Chapter 1

An Account of Universe, Solar System, Moon and Planet Earth

Riddles form. They form to be solved—sometimes demonstrated and applauded, sometimes hypothesised and alluded and sometimes just doomed. Probably it is inevitable—but certainly not when it is intricate. It is utterly plausible that earth's simplest life forms, which are little more than tiny bags of elements, the chemicals, formed from the nuclear waste of the stars acting as natural reactors operative in the cosmos, could have remained unchanged. Our complex cells, with their internal compartmental structures and complex support mechanism, their transportation fleets, their intricate machinery, might never have arisen. But then one fine day, about a few billion years ago, a fluke manifestation occurred, then another and yet another. Organic molecules formed from the reactions of the most ubiquitous of materials—rock, water and carbon-di-oxide—and they are thermodynamically close to inevitable. The result? You and I. The existence traverses through the convoluted web of a countless number of factors. Travelling back in time is enormously exciting. It is the times ahead that life does not know about. This is exciting too and probably fearsome to a great extent. Almost mid-way it is a grave road bump—the domain of environment and climate change, leading to the disruption of nature—all fundamentally self-destructing. Stunningly beautiful nature, the "*Nisarg*" (निसर्ग), the '*Nisargtah'* (निसर्गतः) the '*Nisargah'* (निसर्गः), the *'Prakriti'* (प्रकृति) the

"Kudrat", the "*la nature*", the "*natura*", lives on with sombre grumbles. Let's delve into the primordial, come along—it is through the science and secrets of luck, randomness and probability that we conjointly undertake this exhilarating journey.

We are an integral part of the cosmos, vital in constructing the shape it is in today and cannot be dissociated from it. The substance related to the astronomical concepts forms the subject matter of astronomy, a complex science. All that is comprehended has taken its origin from this concept. Broadly it studies the universe, solar system, planets, galaxies, meteoroids, asteroids and several other astronomical bodies, often thought to be of the status of celestial origin. The universe is the largest of these three astronomical concepts, the other two being the solar system and the galaxy. All these things are included within the realm of the universe and everything known to man is contained within it. When there is talk of the origin and evolution of the universe, we are talking of our own origin and evolution. The most accepted hypothesis tells us that the entire universe of which solar system, the stars, the earth and moon are a part, came into existence in the form of a marble or even smaller. In the beginning, there was nothing, no time or any such thing. It began with a tiny speck of light. It was infinitely hot with all the space inside this tiny ball of fire. Everything—all the matter, all the energy, that we see today were within that ball of the size of a marble, even smaller than it, probably a single atom. The American Astronomer, Edwin Hubble, also nicknamed "pioneer of distant stars" by his brilliant work and analysis changed the very perception about our universe, helping to lay the foundation of the popular *Big Bang Theory*. The thought that the universe was expanding proved to be the game-changer which meant that it must have been small at some point of time in the past. This indisputably came up as a result of Hubble's study of Androbinan Nebula and a galaxy—other than the one we probably thought we knew about. The famous theory of relativity propounded by Albert Einstein earlier provided the footing.

American Theoretical Astrophysicist David Nathaniel Spergel, an expert in *Big Bang Theory*, opined that this theory does not explain how the universe began but explains how it evolved. Immediately, as immediate as a human mind can conceive, probably in less than a trillion trillionth of a second, the super-hot infant universe which was very unstable then, underwent an enormous growth spurt and started expanding and with it, space was also expanding, faster than the speed of light. After a trillion trillionth of a second, the universe was just big enough to fit in our palm; in the next fraction of a second it matched the size of Mars and the following fraction of a second saw the baby universe acquire the size of about 90 times the earth. Till then, the universe did not contain matter. It was just a ball of energy—enormous energy. Einstein's famous equation $E=MC^2$ explains that matter and energy are interchangeable. However, the universe not only produced matter from energy but also created antimatter. They were arch-rivals, by obliterating each other they would have annulled each other and probably no matter would have been formed had the situation been so. As a consequence, the universe would have remained full of energy and the galaxies, stars or even we would never have come to exist. Fortunately, the matter exceeded the antimatter, i.e. for every one million particles of antimatter formed, one million and one particles of matter were formed—thus matter came into existence.

Scientists created the atmosphere that was exactly akin to what it was about one-millionth of a second after the Big Bang in the Relativistic Heavy Ion Collider (RHIC) in Brookhaven National Laboratory located in Long Island, USA. Their experiments changed the basic thought. The particles on collision did not form a gas but a super-hot liquid with no viscosity at all. The temperature was a 100 million times hotter than the sun. This liquid existed for a tiny fraction of a second. Nevertheless, the universe was in turmoil. The subatomic particles were racing incredibly fast and colliding with each other in the young universe. Because of the mind-boggling

speed the particles collided with each other, the electrons were not able to bond to form the atoms. During the next about 300,000 years or more such a situation continued. After a lapse of about 380,000 years following the Big Bang, the universe had become the size of the Milky Ways and its temperature had also come down from a billion degree Fahrenheit to just a few thousand. Later Dr. Arno Penzias of Bell Laboratory conducