four years it takes an extra day: the February 29 that we have every leap year.

The **universe** is 13.6 billion years old − whereas the Earth is only 4.5 billion years old.

Approximately 107 billion people are believed to have lived on earth, and an estimated 40% died before the age of 1.

The Earth's day or night cycle is growing longer year-by-year and 620 million years ago, the Earth day was 21.9 hours.

From 2000 BC until 1992 AD, astronomers had only discovered three new planets. In 2014, **NASA's Kepler space telescope** team announced the discovery of over 700 new planets.

Iron meteorites→almost completely made of metal.
Stony-iron meteorites→made of nearly equal amounts of metal and silicate crystals.
Stony meteorites→made of silicate minerals.

The **Earth** could eventually have a 1000-hour day in 50 billion years because the time it takes Earth to spin once on its axis keeps increasing.

The presence of dark matter was first inferred in the 1930s by the Swiss astronomer **Fritz Zwicky**. He observed the motions of galaxies within the Coma Cluster and found that they were moving much faster than they should be, based on the amount of visible matter in the cluster. **Dark matter** is thought to form a "halo" around galaxies, with the visible matter (stars, gas, and dust) concentrated in the center. The exact shape and size of the dark matter halo is still a topic of research.

If you were on the moon, the **Earth** wouldn't actually move in the sky. It would appear to wobble a little because the moon is elliptical but it would never "rise" or "set".

All the **American flags** placed on the moon are now white due to radiation from the sun.

The earth's deepest known point is the size of 24.7 Empire State Buildings end to end.

Coronal loops are structured arcs of glowing, electrified plasma that flow along the powerful, curved, magnetic fields above the Sun's surface. This one is roughly 4 times the size of Earth.

When a **peacock feather** and a **steel ball** are dropped together − air resistance causes the feather to fall more slowly than a steel ball.

Feather experiences a lot of air resistance.

Steel ball experiences a very little air resistance.

Macroscopic world deals with concepts such as temperature, volume and pressure to describe matter.

Microscopic world deals with concepts such as position, velocity and mass to describe matter.

Massless bosons → moves at speed of light, long range.

High mass bosons → moves at less than speed of light, short range.

Space is shorten in high velocity frames → **Lorentz contraction**

According to **Quantum Mechanics**, reality does not exist when you are not looking at it. This means that the universe may not exist if there was no one born to observe it.

According to the **No-Boundary proposal**, asking what came before the Big Bang is meaningless like asking what is south of the south pole, because there is no notion of the time available to refer to. The concept of time only exists within our universe.

High mass-to-luminosity ratio→ most of the matter is in the form of dark matter.
Low mass-to-luminosity ratio→ most of the matter is in the form of baryonic matter, stars and stellar remnants plus gas

Massive neutrino→Exist but very low mass
Weakly interacting massive particles (WIMPS)→ Little to no evidence of their existence
Cosmic strings→Little to no evidence of their existence

Carbon (nonmetallic chemical element in the Group 14 of the periodic table) is the structural backbone of all the building blocks and material for life − including proteins and DNA.

Neutrons have no charge, meaning that they are not attracted to or repelled by other charged particles. This allows them to penetrate deep into matter without being deflected by the electromagnetic forces that affect charged particles. They play a crucial role in nuclear reactions, as they can be absorbed by atomic nuclei to create new, heavier elements. This process is called **neutron capture** and is used in nuclear power plants and nuclear weapons.

From **Albert Einsteinian special theory of relativity**, we know that the speed of light is a maximum transfer of information. So we have no information for timescales less than the **Planck length** divided by the speed of light.

Gravitational constant→Determines strength of gravity.
Strong force coupling constant→Holds particles together in nucleus of atom.
Electromagnetic coupling constant→ Determines strength of electromagnetic force that couples electrons to nucleus.

Multiverse (many universes):

Universe with life but no intelligence.

Universe with no atomic bonds.

Universe with weak gravity – no planets.

Universe with high gravity – all black holes.

Universe with no light.

Universe with strong weak force – too much radioactivity.

Universe with weak strong force – no nuclear fusion.

Universe with no matter.

Universe with chemistry that builds and sustains intelligent life.

Electromagnetic coupling constant:

If less than its actual value− no electrons are held in atomic orbit.

If higher than its actual value− no electrons will not bond with other atoms (no molecules).

Strong force coupling constant:

If less than its actual value− hydrogen would be the only element in the Universe.

If higher than its actual value− all the elements lighter than the iron would be rare.

Gravitational constant:

If less than its actual value − stars would have insufficient pressure to overcome Coulomb barrier to start thermonuclear fusion (i.e. stars would not shine).

If higher than its actual value− stars burn too fast, use up fuel before life has a chance to evolve.

About 1 to 5% of matter in the Universe is made of baryons.

Physicists have performed an experiment that shows how time emerges from quantum entanglement.

If protons were 0.2% more massive, then they would be unstable and decay into neutrons. That would put an end to life in the universe because there would be no atoms.

Earth's average distance to the Sun = 150 million kilometers

If much lesser than this value– oceans boil away, greenhouse effect kicks in.

If much higher than this value– temperature drops, rapid Glaciation.

absorption → matter absorbs radiation.

emission → matter releases radiation.

scattering → matter and radiation exchange energy.

The most expensive material in the World is **Antimatter**. It costs about $62.5 trillion for one gram.

Dark matter is thought to be responsible for holding galaxies together. Without the presence of dark matter, galaxies would not have enough mass to maintain their shape and would fly apart due to the force of their rotation.

Just 17 grams of antimatter is sufficient enough to fuel a starship or a trip to **Alpha Centauri** which is 4.37 light years from the Sun. Sadly it would take 100 billion years to produce 1 gram of antihydrogen.

Neutrinos are among the most abundant particles in the Universe, and yet are hard to detect. They're similar to electrons, but they have no electrical charge and their mass is almost zero, so they interact very little with normal matter as they stream through the Universe at near light-speed. Billions of neutrinos are zipping through our body right now. Hence, they are also called "ghost particles."

BIOLOGY TELLS US THAT WE ARE 7% BLOOD.

CHEMISTRY TELLS US THAT WE ARE 65% WATER.

PHYSICS TELLS US THAT WE ARE 99.99999999% EMPTY SPACE.

variation + differential reproduction + heredity → **natural selection**

If two pieces of the same type of metal touch in space, they will bond and be permanently stuck together. This amazing effect is called **cold welding**.

There's a highway in Space called the **Interplanetary Superhighway**. It is used to send spacecraft around the solar system with least resistance using gravity.

Both photons and neutrinos are created inside the core of the sun. While photons take tens of thousands of years to reach the edge of the sun, neutrinos just take 2.3 seconds.

Electrons are extremely small, with a mass of only 9.11×10^{-31} kilograms. They are so small that their behavior is governed by the **principles of quantum mechanics**, which describe the behavior of particles at the atomic and subatomic level.

Phosphorus is a solid at room temperature but is self-igniting when in contact with oxygen. It becomes a liquid at 317 Kelvin.

Sulfur is a solid at room temperature and becomes a liquid at 388 Kelvin.

For every action, there is an equal and opposite reaction:

(Rockets eject material out the back at high speed to push the body of the rocket forward)

IN 1977, WE RECEIVED A SIGNAL FROM DEEP SPACE THAT LASTED 72 SECONDS. WE STILL DON'T KNOW HOW OR WHERE IT CAME FROM.

String Theory→Proposes higher dimensions at the atomic scale.
Black Hole cosmology→Every Black Hole has a Universe inside it.
Anthropic principle→Our Universe is a result of consciousness.
Occam's Razor→ If our Universe can exist with so many constrains there might be other universes with relaxed constrains.

Since there is no atmosphere in space, space is completely silent.

In 3.75 billion years the **Milky Way** and Andromeda galaxies will collide.

There is a volcano on **Mars** (Olympus Mons) three times the size of Mount Everest.

It would take 450 million years for a modern spacecraft to reach the center of our galaxy.

Newton' s First law of motion→Inertia.

Newton' s Second law of motion→Force.

Newton' s Third law of motion→Action and reaction.

Zeroth law of thermodynamics→Thermodynamic equilibrium and temperature.

First law of thermodynamics→Work, heat and energy.

Second law of thermodynamics→Entropy.

Milky Way has two major spiral arms that start at the central bar of stars, and slowly taper off. Our **Solar system** is located in one minor spiral arm called the **Orion arm**.

Galaxies come in different sizes, but also different shapes.

The first spiral galaxy we discovered, besides our own, is the **Whirlpool Galaxy** (M51).

Viscosity→ Stickiness

Compressibility→ Springiness

Diffusion→Random motion

Convection→ Ordered motion

Most particles can only travel in the (3 space + 1 time) dimensions.

Gravitons− the 2 spin bosons which propagate a force called gravity − can travel in the extra dimensions.

The most luminous star visible to the naked eye −**34 Cygni**− outshines the Sun by 610,000 times.

Jupiter could contain the other seven planets in just 70 percent of its volume.

The process of falling into a black hole — getting more and more stretched out — is known as **Spaghettification**.

The moon is the reason why we have tides and waves on Earth.

The **universe** has no centre and is constantly expanding (getting bigger) every second – making it impossible to reach the edge.

A **black hole** is created when big stars explode. Its gravitational force is so strong that nothing can escape from it – luckily the closest black hole is about 10,000 light-years from Earth.

John Michell was one of the first scientists to propose the existence of black holes. In 1783, he wrote a paper suggesting that there could be objects in the universe so massive that their gravity would be strong enough to prevent anything, including light, from escaping.

According to the **uncertainty principle**, it is impossible to know both the position and velocity of a quantum particle with absolute precision. The **uncertainty principle** leads to quantum tunneling, which is the ability of quantum particles to "tunnel" through potential barriers that would be impenetrable according to classical physics.

If we could squeeze the **Earth** down to the size of a wedding ring, it would become a black hole. We could even become a **black hole**, if we were squished down to the size of an atom.

If we were to orbit a black hole in its photon sphere and look to one direction, we would see the back of our own head.

Star orbiting the supermassive black hole at the center of the Milky Way galaxy moves just as predicted by **Albert Einstein's general theory of relativity**.

The asteroid impact at Chicxulub ejected sulfur and carbon dioxide gases that cooled Earth's average surface air temperature by as much as 26°C. This event caused a **planetary mass extinction**, including that of non-avian dinosaurs.

Black holes are smaller than we think. The radius of a typical black hole is only about 30 kilometers. If our sun were to shrink into a black hole, it would only have a radius of 3 kilometers.

Inertial frame→ one in rest or uniform motion.

In 1915, **Einstein's theory of general relativity** predicted the existence of Black Holes first.

In a **vacuum**, Electromagnetic radiation moves at a **constant speed** of about 299,792,458 meters per second. This speed is known as the speed of light and is the fastest known speed in the universe.

Most black holes are formed from the collapsed cores of massive stars that have run out of fuel and can no longer support themselves against the force of gravity. When two black holes come close to each other, they can merge to form an even larger black hole. Through this process, enormous amounts of energy are released as **gravitational waves**.

About 10^{40} years from now, matter in the Universe will be present only in the form of **black holes** and subatomic particles separated by huge distances.

Electrons play a crucial role in electricity, as they are the carriers of electric charge. When a voltage is applied to a conductor, electrons flow through it, creating an electric current. **Electrons** can be shared between atoms to form chemical bonds, or they can be transferred from one atom to another in a chemical reaction.

If you could produce asound louder than 1100 dB, you would create a black hole and ultimately destroy the galaxy.

Magnetar→ one of the most powerful objects in the Cosmos. The biggest spinning magnet to ever exist. It's the cosmic equivalent of a great white shark. But it wouldn't eat us, it would just turn all our atoms to dust!

Electrons can emit light when they move from a higher energy state to a lower energy state. This is the principle behind many types of lighting, including **fluorescent and LED lights**. Electrons play a crucial role in biological systems, as they are involved in many biological processes, including **photosynthesis** and **cellular respiration**.

Why haven't we met Extraterrestrial beings?

We are the only intelligent life in the Cosmos.

Other Intelligent Extraterrestrial beings died in mass extinction events. We might even be the next!

Other Extraterrestrial beings are too intelligent and we are simply not worth their time.

Life first began on planet Earth. We are the most advanced beings. They are too far and out of our reach.

Extinction = Absorption + Scattering

Slow neutron capture→ There is sufficient time for the radioactive decay to occur before another neutron is captured.

Rapid neutron capture→There is no sufficient time for the radioactive decay to occur before another neutron is captured.

CHUNKS OF GALAXY ARE BEING PULLED AWAY INTO COMPLETE DARKNESS IN A PHENOMENON KNOWN AS 'DARK FLOW'

If reaction products have larger binding energy than reactants, reaction is exothermic and releases energy (heat).

A **meteor shower** is a phenomenon in which many meteors fall through the atmosphere in a short period of time.

Asteroids are rocky objects that orbit the Sun and are found primarily in the asteroid belt, a region between Mars and Jupiter. They occasionally collide with each other, creating fragments that can be scattered throughout the Solar System and potentially impact Earth. The **asteroid impact** that occurred 65 million years ago is believed to have caused the extinction of the **dinosaurs** and many other species. **Asteroid mining** is a proposed industry that could involve extracting valuable resources, such as water and metals, from asteroids for use in space exploration and commerce.

Meteorites are the rocks that survive the fiery descent through Earth's atmosphere.

Bound-free absorption→The absorption of light during ionization of a bound electron.
Free-free absorption→ The absorption of light when scattering a free ion.

Kirchhoff's law of thermal radiation: In thermal equilibrium, the emissivity of a body is equal to its absorptivity.

Sometimes comets are referred to as **"dirty snowballs"** or **"cosmic snowballs".** This is because they are composed mostly of ice, rock, gas and dust.

60 % of Earth's Population Lives on 30% of Earth's Landmass.

Earth's Tilt→The Reason For Change In The Seasons.

Quantum fluctuations occur even in the vacuum of empty space, where there are no particles or fields present. **Quantum fluctuations** play a crucial role in many phenomena in physics, including the **Casimir effect**, which is a force that arises between two parallel metal plates due to the fluctuating electromagnetic fields in the vacuum.

For low mass stars, temperature never reaches that required for **Carbon burning**.

There are 45 miles of nerves in the body.
Number of bones in arms → 6.
Number of bones in human foot →33.
Number of bones in each wrist → 8.
Number of bones in hand → 27.
Number of bones in each human ear → 3.

Human fingers can detect nano-size objects. This means we not only have the ability to feel a tiny bump the size of a large molecule, but if our finger was the size of Earth, we could determine the difference between a house and a car.

The **human brain** (when awake) produces enough electricity to power a 40 watt light bulb for 24 hours.

Biology is the only branch of science in which multiplication means the same thing as division.

Neutrinos are produced in many different types of nuclear reactions, including those that occur in stars, nuclear reactors, and cosmic rays. They have very weak interactions with matter and can pass through solid objects such as the Earth without being stopped. Hence, they may be challenging to find them.

Even though our **brain** is only about 2% of our body's weight, about 3 pounds, it uses 20-30% of the calories we consume.

Sir **Issac Newton** stuck a sewing needle under his eyeball, pushed it all the way to the back of his eye socket, and wiggled it around to test his theory of optics.

An average human produces enough saliva in a lifetime to fill two swimming pools.

The name **virus** was coined from the Latin word meaning slimy liquid or poison.

When eyelashes are disturbed, the nerve at its bases initiates reflex action to close the eyelids.

The acid in our stomach is strong enough to dissolve razor blades.

A piece of brain tissue the size of a grain of sand contains 100,000 neurons and 1 billion synapses, all "talking" to one another.

EVERY NUCLEUS IN THE HUMAN BODY HAS DNA OF 6 FEET LONG.

Honey is the only food that doesn't rot. A Honeypot can remain edible for more than 3000 years.

A **chicken egg** is one giant cell. One chicken egg is about 1000 times larger than the average cell in your body.

Butterflies taste something not with their mouth but with their feet.

The **color of a star** is an indication of its temperature, with blue stars being hotter than red stars. However, the exact relationship between a star's color and its temperature is still not fully understood.

Time dilation is a fundamental aspect of the **theory of relativity**, and has been verified by numerous experiments and observations, including the famous **"twin paradox"** thought experiment. The amount of **time dilation** increases as the speed of the moving object approaches the speed of light. **Time dilation** has important implications for space travel, as it means that time would appear to pass more slowly for astronauts on a high-speed spacecraft or in a region of strong gravitational field.

The average human body contains 10 times more bacterial cells than human cells.

The number of bacteria in a person's mouth is equal to the number of people living on earth, or even more.

More than 100000 chemical reactions occur every second in our brain.

A NEW BORN CHILD RESPIRES 32/MIN
A FIVE YEAR OLD CHILD RESPIRES 26/MIN
A FIFTY YEAR OLD MAN RESPIRES 18/MIN

If even a Small amount of Liquor is put on a Scorpion, it will go mad and Sting itself. If we pour cold water into a person's ear, his eyes will move in direction of the opposite ear. If we pour warm water into his ear, his eyes will move towards that ear. This is used to test for brain damage and is called **'Caloric Stimulation.'**

In 2015, scientists sent flatworms to the **International Space Station** for five weeks, to see how space affected their growth. One of the worms grew a second head. Scientists later amputated the heads, and both of them grew back, showing that space had permanently changed the worm.

The longest bone in an adult human is the **thighbone**, measuring about 18 inches (46 cm). The shortest bone is in the ear and is just 0.1 inches (0.25 cm) long, which is shorter than a grain of rice.

Universe is 13.7 billion years old
Planet Earth is 4.5 billion years old
Modern humans are 150 thousand years old

Helium has two protons, two neutrons and two electrons. Together, helium and hydrogen make up 99.9 percent of known matter in the universe.

Rare Earth hypothesis: Complex extraterrestrial life is improbable and extremely rare.

Abiogenesis: Life arose from nonlife more than 3.5 billion years ago on Earth.

Biogenesis: Life is derived from the reproduction of other life.

A person's feet has about 500,000 sweat glands and can produce about a pint of sweat a day.

There are more than a trillion life forms living on our skin.

Today there are **eight billion people** living on the planet earth.

In other words, there are 100 times more life forms living on our skin than the number of humans living on the planet!

Only one letter doesn't appear in the periodic table. It's the letter "J".

If a human being's DNA were uncoiled, it would stretch 10 billion miles, from Earth to Pluto and back.

Lithium is the most reactive metal in the entire periodic table.

The **taste cells** in our taste buds live for only about two weeks.

There are 90 elements on the **periodic table** that occur in nature. All of other elements are artificially synthesized in laboratory.

One ampere = one coulomb of electrical charge ($6.24150974 \times 10^{18}$ electrons) moving through a specific point in one second.

Solar wind: Stream of electrons and protons with energies usually between 1.5 and 10 keV ejected from the upper atmosphere of the Sun.

Nuclides with the same mass number were termed **isobars**.
Nuclides with the same atomic number were termed **isotopes**.
Nuclides with the same neutron number were termed **isotones**.

Geomorphology: The study of landforms, their classification, origin, development and history.

Perhaps **Benjamin Franklin's most well-known experiment**, which contributed to the creation of the lightning rod and the understanding of positive and negative charges, was flying a kite in a storm.

A photon may turn into an electron-positron pair if its energy $h\upsilon$ exceeds the rest-mass energy of the pair ($h\upsilon > 2m_ec^2$).

Our Sun has a mass of approximately 2,000,000,000,000,000,000,000,000,000,000 kilograms, there are about 300,000,000,000 stars in our Milky Way galaxy, and there are between 50,000,000,000 and 1,000,000,000,000 galaxies in the observable Universe.

If the Earth's crust were significantly thicker, plate tectonic recycling could not take place.

The atmosphere inTitan, Saturn's Moon, is so thick and the gravity so low, that humans could fly through it by flapping "wings" attached to their arms.

Earth mass and size: If smaller than its actual value − its magnetic field would be weaker, allowing the solar wind to strip away our atmosphere held in place by the earth's gravity, slowly transforming our planet into a dead, barren world much like planet Mars.

The sky always appears dark on the moon because it doesn't have an atmosphere. On Earth, the sky is blue because molecules in the air scatter blue light from the sun.

In some cases lightning can go upward into space. It was spotted near the island of **Naru** in the Pacific Ocean.

Comets are icy objects that orbit the Sun and are known for their bright tails and periodic appearances in the night sky. They were once believed to be omens of disaster or upheaval, and their appearance was often seen as a sign of impending doom. The famous **Halley's Comet** is a short-period comet that orbits the Sun every 76 years and was last visible from Earth in 1986. It is named after the astronomer **Edmond Halley**, who accurately predicted its return.

Accretion disks are commonly observed around black holes, which are some of the most massive and dense objects in the universe. The intense gravity of a black hole can draw in matter from nearby stars or gas clouds, forming a disk around the black hole. The study of **accretion disks** has helped astronomers to understand the processes of star formation and the behavior of black holes.

The **octopus** is incredibly intelligent life form. It is the only invertebrate that is capable of emotion, empathy, cognitive function, self-awareness, personality, and even relationships with humans. Some speculate that, without humans, octopi would eventually take our place as the dominate life form on Earth.

Mars atmosphere is filled with 96% of $CO_2$and just 2% O_2.

Satellites can travel at 18000 miles per hour that means that in a day a satellite can go around the earth 14 times. There are over 2500 satellites orbiting earth at this moment.

When we see a halo around the sun, or moon, it means that rain or storm is coming.

Some stars are known as **variable stars**, meaning that their brightness changes over time. The reasons for these variations are not fully understood, but they may be due to changes in the star's internal structure or the presence of companion stars in a binary system.

The concept of zero point energy was first proposed by **Albert Einstein** and **Otto Stern** in 1913. **Zero point energy** is a fundamental aspect of the quantum mechanical description of the universe, and it has been observed in numerous experiments. One of the most famous experiments that demonstrated the existence of zero point energy is the **Casimir effect**, which shows that two metal plates placed in a vacuum, will be attracted to each other due to the presence of zero point energy.

When magnetic ferrofluid comes in contact with a magnetic object, it becomes a moving sculpture that reflects the shape of the object's magnetic field.

On average, gravity on a neutron star is 2 billion times stronger than gravity on Earth. In fact, it's strong enough to significantly bend radiation from the star in a process known as **gravitational lensing**, allowing astronomers to see some of the back side of the star.

The word atom means undivided.

The **boiling point** is the temperature at which a substance changes from a liquid to gas.

Protons have a mass of approximately 1.0073 atomic mass units. This makes them much heavier than electrons, which have a mass of approximately 0.0005 atomic mass units. The number of protons in an atom's nucleus determines what element it is. For example, all atoms with six protons are carbon, while atoms with eight protons are oxygen.

Fusion reactions can take place only at very high temperature of the order of $10^7$to 10^9 Kelvin. Hence, **fusion reactions** are termed thermonuclear reactions.

If we were to fill a bucket the size of the Sun with water and pour it on the **Sun**, it wouldn't extinguish it. Instead, it will add to the Sun's mass and increase its **Hydrogen and Oxygen** reserves − creating a bigger blue-white star 13 times the original size, and would fry nearby planets.

Empty space is not truly empty, as it still contains energy and virtual particles that appear and disappear continuously. The existence of virtual particles in empty space is a consequence of **quantum mechanics**, which predicts that even in a vacuum, particles and anti-particles can spontaneously appear and annihilate each other. The **study of empty space** has led to important advances in our understanding of fundamental physics, such as the development of **quantum field theory** and the **prediction of the Higgs boson**.

An average human emits about **150 anti-electrons** (positrons) per hour. These positrons come from the decay of potassium-40 isotope present in your body. At this rate, we need about 10^{21}years to produce just 1 gram of positrons.

The **earth** is not the center of the Universe.

The **twin paradox** was first proposed by **Paul Langevin** in 1911, before the development of special relativity. In the **twin paradox**, one twin remains on Earth while the other twin travels away from Earth at high speeds and then returns. Due to time dilation, the traveling twin appears to age more slowly than the twin who remained on Earth. The **twin paradox** has important implications for space travel, as it suggests that astronauts traveling at high speeds could experience significant time dilation compared to people on Earth.

The **Big Bang theory**, which is the prevailing scientific explanation for the origin of the universe, suggests that everything started from a single point of infinite density and temperature. So, the entire universe was once the size of a single atom.

The **cornea** is the only organ in the entire human body that has no blood supply. It gets oxygen directly from the air.

The **arrow of time** is a concept that describes the direction of time's flow, from the past to the future, and is related to the increase in entropy over time.

The **photoelectric effect** was first observed in the late 19th century by the German physicist **Heinrich Hertz**. It was further studied and explained by the physicist **Albert Einstein** in 1905, as part of his theory of the quantum nature of light. The **photoelectric effect** played a key role in the development of quantum mechanics, as it provided experimental evidence for the idea that energy is quantized in discrete units, rather than being continuous.

Hydrogen is an explosive gas. Oxygen supports combustion. Still when these are combined it is water which is used to put out fires.

There are 2,271 Satellites currently in orbit! Russia has the most satellites currently in orbit, with 1,324 followed by the U.S.A. with 658.

There is a **giant cloud of alcohol** in the Milky Way galaxy that could fill 400 trillion trillion pints of beer. So, if you ever run out of alcohol on a long space journey, you know where to go.

Wormholes were first proposed by Albert Einstein and Nathan Rosen in 1935 as a solution to the equations of general relativity. They are often referred to as **"Einstein-Rosen bridges"** after the two scientists who first proposed their existence. **Wormholes** are often depicted in science fiction as a means of faster-than-light travel, allowing spacecraft to travel vast distances across the universe in a short amount of time.

The **Kessler effect** is the theory that a single destructive event in low earth orbit could create a cascade where satellites break up into tiny fragments taking out other satellites, breaking up into smaller fragments and so on.

The **Solar System** is thought to have originated from the Solar Nebula, a cloud of gas and dust, some 5 billion years ago.

> The elements that make up our bodies, such as carbon, nitrogen, and oxygen, were created in the hearts of stars billions of years ago. So, in a sense, **we are all children of the cosmos**.

These are some of the **fascinating scientific facts** that everyone should be aware of. We refer to the totality of all objects that exist in space as the "universe." It contains countless stars, galaxies, black holes, vast gas clouds, and a variety of other amazing objects. For many of us, it has always been an intriguing place. It is full of strange and exotic objects, such as black holes, quasars, and pulsars. Some of these objects are so bizarre that they almost seem like something out of science fiction. We are all enthralled by the components of our universe, from its acceleration and expansion to dark matter and energy, and we have always been curious about its various mysteries. The cosmos is so enigmatic, yet we continually learning more about it, so it's always interesting to learn anything new about it. These amazing universe facts will help you understand how insignificant we are all in the scheme of things. The universe is a vast and fascinating place, filled with incredible wonders and mysteries that continue to baffle scientists and amaze ordinary people.

◆ ◆ ◆

CHAPTER 5

The Hall of Shame: How Bad Science can cause Real Harm in Real Life

Although Nature needs thousands or millions of years to create a new species, man needs only a few dozen years to destroy one.

−Victor Scheffer

◆ ◆ ◆

There are no qualms in accepting the fact that − in the past −things were different from what they are now. Even though science transformed extensively from our personal laptops, tablets, and phones to advanced machinery, it is yet a continuing effort to discover and increase human knowledge and understanding. **Science** is ubiquitous and has made very rapid progress and completely transformed outwardly the manner of our living— allowing us to develop new technologies, solve practical problems, and make informed decisions— both individually and collectively. **New medications**, therapies, and medical advancements made possible by science have helped people all over the world live longer and healthier lives. **Improved crop yields** as a result of agricultural science advancements have helped feed the world's expanding population. Technology improvements in communication technologies have made it possible for us to quickly communicate with individuals all around the world. In its pursuit of excellence, it has lead to pollution, **environmental crisis**, greater violence, sorrow, tension, new pathogenic diseases, chemical and biological war to name a few. The **advancement of technology and automation** in many industries has led to job losses and social unrest. Some technological advancements, such as the widespread use of electronic devices, have been linked to health risks such as eye strain, insomnia, and addiction. On the one hand, **Science** (a system of acquiring knowledge based on scientific method and research) has been a boon to mankind and on the other hand, it has also proved to be a cause of great distress or annoyance.

We **humans**, who began as a mineral and then emerged into plant life and into the animal state and then to beingaggressive mortal beings who fought a **survival struggle** in caveman days, to get more food, territory or partner with whom to reproduce, now are glued to the TV set, marveling at the adventures of science and their dazzling array of **futuristic technology** from teleportation to telekinesis: rocket ships, fax machines, supercomputers, a worldwide communications network, gas-powered automobiles and high-speed elevated trains. The science has opened up an entirely new world for us. And our lives have become easier and more comfortable. **Advances in technology**, such as smartphones, computers, and the internet, have made our lives more convenient and connected. We can now shop online, work from home, and communicate with people all over the world with ease. Science has led to the development of faster and more efficient modes of transportation, such as cars, planes, and trains. These advancements have made travel more comfortable, affordable, and accessible. **Science** has enabled us to harness new sources of energy, such as solar and wind power. This has led to a more sustainable and environmentally friendly way of producing energy, making our lives more comfortable while minimizing the impact on the planet. With the help of **science** we have estimated about 8,000 chemotherapeutic exogenous nonnutritive chemical substances which when taken in the solid form by the mouth enter the digestive tract and there they are transformed into a solution and passed on to the liver where they are chemically altered and finally released into the blood stream. And through blood they reach the site of action and binds reversibly to the target cell surface receptors to produce their pharmacological effect. And after their pharmacological effect they slowly detaches from the receptor. And then they are sent to the liver. And there they are transformed into a more water soluble compound called

metabolite and released from the body through urine, sweat, saliva, and excretory products. However, the long term use of **chemotherapeutic drugs** for diseases like cancer, diabetes leads to side effects. And the side effects —including nausea, loss of hair, loss of strength, permanent organ damage to the heart, lung, liver, kidneys, or reproductive system etc.— are so severe that some patients rather die of disease than subjecting themselves to this torture. And **smallpox** (an acute contagious disease caused by the variola virus, a member of the orthopoxvirus family) was a leading cause of death in 18th century, and the inexorable spread of the disease reliably recorded the death rate of some hundred thousand people. And the death toll surpassed 5000 people a day. Yet **Edward Jenner**, an English physician, noticed something special occurring in his small village. People who were exposed to **cowpox** did not get smallpox when they were exposed to the disease. Concluding that cowpox could save people from smallpox, **Edward** purposely infected a young boy who lived in his village first with cowpox, then with smallpox. Fortunately, **Edward's hypothesis** worked well. He had successfully demonstrated the world's first vaccine and eradicated the disease. And vaccines which once saved humanity from the **smallpox** (which was a leading cause of death in 18th-century England), now have associated with the outbreaks of diseases like **pertussis** (whooping cough) which have begun showing up in the **United States** in the past forty years.

TOP 5 DRUGS WITH REPORTED SIDE EFFECTS

(Withdrawn from market in September 2004)

Drug: Byetta

Used for: Type 2 diabetes

Side effect: Increase of blood glucose level

Drug: Humira

Used for: Rheumatoid arthritis

Side effect: Injection site pain

Drug: Chantix

Used for: Smoking cessation

Side effect: Nausea

Drug: Tysabri

Used for: Multiple sclerosis

Side effect: Fatigue

Drug: Vioxx*

Used for: Arthritis

Side effect: Heart attack

In 1930s, **Paul Hermann Muller** a research chemist at the firm of Geigyin Basel, with the help of science introduced the first modern insecticide

(DDT: dichloro diphenyl trichloroethane) and it won him the1948 **Nobel Prize in Physiology and Medicine** for its credit of saving thousands of human lives in **World War II** by killing typhus carrying lice and malaria carrying mosquitoes, dramatically reducing **Malaria** and **Yellow Fever** around the world. But in the late 1960s **DDT** which was a world saver was no longer in public favor – it was blamed moderately hazardous and carcinogenic. And most applications of **DDT** were banned in the U.S. and many other countries. However, **DDT** is still legally manufactured in the U.S., but only sold to foreign countries. At a time when **Napoleon** was almost disturbing whole of Europe due to his aggressive policies and designs and most of the world was at war – the **science** gave birth to the many inventions which included changes in the textile industry, the iron industry, the transportation and communication industry, and consumer goods. Though it gave birth in England, yet its inventions spread all over the world in a reasonably period. The inventions transformed human lives and made the world a better place. And **rapid industrialization** was a consequence of new inventions and demand for expansion of large industrial cities led to the large scale exploitation of agricultural land. And socio-economic growth was peaking, as industries were booming, and agricultural lands were decreasing, as the world enjoyed the fruits of the **rapid industrialization**. As a result of this, the world's population was growing at an exponential rate and the world's food supply was not in the pace of the population’s increase. And this resulted in widespread famine in many parts of the world, such as England, and as **starvation** was rampant.

In that time line, science suppressed that situation by producing more ammonia through the **Haber Bosch Process** (more ammonia, more fertilizers. more fertilizers, more food production and thus prevented widespread famine). But at the same time, science which solved the world's hunger problems also led to the production of megatons of **TNT** (trinitrotoluene) and other explosives which were dropped on all the cities leading to the death of some hundred million people. Certain scientific developments, like the usage of **fossil fuels** and the release of **pollutants** into the air and water, have resulted in environmental harm and degradation. **Rapid industrialization** which once raised the economic and living standard of the people has now become a major global issue. The full impact of an industrial fuel economy has led to the **global warming** (i.e., the increase of Earth's average surface temperature due to effect of too much carbon dioxide emissions from industrial centers which acts as a blanket, trap heat and warm the planet). And as a result, **Greenland's ice shelves** have started to shrink permanently, disrupting the world's weather by altering the flow of ocean and air currents around the planet. And violent swings in the climate have started to appear in the form of floods, droughts, snow storms and hurricanes. And industries are the main sources of **sulfur dioxide emission** and automobiles for nitrogen oxides. And the oxides of nitrogen and sulfur combine with the moisture in the atmosphere to form acids. And these acids reach the **Earth** as rain, snow, or fog and react with minerals in the soil and release **deadly toxins** and affect a variety of plants and animals on the earth. And these acids damage buildings, **historic**

monuments, and statues, especially those made of rocks, such as limestone and marble, that contain large amounts of calcium carbonate. For example, acid rain has reacted with the marble **(calcium carbonate)** of **Taj Mahal** (an ivory white marble mausoleum on the south bank of the Yamuna river in the Indian city of Agra) causing immense damage to this wonderful structure **(i.e., Taj is changing color)**. And science once introduced refrigerators for prolonging storage of food but now refrigerators are the active sources of **chlorofluorocarbons** (CFC) which interact with the UV light during which chlorine is separated. And this chlorine in turn destroys a significant amount of the ozone in the **high atmosphere** admitting an intense dose of **harmful ultraviolet radiation**. And the increased ultraviolet flux produces the related health effects such as skin cancer, cataracts, and immune suppression and produces a permanent change in the nucleotide sequence and lead to changes in the molecules the cell produce, which modify and ultimately affect the process of **photosynthesis** and destroy green plants. And the massive extinction of green plants may lead to famine and immense death of all living species including man. **Fertilizers** which once provided a sufficient amount of the essential nitrates to plants to synthesize chlorophyll and increase crop growth to feed the growing population and satisfy the demand for food, has now blamed for causing **hypertrophication** i.e., fertilizers left unused in soil are carried away by rain water into lakes and rivers, and then to coastal estuaries and bays. And the overload of **fertilizers** induces explosive growth of algal blooms, which prevents light from getting into the water and thereby preventing the aquatic plants from **photosynthesizing**, a process which provides oxygen in the water to animals that need it, like fish and crabs. So, in addition to the lack of oxygen from **photosynthesis**, when algal blooms die they decompose and they are acted upon by microorganisms. And this **decomposition** process consumes oxygen, which reduces the concentration of dissolved oxygen. And the depleted oxygen levels in turn lead to fish kills and a range of other effects promoting the loss of species **biodiversity**. And the large scale exploitation of forests for industrialization and residential purposes has not only led to the loss of biodiversity but has led the diseases like **AIDS** (Acquired immunodeficiency syndrome caused by a virus called **HIV (Human immunodeficiency virus)** which alters the immune system, making victim much more vulnerable to infections and diseases) to transmit from forests to cities. At the dawn of the early century, the entire world was thoroughly wedded to fossil fuels in the form of oil, natural gas, and coal to satisfy the demand for energy. And as a result, **fossil fuels** were becoming increasingly rare and were slowly dooming to extinction. In that period, **science** (upon the work of Marie Curie and Albert Einstein) introduced nuclear fission reaction (the process by which a heavy nucleus breaks down into two or more smaller nuclei, releasing energy. For example: if we hit a uranium-235 nucleus with a neutron, it split into a krypton nucleus, a barium nucleus, three neutrons, and energy) as an alternate to the world's energy supply and therefore prevented the world economy from coming to a grinding halt. But at the same time **science** introduced **nuclear fission reaction** to produce thousands of nuclear weapons, which were dropped on all the cities in World War II amounted to some two million tons, **two megatons, of TNT**, which flattened heavily reinforced buildings many kilometers away, the firestorm, the gamma rays and the thermal neutrons, which effectively fried the people. A **school girl** who survived the nuclear attack on Hiroshima, the event that ended the Second World War, wrote this first-hand account:

"Through a darkness like the bottom of hell, I could hear the voices of the other students calling for their mothers. And at the base of the bridge, inside a big cistern that had been dug out there, was a mother weeping, holding above her head a naked baby that was burned red all over its body. And another mother was crying and sobbing as she gave her burned breast to her baby. In the cistern the students stood with only their heads above the water, and their two hands, which they clasped as they imploringly cried and screamed, calling for their parents. But every single person who passed was wounded, all of them, and there was no one, there was no one to turn to for help. And the singed hair on the heads of the people was frizzled and whitish and covered with dust. They did not appear to be human, not creatures of this world."

Nuclear breakthroughs have now turned out to be the biggest existential threat to human survival. Nuclear waste is banking up at every single nuclear site. And as a result, every nation is suffering from a massive case of **nuclear constipation** (that Causes Intractable Chronic Constipation in Children). Ninety-one percent of world adults and 60 percent of teens own this device that has revolutionized the most indispensable accessories of professional and social life. **Science** once introduced this device for wireless communication but now they are pointed to as a possible cause of everything from infertility to cancer to other health issues. And in a study conducted at the **University of London**, researchers sampled 390 cell phones to measure for levels of pathogenic bacteria. The results of the study showed that 92 percent of the cell phones sampled had heavily colonized by high quantities of various types of disease-prone bacteria with high resistances to commonly used antibiotics **(around 25,000 bacteria per square inch)** and the results concluded that their ability to transmit diseases of which the mobile phones are no exception. Several technological discoveries raise ethical concerns, such as the use of genetic engineering to modify **human embryos** or the **creation of artificial intelligence** that could potentially surpass human intelligence and control. Advances in technology have also raised concerns about privacy and data security, as personal information is collected and stored by companies and governments. The **fluoridation of water** at optimal levels has been shown to be highly beneficial to the development of tooth enamel and prevention of dental cavities since the late 1800s. And studies showed that children who drink water fluoridated at optimal levels can experience 20 to 40 percentless tooth decay. But now **fluoridation of water** has termed to cause lower IQ, memory loss, cancer, kidney stones and kidney failures – faster than any other chemical. **Science** once introduced **irradiation** to prevent food poisoning by destroying molds, **bacteria** (such as one – celled animal 'Amoeba ' – that have as much information in their DNA as 1,000 Encyclopedia Britannicas – which is almost unbelievably minute form of life which, after being cut into six separate parts, is able to produce six complete bodies to carry on as though nothing had happened),yeast and **virus** (the smallest living things which cannot reproduce itself unaided and therefore it is lifeless in the true sense. But when placed in the plasma of a living cell and, in forty eight minutes it can reproduce itself four hundred times) and control microbial infestation. But now it has been blamed to cause the loss of nutrients, for example **vitamin E levels** can be reduced by 25% after irradiation and **vitamin C** by 5-10% and damage food by breaking up molecules and creating free radicals. And these free radicals combine with existing chemicals **(like preservatives)** in the food to produce deadly toxins. This has caused some food manufacturers to limit or avoid the process and bills have even been introduced to ban irradiated foods in public cafeterias or to require irradiated food to carry sensational warning labels. **Advances in technology** lead to job losses or displacement of workers. It occurs when **machines or automation** replace **human labor** in a particular industry or task, leading to a reduction in employment opportunities for workers. With the increasing use of automation, **artificial intelligence**, and robotics in industries such as manufacturing, transportation, and retail, there is growing concern that **technological unemployment** could become a major problem. Some experts predict that automation could lead to widespread job losses in the coming years, particularly in sectors where routine tasks are common. While **technological unemployment** is a real concern, it is important to note that advances in technology also create new job opportunities in other industries. **For example**, the growth of the internet and e-commerce has led to the creation of new jobs in areas such as **digital marketing**, **software development**, and **cybersecurity**. And the rapid advancement of science combined with human aggression and aim for global supremacy has led even the smaller nations to weaponize **anthrax spores** and other **viruses** for maximum death and destruction. And thus the entire planet is gripped with fear that one day a terrorist group may pay to gain access to weaponized **H5N1 flu** and other viruses. And the enormous automation, capacity of **artificial intelligence** and their ability to interact like humans has caused the humans to be replaced by artificial intelligence. But now **artificial intelligence** is taking off on its own, and redesigning itself at an ever increasing rate. And this has turned out to be the biggest existential threat to human survival (i.e., one day artificial intelligence may plan for a war against humanity). Highly toxic gases, poisons, defoliants, and **every technological state are planning for it** to disable or destroy people or their domestic animals, to damage their crops, and/or to deteriorate their supplies, threaten every citizen, not just of a nation, but of the world. While it is true that **technology and science** have brought about many positive changes in society, including improved healthcare, transportation, and communication, it is also true that these advancements have had unintended negative consequences, including an increase in certain types of crime. Advances in technology have made it easier for criminals to carry out **cybercrime**, identity theft, and other forms of financial fraud. **Social media** and the **internet** have also made it easier for criminals to target and victimize vulnerable populations, including children and the elderly. At the same time, advances in science and technology have also improved the ability of law enforcement agencies to investigate and prevent crimes. **For example,** DNA analysis and forensic science have revolutionized the way crimes are solved, and new technologies such as facial recognition and predictive analytics are helping law enforcement agencies to prevent crimes before they occur. It is important to note that the relationship between **technology and crime** is complex and multifaceted. While technology can be both a cause and a solution to crime, it is ultimately up to society to address the underlying social and economic factors that contribute to criminal behavior, including poverty, inequality, and social exclusion. While **science** has brought about many positive advancements and benefits to humanity, it is also true that some of its applications can have negative effects.

CONCLUSION

◆ ◆ ◆

What makes the universe what it is? To address this question, which appears to be as old as human civilization itself, ancient civilisations all around the world recounted creation tales. The question is not just relevant to cosmology; in fact, it offers potential avenues for deciphering the **underlying physics of our universe**. Despite some significant achievements, not all problems have been resolved. The whole form of the laws of nature is not yet well understood. Without this knowledge, we are unsure of how far we can advance in our quest to comprehend the universe's future. Will it keep growing indefinitely? **Is inflation a natural law?** Or will the universe eventually collapse? Theoretical developments and new observational findings are pouring in quickly.

Despite the billions of galaxies and stars in the universe, most of the universe is actually empty space. In fact, more than 99% of the observable universe is empty space, with galaxies and stars making up less than 1% of the total volume. Massive stars end their lives by the **supernova explosion** and the remnants become incredibly dense objects **(black holes)** in the universe. While we have observed many black holes, there are still many questions about how they form, how they evolve over time, and how they interact with the surrounding matter. The **universe** is a curious place, brimming with wonder and magnificence as well as a myriad of questions left unanswered and unexplained mysteries. **Cosmology** is a very dynamic and intriguing field that involves the scientific study of the big-scale characteristics of the universe as a whole. New understandings of the huge universe emerged at the beginning of the 20th century. The answers to the ages-old queries are nearing completion through observations of outer space. What brings us here? What is our origin? **Are space and time fundamental or emergent?** Is there a beginning to the cosmos, or is it eternal? Despite the challenges, continued research and advancements in observational techniques and theoretical models are gradually shedding light on these mysteries and expanding our understanding of the universe.

The laws of physics: Life, the universe and everything… If the rules of physics had been a little distinct, life as know it would not have been evolved into literally something.We can estimate the age of the cosmos by tying its various components, such as planetary systems, stars, galaxies, and all other types of matter and energy, to the timeline of its expansion using Albert Einstein's general relativity theory. **Quantum Mechanics** and **General Relativity** do not work together. What about: **Before the Big**

Bang? Neither theory can predict what happened. The unification of so called **weak nuclear forces** with the **Maxwell equations** is what known as the **electroweak theory**. And the electroweak theory and quantum chromodynamics together constitutes the so called **Standard Model of particle physics**, which describes everything except gravity. Even hundreds of years later, the desire to comprehend the interconnected nature of the universe and how we fit within it is still intense. In some ways, the universe does prove to be much bigger and more magnificent than our progenitors could have ever imagined, which makes puzzles about its beginnings and design much more appealing to research.

The **fate of the universe** depends on the balance between the expansion of the universe and the gravitational forces that are pulling matter together. While current observations suggest that the universe will continue to expand indefinitely, there are still questions about what will happen in the very distant future, such as whether the universe will continue to expand at an accelerating rate or eventually collapse in on itself. We believe that there is more of the universe—more planets, stars, constellations, galaxies, and everything else—beyond the observable universe's boundary. But we don't know how big the cosmos is, because it's not observable. Trying to understand what is visible to us while pondering the nature of the cosmos. We are interested in discovering a comprehensive theory of everything that encompasses gravity, **quantum mechanics**, and all other physical interactions. If we succeed in this, we will truly comprehend the universe and our place in it. The question, "**What occurred before the big bang?**" may now have an answer. This ground-breaking discovery might be the achievement of Albert Einstein's long-held desire for a Theory of Everything, which would combine the laws of the universe into a definitive explanation for all known forces in the cosmos. It provides answers to our most pressing inquiries: Is time merely a figment of the imagination? What is space and time composed of? Where does matter come from? And what laws govern our universe? What produced those laws? It's just a set of rules and equations. **What is it that breathed fire into the cosmos and made us exist to justify something rather than nothing, why it is that we and the universe exist?**

Planets are some of the most fascinating objects in our solar system and beyond. The composition and behavior of planetary atmospheres are still not fully understood. For example, the clouds on **Venus** are composed of sulfuric acid, which is not well understood, and the atmospheric conditions on gas giants like **Jupiter and Saturn** are still being studied. In a few hundred billion years, practically all galaxies will be invisible to us due to the **Hubble expansion**. The Milky Way will eventually exhaust its supply of new gas needed to generate stars. In trillions of years, the galaxies will fade away, leaving behind a thin soup of elementary particles that will eventually cool to absolute zero. Gravity pulls everything in, but a mysterious force called dark energy tries to push it all back together again. The ultimate of the universe relies on which force will win the desire to succeed. **Questions abound in cosmology.** There is always something new to learn in cosmology, even if it's just answering a question we've never thought to ask before. This is what keeps cosmology so exciting and intriguing. Its compelling explanations encourage us to visualize a completely unexplored realm that lies beyond our constantly shifting perception of reality. While we have made great strides in understanding the universe, there is still much that we do not know. For example, we do not yet have a complete understanding of the nature of black holes, the origins of cosmic rays, or the nature of the first stars and galaxies. **Cosmology** is limited by our ability to observe the universe. We are limited by the quality of our telescopes and instruments, and by the fact that we can only observe the universe from one vantage point **(Earth)**. This means that there may be important phenomena or objects in the universe that we have yet to discover. There are several reasons why some people believe that we should **colonize space**. First, it could potentially serve as a backup plan for the survival of humanity in case of a catastrophic event, such as an asteroid impact or a major nuclear war. Additionally, it could offer new resources, such as rare minerals or energy sources that could be used to sustain and improve life on Earth. **Space colonization** could also lead to scientific discoveries and technological advancements that could benefit humanity in numerous ways. However, there are also significant challenges associated with space colonization. It would require a tremendous amount of resources, including funding, technology, and human labor. It would also present significant environmental and logistical challenges, as the harsh conditions of space make it difficult to sustain life and infrastructure. Furthermore, it could raise ethical questions about the allocation of resources and the potential impact on other life forms in space. Overall, the decision to colonize space is a complex one that requires careful consideration of the potential benefits and challenges. Ultimately, it is up to individuals, organizations, and governments to decide whether or not it is worth pursuing. **Stars** are mysterious objects that continue to captivate astronomers and researchers around the world. They are born in massive clouds of gas and dust known as **stellar nurseries**. These clouds can be several light-years across and contain enough material to form thousands of stars. However, the exact process by which stars form from these clouds is not fully understood. The exact details of how stars die are still not fully understood. Depending on their mass, stars can end their lives in a variety of ways, including exploding as **supernovae**, collapsing into neutron stars or black holes, or simply cooling down and fading away. As we continue to study and explore the universe, it is likely that we will uncover even more mysteries about these fascinating celestial bodies.

Something unknown is running behind every atom we don't know what…

No one knows who tuned the music of dancing mysteries or what powered the Big Bang.

It's completely a Baffling Mystery.

The fact that we are only an advanced strain of **talking monkeys** purely concerned with survival have been able to get this close to an understanding of our universe is a big victory for our continuing quest. Despite all that we have learned about the universe, the majority of it remains unknown and mysterious. We have yet to understand the true nature of **dark matter** and **dark energy**, and there is much more to discover about the structure and evolution of the universe. Overall, the **universe** is full of mysteries that scientists are still working to understand. Through ongoing research and exploration, we may be able to unlock some of the universe's deepest secrets and better understand our place within it.

◆ ◆ ◆

GLOSSARY

Absolute zero: The lowest possible temperature T, at which substances contain no heat energy Q.

Acceleration: The rate at which the speed of an object is changing and it is given by the equation $a = dv/dt$.

Anthropic principle: We see the universe the way it is because if it were different we would not be here to observe it through a gigantic telescopes pointing deep into the immense sky – merely stating that the constants of nature must be tuned to allow for intelligence (otherwise we would not be here). Some believe that this is the sign of a cosmic creator. Others believe that this is a sign of the multiverse.

Antiparticle: Each type of matter particle has a corresponding antiparticle – first predicted to exist by **P. A. M. Dirac.** When a particle collides with its antiparticle, they annihilate, leaving only pure energy in the form of discrete bundle (or quantum) of electromagnetic (or light) energy called photons.

Astrochemistry: The scientific discipline that investigates the chemical interactions between the gas and dust found between stars. It involves the study of the chemical reactions that occur in space, as well as the analysis of the spectra of stars, planets, and other celestial bodies to determine their composition. Astrochemistry is an interdisciplinary field that combines principles and techniques from chemistry, physics, and astronomy to study the chemical makeup and processes of objects in the universe.

Atom: The basic unit of ordinary matter, made up of a tiny nucleus **(consisting of positively charged protons and electrically neutral neutrons – which obey the strong interactions)** surrounded by orbiting negatively charged weakly interacting particles called the electrons. The atom is the basic unit of matter, and scientists have developed several theories to explain its structure and behavior over time. Here are some of the major theories of the atom:

Democritus' Theory: Democritus, a Greek philosopher, was one of the first to propose the idea of the atom. He believed that all matter was made up of tiny, indivisible particles that he called atoms.

Dalton's Theory: In the early 19th century, John Dalton proposed a theory that built upon Democritus' ideas. Dalton's theory stated that atoms were indivisible and that each element was made up of a unique type of atom. He also proposed that atoms combine in specific ratios to form compounds.

Thomson's Theory: Sir Joseph John Thomson made the discovery of the electron, a negatively charged subatomic particle, in 1897. He proposed a model of the atom that had a positive charge throughout with negatively charged electrons dispersed within it, much like plums within a pudding. The "plum pudding" model was the name given to this model.

Rutherford's Theory: In 1911, Ernest Rutherford performed the famous gold foil experiment, which led to the discovery of the atomic nucleus. Rutherford proposed a model of the atom in which electrons orbited a small, dense nucleus that contained most of the mass of the atom.

Bohr's Theory: In 1913, Niels Bohr proposed a new model of the atom that incorporated the newly discovered electron orbits. In this model, electrons orbit the nucleus in specific energy levels, and they can move between these levels by absorbing or emitting energy in the form of light.

Modern Quantum Mechanical Theory: The current theory of the atom is based on quantum mechanics, which describes the behavior of particles on a very small scale. This theory takes into account the wave-like nature of electrons and describes them as existing in a cloud of probability around the nucleus, rather than in specific orbits.

These theories have been refined and expanded upon over time, as new discoveries and technologies have allowed scientists to better understand the structure and behavior of the atom.

Axion: A hypothetical elementary particle postulated by the **Peccei–Quinn theory** in 1977 to explain **why charge parity (CP) invariance** holds in the strong interactions but not in the weak interactions.

Asteroid: An asteroid is a small, rocky object that orbits the Sun. Most asteroids are found in the asteroid belt, a region between the orbits of Mars and Jupiter. However, some asteroids have orbits that bring them closer to Earth, and these are of particular interest to astronomers. Asteroids range in size from a few meters to several hundred kilometers in diameter, with the largest known asteroid, **Ceres**, measuring about 940 km in diameter. They are believed to be remnants from the early solar system, left over after the formation of the planets. Asteroids are composed of rock and metal, and some may contain valuable minerals such as iron, nickel, and platinum. Some asteroids also contain water and other volatile compounds, making them potential targets for future space exploration and resource extraction.

Asteroids can pose a potential threat to Earth if they collide with our planet. While the likelihood of a major impact is small, such an event could have catastrophic consequences. Efforts are underway to identify and track near-Earth asteroids, and plans are being developed to deflect any asteroids that may pose a threat to Earth. Asteroids have been the subject of scientific study for many years, and numerous spacecraft missions have been sent to study asteroids up close. These missions have provided valuable insights into the origins and evolution of the solar system, as well as the potential for future space exploration and resource utilization.

Astronomy: Astronomy is the study of celestial objects and phenomena beyond the Earth's atmosphere, including stars, galaxies, planets, moons, asteroids, comets, and other objects in space. Astronomers use a variety of tools and techniques, including telescopes, satellites, and computer simulations, to observe and analyze these objects and phenomena. Astronomy is one of the oldest sciences, with roots dating back to ancient civilizations such as the Babylonians, Greeks, and Chinese. In modern times, astronomy has advanced rapidly, with new technologies and discoveries leading to a deeper understanding of the universe. One of the primary goals of astronomy is to understand the structure, evolution, and origins of the universe. This includes studying the properties and behavior of individual celestial objects, as well as investigating the larger-scale structure of the universe, including its galaxies, clusters, and superclusters. Astronomy also has practical applications, such as in navigation, timekeeping, and communication. It has also led to important technological advancements, including the development of space exploration vehicles, satellite technology, and imaging technology used in fields such as medicine and manufacturing. The study of astronomy is a collaborative effort involving scientists and researchers from a variety of disciplines, including physics, mathematics, and engineering. Astronomical discoveries continue to shape our understanding of the universe and inspire new questions and avenues of research.

Big Bang: The singularity at the beginning of the universe. The titanic explosion that created the universe, sending the galaxies hurtling in all directions. When the universe was created, the temperature was extremely hot, and the density of material was enormous i.e., infinite. The big bang took place 13.7 billion years ago, according to the **WMAP satellite**. The afterglow of the big bang is seen today as the cosmic background microwave radiation **(of temperature 2.7 degrees above absolute zero)**. There are three experimental **"proofs"** of the big bang: the redshift of the galaxies, the cosmic background microwave radiation, and nucleosynethsis of the elements.

Big crunch: The singularity at the end of the universe i.e., The final collapse of the universe. If the density of matter is large enough **(Omega – The parameter that measures the average density of matter in the universe – being larger than 1)**, then there is enough matter in the universe to reverse the original expansion and cause the universe to recollapse. Temperatures rise to infinity at the instant of the big crunch.

Big freeze: The end of the universe when it reaches near absolute zero. The big freeze is probably the final state of our universe, because the sum of **Omega** and **Lambda** (Cosmological constant) is believed to be 1.0, and hence the universe is in a state of inflation. There is not enough matter and energy to reverse the original expansion of the universe, so it will probably expand forever.

Big Bang nucleosynthesis: The production of deuterium, Helium-3 and Helium-4 **(the latter to about 25% mass fraction)** in the first 500 to 1000 sec of the early universe. These light isotopes, plus measurable amounts of lithium-7 and trace amounts of elements B, Be, are the result of non-equilibrium nuclear reactions as the universe cooled to about 10^8 K. Heavier isotopes were produced in stellar nucleosynthesis.

Black hole: A region of space-time from which nothing, not even light, can escape, because gravity is so strong and **escape velocity equals the speed of light.** Because the speed of light is the ultimate velocity in the universe, this means that nothing can escape a black hole, once an object has crossed the event horizon. Black holes can be of various sizes. Galactic black holes, lurking in the center of galaxies and quasars, can weight millions to billions of solar masses. Stellar black holes are the remnant of a dying star, perhaps originally up to forty times the mass of our Sun. Both of these black holes have been identified with our instruments. Mini–black holes may also exist, as predicted by theory, but they have not yet been seen in the laboratory conditions.

Black Hole Escape Velocity: It is widely held by astrophysicists and astronomers that a black hole has an escape velocity c **(or c, the speed of light in Vacuum)**.

Zero point Energy: an intrinsic and unavoidable part of quantum physics. The ZPE has been studied, both theoretically and experimentally, since the discovery of quantum mechanics in the 1920s and there can be no doubt that the ZPE is a real physical effect.

Casimir effect: The attractive pressure between two flat, parallel metal plates placed very near to each other in a vacuum. The pressure is due to a reduction in the usual number of virtual particles in the space between the plates. This tiny effect has been measured in the laboratory. The Casimir effect may be used as the energy to drive a time machine or wormhole, if its energy is large enough.

Chandrasekhar limit: The Chandrasekhar limit is a physical limit on the maximum mass that a stable white dwarf star can have. It is named after **Subrahmanyan Chandrasekhar**, an Indian astrophysicist who discovered the limit in 1930. A white dwarf is a small, dense star that forms after a star exhausts all of its nuclear fuel and sheds its outer layers. The mass of a white dwarf is typically about 0.6 times the mass of the sun, and it is supported against gravitational collapse by electron degeneracy pressure.

This means that the pressure exerted by electrons, which cannot occupy the same energy state due to the **Pauli Exclusion Principle**, is sufficient to counteract the force of gravity. However, as a white dwarf's mass increases, so does its density and gravitational force. When a white dwarf exceeds the Chandrasekhar limit of about 1.4 times the mass of the sun, the electron degeneracy pressure is no longer sufficient to support the star against gravitational collapse. The star will then begin to collapse, leading to a catastrophic event known as a Type Ia supernova. The **Chandrasekhar limit** is an important concept in astrophysics, as it helps to explain the properties and behavior of white dwarf stars and the role they play in the universe. In particular, Type Ia supernovae, which are thought to be caused by the explosion of a white dwarf that exceeds the Chandrasekhar limit, are used as standard candles to measure the distances to galaxies and to study the expansion of the universe.

Conservation of energy: The law of science that states that energy **(or its equivalent in mass)** can neither be created nor destroyed i.e., they never change with time. For example, the conservation of matter and energy posits that the total amount of matter and energy in the universe is a constant.

Coordinates: Numbers that specify the position of a point in 4 dimensional space-time.

Cosmogony: The examination of celestial bodies, such as the solar system, stars, galaxies, and galaxy clusters.

Cosmological constant: A mathematical parameter **(which measures the amount of dark energy in the universe)** introduced by **Albert Einstein** to give space-time an inbuilt tendency to expand. At present, the data supports **density parameter + cosmological constant = 1**, which fits the prediction of inflation for a flat universe. **Cosmological constant**, which was once thought to be zero, is now known to determine the ultimate destiny of the universe.

Cherenkov radiation: Produced by charged particles when they pass through an optically transparent medium at speeds greater than the speed of light in that medium.

Cosmology: The study of the universe as a whole.Cosmology is the scientific study of the origin, evolution, and structure of the universe as a whole. It is an interdisciplinary field that combines principles from physics, astronomy, and philosophy to understand the fundamental properties and behavior of the universe. One of the key goals of cosmology is to understand the large-scale structure and properties of the universe. This includes the distribution of matter and energy, the formation and evolution of galaxies and other large structures, and the overall geometry and expansion of the universe. Cosmologists use a range of observational and theoretical tools to study the universe, including telescopes and other instruments to observe celestial objects and phenomena, computer simulations to model the behavior of matter and energy on cosmic scales, and mathematical models and theories to explain the underlying physics of the universe. Some of the key concepts and theories in cosmology include the Big Bang theory, which describes the origin and early evolution of the universe, dark matter and dark energy, which are believed to make up the majority of the mass-energy content of the universe, and cosmic inflation, which proposes that the universe underwent a brief period of exponential expansion shortly after the Big Bang. **Cosmology** is a rapidly evolving field, with new discoveries and insights continually expanding our understanding of the universe and its properties. Some of the key open questions in cosmology include the nature of dark matter and dark energy, the possibility of a multiverse, and the ultimate fate of the universe.

COBE: The Cosmic Observer Background Explorer (COBE) satellite was a NASA mission launched in 1989 with the goal of studying the cosmic microwave background radiation (CMB), which is the residual heat left over from the Big Bang. The COBE satellite was designed to measure the CMB's temperature and spectral distribution with unprecedented accuracy, providing critical information about the early universe. One of the key objectives of the **COBE** mission was to test the predictions of the Big Bang theory, which postulates that the universe began in a state of extremely high temperature and density and has been expanding and cooling ever since. The **CMB** is thought to be a direct remnant of this early period, and its properties can provide insight into the nature of the universe at its earliest stages. The **COBE** mission made several important discoveries, including the detection of temperature variations in the **CMB** that were consistent with the predictions of the **Big Bang theory**, providing strong support for this model of the universe's origin. The mission also detected a faint background radiation that was later identified as infrared radiation from dust in the Milky Way galaxy, and it discovered several sources of cosmic infrared radiation that were previously unknown. The **COBE mission** was a major milestone in cosmology, providing key data and insights into the early universe and helping to establish the standard model of cosmology. The mission's success paved the way for future missions and experiments, such as the **Wilkinson Microwave Anisotropy Probe** (WMAP) and the **Planck mission**, which have further refined our understanding of the CMB and the early universe.

Collisional excitation: Excitation of an atom can occur when 2 atoms collide.

Constellation: A collection of stars that together form an abstract image in the sky.

Cosmic rays: High energy protons that have their origin in the solar wind produced by the sun.

Comet: A comet is a small celestial body that orbits the Sun and consists of a nucleus, a coma, and a tail. Comets are typically composed of rock, dust, and frozen gases such as water, carbon dioxide, methane, and ammonia. They are believed to have formed in the outer regions of the solar system and are thought to be remnants from the early formation of the solar system.

Comets are visible from Earth as bright, fuzzy objects with tails that can stretch across the sky. They have fascinated humans for thousands of years and have been associated with many cultural beliefs and superstitions. In recent times, comets have been studied extensively by astronomers using telescopes, spacecraft, and flybys, providing valuable information about the composition and origins of the solar system.

Celestial Sphere: An imaginary sphere in which the planets and stars seem to be positioned around the Earth.

Cepheid: A kind of **pulsating variable star** whose luminance can be calculated from the period of its variation: Long pulsation period Cepheids are larger and more luminous than short pulsation period Cepheids.

Crater: A bowl-shaped depression left behind by an asteroid or meteorite impact.

Dark matter: Invisible Matter usually found in a huge halo around galaxies, clusters, and possibly between clusters, that cannot be observed directly but can be detected by its gravitational effect and they does not interact with light. As much as **90 percent of the mass of the universe may be in the form of dark matter** and they makes up 23 percent of the total matter or energy content of the universe. According to string theory, dark matter may be made of subatomic particles, such as the neutralino, which represent higher vibrations of the superstring.

Duality: A correspondence between apparently different theories that lead to the same physical results.

Double Asteroid: Two asteroids that orbit one another and are kept together by the gravity between them. Known as a binary asteroid as well.

Double Beta Decay: A nuclear transition in which an initial nucleus (Z, A), with atomic number Z and mass number A decays to (Z+2, A) emitting two electrons and two antineutrinos in the process.

Einstein-Rosen bridge: The Einstein-Rosen Bridge, also known as a wormhole, is a hypothetical solution to the equations of general relativity proposed by **Albert Einstein and Nathan Rosen** in 1935. It is a shortcut between two separate points in space-time that could, in theory, allow for faster-than-light travel or even time travel. In the simplest terms, a wormhole can be visualized as a tunnel or bridge that connects two points in space-time. The two ends of the wormhole are known as the mouth, and they can be separated by vast distances in space or time. According to the theory, an object or person entering one mouth of the wormhole would emerge at the other mouth, potentially in a different location or time. While the concept of wormholes is theoretically possible according to the laws of general relativity, there are significant obstacles to their formation and stability. One of the key challenges is the extreme curvature of space-time that would be required to form a stable wormhole, which would require the presence of exotic matter with negative energy density. Although there is no direct evidence for the existence of wormholes, they are a subject of active research and speculation in both theoretical physics and science fiction. Some scientists believe that wormholes could provide a possible solution to the challenge of interstellar travel, while others view them as a fascinating and exotic feature of the universe that can help us better understand the nature of space-time and gravity.

Electric charge: A property of a particle by which it may repel **(or attract)** other particles that have a charge of similar **(or opposite)** sign.

Electromagnetic force: The force of electricity and magnetism that arises between particles with electric charge; the second strongest of the four fundamental forces –which obeys **Maxwell's equations**.

Electron: A negatively charged subatomic particle with negative electric charge that orbits the nucleus of an atom and determines the chemical properties of the atom. **The threshold temperature of the electron is:**

$$T = m_0c^2/ k_B$$

and so once the universe has cooled below this temperature the electrons and antielectrons each other and the electron become a very rare object − compared to photons.

Electroweak unification energy: The energy **(around 100 GeV)** above which the distinction between the electromagnetic force and the weak force disappears.

Elementary particle: A particle that, it is believed fundamental building block of Nature, cannot be subdivided and are not composed of other simpler particles.

Extraterrestrial: A term used to describe anything that is not Earth-born.

Event: A point in space-time, specified by its time and place.

Extragalactic: A term that means outside of or away from our galaxy.

Event horizon: The boundary of a black hole. The point of no return, often called the horizon.

Exclusion principle: The idea that two identical spin-1/2 particles cannot have **(within the limits set by the uncertainty principle)** both the same position and the same velocity. This means that two electrons cannot occupy precisely the same point with the same properties, so that there is a net force pushing the electrons apart **(in addition to electrostatic repulsion)**.

Field: Something that exists throughout 4 dimensional fabric of space - time, as opposed to a particle that exists at only one point at a time.

Flare Star: A Faint red star whose brightness appears to fluctuate due to explosions on its surface.

Frequency: For a wave, the number of complete cycles per second.

The different frequencies of light appear as different colors.

Light waves are similar to water waves. Both are characterized by their wavelength, speed and frequency (or period).

If not for a force called gravity, we would all go zinging off into outer space.

The **wavelength of a wave** is the distance between successive peaks or troughs.

Gamma rays: Electromagnetic rays of very short wavelength, produced in radio-active decay or by collisions of elementary particles.

Greenhouse Effect: A rise in temperature brought on when outgoing thermal energy from the sun is blocked by the atmosphere but incoming solar radiation is not. Two of the main gases causing this phenomenon are carbon dioxide and water vapor.

General relativity: Einstein's theory of gravity based on the idea that the laws of science should be the same for all observers, no matter how they are moving. It explains the force of gravity in terms of the curvature of a four dimensional space-time; so that the curvature of space-time gives the illusion that there is a force of attraction called **gravity.** It has been verified experimentally to better than **99.7 percent accuracy** and predicts the existence of black holes and the expanding universe. The theory, however, break down at the center of a black hole or the instant of creation, where the theory predicts nonsense. To explain these phenomena, one must resort to a theory of subatomic physics.

Geodesic: The shortest **(or longest)** path between two points.

Gravitational redshift: A shift to longer wavelengths of spectral lines in the radiation emitted by a body in a gravitational field.

Grand unification energy: The energy above which, it is believed, the electromagnetic force, weak force, and strong force become indistinguishable from each other.

Grand unified theory (GUT): A theory which unifies the electromagnetic, strong, and weak forces **(but not gravity)**. The proton is not stable in these theories and can decay into positrons. GUT theories are inherently unstable **(unless one adds super symmetry)**. GUT theories also lack gravity. **(Adding gravity to GUT theories makes them diverge with infinities.)**

Gravitational lensing: The big galaxy cluster at the center of the image acts like the lens of a telescope. Any light from a distant object would converge as it passes around the galaxy. When we gaze at the distant galaxy, we see a ring like pattern called Einstein ring, an optical illusion caused by general relativity.

Kuiper belt: A region of the Solar System extending from the orbit of Neptune **(at 30 AU)** to approximately 50 AU from the Sun **(consists mainly of small bodies or remnants from the Solar System's formation).**

Imaginary time: Time measured using imaginary numbers.

Inflation: The theory which states that the universe underwent an incredible amount of superliminal expansion at the instant of its birth **i.e., A distance of one nanometer was enlarged to a quarter of a billion light-years.**

Inertia: Resistance to change in velocity and it increases with the mass of the object.

Hyperspace: Dimensions higher than four.

Light cone: A surface in space-time that marks out the possible directions for light rays passing through a given event.

Light year: The distance light travels in one year, or approximately 5.88 trillion miles **(9.46 trillion kilometers)**.

LIGO: The **Laser Interferometry Gravitational-Wave Observatory**, based in Washington state and Louisiana,which is the world's largest gravity wave detector.

LISA: The **Laser Interferometry Space Antenna**- which is a series of three space satellites using laser beams to measure gravity waves. It is sensitive enough to confirm or disprove the inflationary theory and possibly even string theory.

Magnetic field: The field responsible for magnetic forces, now incorporated along with the electric field, into the electromagnetic field.

Muon: A subatomic particle identical to the electron but with a much larger mass. It belongs to the second redundant generation of particles found in the Standard Model.

Mass: The quantity of matter in a body; its inertia, or resistance to acceleration.

Microwave background radiation: The remnant radiation **(with a temperature of about 2.7 degrees K)** from the glowing of the hot early universe **(big bang)**, now so greatly red-shifted that it appears not as light but as microwaves **(radio waves with a wavelength of a few centimeters)**. Tiny deviations in this background radiation give scientists valuable data that can verify or rule out many cosmological theories.

Mesons: Hadronic subatomic particles composed of an equal number of quarks and antiquarks which do not exist in ordinary matter but have been observed in the laboratory and cosmic rays.

Naked singularity: A space-time singularity without an event horizon.

Neutrino: An extremely light **(possibly massless)** subatomic particle that react very weakly with other particles and may penetrate several light-years of lead without ever interacting with anything and is affected only by the weak force and gravity. **Sun emits 2 $\times 10^{38}$ neutrinos per second but only 30 neutrinos are interacting in a person per year.**

Neutron: A neutral subatomic particle, very similar to the proton, which accounts for roughly half the particles in an atomic nucleus.

Neutron → proton + electron + antineutrino

At the quark and lepton level:

Down quark → up quark + electron + antineutrino

Neutron star: A cold collapsed star consisting of a solid mass of neutrons — which is usually about 10 to 15 miles across — supported by the exclusion principle repulsion between neutrons. If the mass of the neutron stars exceeds **(3-4 solar masses)** i.e., if the number of neutrons becomes **≥ 5.9×10^{57}**, then the degenerate neutron pressure will not be large enough to overcome the gravitational contraction and the star collapses into the next stage called black holes. **Gamma ray bursts** may happen when a neutron star falls into another neutron star or black hole. The **resulting explosion** sends out particles and radiation all over the spectrum.

Nuclear star cluster (NSC): A compact and dense concentration of stars located at the center of a galaxy.

No boundary condition: The idea that the universe is finite but has no boundary **(rooted in the Euclidean formalism)** to account for the initial conditions in the **big bang.**

Open universes are spatially infinite in extent and will expand forever.

Closed universes are spatially finite in extent and will re-collapse eventually and have a density

$>3H^2/8\pi G$.

Nebular model: The sun and planets formed from a cloud of gas and dust that collapsed because of gravity.

Nuclear fusion: The process by which two nuclei collide and coalesce to form a single, heavier nucleus.

Nucleus: The tiny core of an atom, which is roughly 10 $^{-13}$ cm across, consisting only of protons and neutrons, held together by the strong force.

Non-contact force: A force which acts on an object without coming physically in contact with it. All four known fundamental interactions are non-contact forces.

Particle accelerator: A machine — based in Geneva, Switzerland — that, using **electromagnets**, can accelerate moving charged particles, giving them more energy.

Phase: For a wave, the position in its cycle at a specified time: a measure of whether it is at a crest, a trough, or somewhere in between.

Photon: A quantum of light **(which was first proposed by Einstein to explain the photoelectric effect—that is, the fact that shining light on a metal results in the ejection of electrons)**.

Planck's quantum principle: The idea that light **(or any other classical waves)** can be emitted or absorbed only in discrete quanta, whose energy **E** is inversely proportional to their wavelength **λ** **(i.e., $E = hc/\lambda$)**.

Positron: The **(positively charged)** antiparticle of the electron. **Positron is captured by antiproton and an atom of antihydrogen is formed**.

Primordial black hole: A primordial black hole is a hypothetical type of black hole that is believed to have formed in the early universe, shortly after the Big Bang. Unlike black holes that form from the collapse of massive stars, primordial black holes are thought to have formed directly from the density fluctuations that existed in the very early universe. The precise conditions required for the formation of primordial black holes are not well understood, but they are believed to have formed during a period of rapid expansion known as cosmic inflation, which occurred in the first fraction of a second after the Big Bang. **During this period, density fluctuations in the early universe would have been amplified, leading to the formation of regions of extremely high density that could have collapsed to form black holes.** Primordial black holes are thought to have a wide range of masses, from less than a gram to several hundred times the mass of the sun. They are also believed to be extremely rare, with only a small number expected to exist in the Milky Way galaxy. Despite their rarity, primordial black holes are of interest to physicists and astronomers because they could potentially provide insights into the nature of dark matter, which is believed to make up a significant fraction of the mass of the universe. Some theories suggest that primordial black holes could account for some or all of the dark matter in the universe, although this remains a subject of active research and debate. While there is no direct evidence for the existence of primordial black holes, scientists are actively searching for them using a variety of observational and theoretical techniques, including gravitational lensing, cosmic microwave background radiation, and gravitational wave detectors.

Negative energy: Energy that is less than zero.

Proton: A positively charged subatomic particle, very similar to the neutron, that accounts for roughly half the particles in the nucleus of most atoms. They are stable, but **Grand Unification theory** predicts that they may decay over a long period of time.

Pulsar: A rotating neutron star that emits regular pulses of radio waves.

Quantum: The indivisible unit in which waves may be emitted or absorbed.

Quark: A subatomic particle that makes up the proton and neutron and feels the strong force. Three quarks make up a proton or neutron, and a quark and antiquark pair makes up a meson.

Quantum chromodynamics (QCD): The theory that describes the interactions of quarks and gluons. Quantum Chromodynamics (QCD) is a branch of theoretical physics that seeks to understand the behavior of subatomic particles known as quarks and gluons, which are the building blocks of protons, neutrons, and other particles known as hadrons. QCD is a part of the **Standard Model of particle physics** and describes the strong force, one of the four fundamental forces of nature. The strong force is responsible for holding atomic nuclei together and is stronger than the electromagnetic force that governs the behavior of charged particles. In QCD, quarks are considered to be fundamental particles that come in six different "flavors" (up, down, charm, strange, top, and bottom), while gluons are particles that mediate the strong force between quarks. The theory describes how quarks interact with each other through the exchange of gluons, and how these interactions lead to the formation of bound states such as protons and neutrons. One of the key features of QCD is that it exhibits a phenomenon known as confinement, which means that quarks and gluons cannot exist as isolated particles but must always be confined within hadrons. This explains why individual quarks have never been observed in isolation and why it is not possible to break a proton or neutron into its constituent quarks. QCD is a highly complex and mathematically challenging theory, and its predictions are often difficult to test experimentally. However, it has been extremely successful in describing the behavior of subatomic particles in a wide range of experimental settings, and it is considered to be one of the most successful and fundamental theories in physics today.

Quantum Electrodynamics (QED): QED is a branch of theoretical physics that studies the behavior of electromagnetic interactions between charged particles in the quantum regime. It is a quantum field theory that describes the interactions between matter and the electromagnetic field, which is mediated by particles known as photons. QED is a part of the **Standard Model of particle physics** and is considered to be one of the most well-established and accurate physical theories ever developed. It describes the behavior of charged particles in terms of quantum mechanical principles, such as wave-particle duality, and predicts the probability of interactions between particles in terms of Feynman diagrams. In QED, the fundamental objects of study are electrons and photons, which interact through a series of exchanges. The theory describes how electrons emit and absorb photons, and how photons mediate the electromagnetic interactions between charged particles. The interactions between charged particles are described by a mathematical framework called **quantum electrodynamics perturbation theory**, which allows physicists to calculate the probability of specific interactions. One of the key predictions of QED is the Lamb shift, which is a small but measurable shift in the energy levels of electrons in a hydrogen atom due to their interactions with the electromagnetic field. The prediction of the Lamb shift was one of the first successful predictions of QED and provided strong evidence for the validity of the theory. QED has been extremely successful in predicting the behavior of electromagnetic interactions in a wide range of experimental settings, and its predictions have been confirmed with extraordinary precision by a variety of experimental techniques, such as spectroscopy and scattering experiments. The theory has also led to the development of important technologies such as lasers and transistors.

Quantum mechanics: The theory developed from wave equations, **Planck's quantum principle** and **Heisenberg's uncertainty principle**. No deviation from quantum mechanics has ever been found in the laboratory. Its most advanced version today is called **quantum field theory**, which combines **special relativity and quantum mechanics**. A fully quantum mechanical theory of gravity, however, is exceedingly difficult.

Quasar: Quasi-stellar object. They are huge galaxies that were formed shortly after the gigantic explosion called the big bang.

Quantum foam: Tiny, foam like distortions of 4 dimensional fabric of space-time at the level of the Planck length.

Quintessence: A theory that allows the cosmological constant "**Λ**" to vary with time.

Radioactivity: The spontaneous breakdown of one type of atomic nucleus into another. Radioactivity refers to the process by which certain unstable atomic nuclei spontaneously decay, emitting particles and energy in the form of radiation. **The three main types of radiation emitted by radioactive decay are alpha particles, beta particles, and gamma rays.** Two protons and two neutrons make up alpha particles, which are positively charged. They have a short range and can be stopped by a sheet of paper or the outer layer of skin. Beta particles are high-energy electrons or positrons (the antimatter counterpart of electrons) that are emitted by some types of radioactive nuclei. They have a greater range than alpha particles and can penetrate several millimeters into the body, but can be stopped by thicker materials such as wood or aluminum. Gamma rays are high-energy photons (particles of light) that are emitted by the most energetic forms of radioactive decay. They have the greatest range and can penetrate through several centimeters of dense material, but can be stopped by several meters of concrete or several feet of soil. Radioactivity can occur naturally or as a result of human activities, such as nuclear power generation, nuclear weapons testing, and medical radiation. Exposure to high levels of radiation can have harmful effects on living organisms, including genetic damage and increased risk of cancer. However, radiation can also have beneficial uses, such as in cancer treatment and medical imaging. The principles of radioactivity have also contributed to our understanding of the structure and behavior of atoms and have led to important developments in fields such as nuclear physics, nuclear engineering, and radiation protection.

Red shift: The reddening or decrease in frequency of light from a star that is moving away from us, due to the Doppler effect.

Singularity: A point in space-time at which the space-time curvature becomes infinite – which represent a **breakdown of general relativity**, forcing the introduction of a quantum theory of gravity.

Singularity theorem: A theorem that states that the universe must have started with a singularity.

Space-time: The four-dimensional space whose points are events.

Ptolemaic Model → Earth centered model of the universe.

Copernican Model → Sun centered model of the universe.

Spatial dimension: Any of the three dimensions that are space like – that is, any except the time dimension.

Special relativity: **Einstein's 1905 theory** based on the idea that the laws of science should be the same for all observers, no matter how they are moving, in the absence of gravitational phenomena. Consequences include: time slows down, mass increases, and distances shrink the faster you move. Also, matter and energy are related via $\mathbf{E = mc^2}$**.** One consequence of special relativity is the atomic bomb.

Stars moving away → Red shift

Stars moving toward → Blue shift

Greater the shift → faster the speed

Spectrum: The different colors or component frequencies that make up a wave. By analyzing the spectrum of starlight, one can determine that stars are mainly made of hydrogen and helium.

Supersymmetry: The theory predicts that every fermion particle should have a boson equivalent **(e.g. a quark will have a squark)** and that every boson should have an equivalent fermion **(e.g. photon and photino).**

Supercooling: The process of lowering the temperature of a liquid or a gas below its freezing point without it becoming a solid.

Spin: An internal property of elementary particles.

Stationary state: One that is not changing with time.

Spectrum: The range of colors that visible white light is composed of. When visible light travels through a prism, a spectrum is created.

Supernova: **Catastrophic stellar explosion** in which so much energy **(nearly of the order of 10^{42}J)** is released that the explosion alone can outshine for weeks an entire galaxy of billions of stars.

Type I supernova explosion: Explosion of a smaller star that is being fed fuel from a companion star.

Type II supernova explosion: Explosion of a massive star that has run out of nuclear fuel.

String theory: A theory of physics based on tiny vibrating strings, such that each particle is described as a wave on a string. It is the only theory that can combine gravity with the quantum theory, making it the leading candidate for a theory of everything.

Different vibrations → Different particles

String combinations → Particle interactions

A sterile neutrino is one that is not paired up with one of the three charged leptons (electron, muon and tau) in the standard model of particle physics.

Strong force: The strongest of the four fundamental forces, with the shortest range of all. It holds the quarks together within protons and neutrons, and holds the protons and neutrons together to form atoms.

Spectroscopy: The process of analyzing an object's visible light spectrum to learn about its composition, temperature, density, and mobility.

Steady state theory: The theory which states that the universe had no beginning but constantly generates new matter as it expands, keeping the same density.

Sunyaev-Zeldovich effect: Scattering of cosmic microwave background radiation photons by rapidly moving electrons in the hot gas in clusters of galaxies.

Umbra: The region in the shadow produced by an eclipse that is completely dark.

Uncertainty principle: The principle, formulated by **Heisenberg,** that one can never be exactly sure of both the position and the velocity of a particle; the more accurately one knows the one, the less accurately one can know the other.

$$\Delta x \, \Delta p \geq h/4\pi$$

$$\Delta E \, \Delta t \geq h/4\pi$$

Virtual particle: In quantum mechanics, a particle that briefly dart in and out of the vacuum but can never be directly detected, but whose existence does have measurable effects. They violate known conservation laws but only for a short period of time, via the uncertainty principle.

Thomson's model → The atom is composed of electrons surrounded by a soup of positive charge to balance the electrons' negative charges.

Rutherford model → The negatively charged electrons surround the nucleus of an atom.

Wave-particle duality: The concept in quantum mechanics that there is no distinction between waves and particles; particles may sometimes behave like waves, and waves like particles.

Wavelength: For a wave, the distance between two adjacent troughs or two adjacent crests.

Weak force: The second weakest of the four fundamental forces – which is carried by the W and Z bosons that makes possible nuclear decay. It affects all matter particles, but not force carrying particles.

Weight: The force exerted on a body by a gravitational field. It is proportional to, but not the same as, its mass.

White dwarf: A stable cold star consisting of lower elements such as oxygen, lithium, carbon, and so forth, supported by the **exclusion principle** repulsion between electrons.

Wormhole: A passageway between two universes or a thin tube of space-time connecting distant regions of the universe. **Wormholes** might also link to parallel or baby universes and could provide the possibility of time travel.

◆ ◆ ◆

ACKNOWLEDGEMENT

Without the amazing work of some renowned cosmologists and physicists, their creativity, and their inventiveness in the field of cosmology, this book would not have been accomplished. I would like to use this opportunity to thank my **scientific colleagues** for their unwavering support during the **COVID crisis** and for giving me access to all the resources I needed to finish this book. I want to express my gratitude to my family for their support and encouragement as I wrote this book, especially to my mother, who has been a tremendous source of inspiration in my life. I owe a lot of gratitude to my mother for teaching me how to be perseverant and strong in life. Finally, I want to emphasize how crucial patience is when writing a book or taking on any other project in life.

ONE FINAL THOUGHT

◆ ◆ ◆

If you feel that this information has been useful to you, please take a moment to share it with your friends on LinkedIn, Facebook and Twitter. Think about leaving a quick review on **Amazon** if you think this book has given you insight into the grand narrative of the cosmos from a fresh, inspired perspective and you have learnt something valuable.

Cosmology is a study area that combines the astronomy and physics in an endeavour to comprehend the physical universe as a cohesive whole. It is both incredibly fun and fascinating. I want to spread my passion to as many individuals as I can. I also hope that this isn't the end of your quest for solutions to the mysteries that have plagued mankind since its beginning. **How did the cosmos start, and how will it wrap up?** Why is the universe accelerating its expansion and what is dark energy? **What are Superstrings?** How can we calculate the universe's size and age? What role does humanity have in the universe's 14 billion year history? **What role**

does humanity play in the history of this planet? How does humanity participate in the complex chain of life here on Earth?

Thank you!

◆ ◆ ◆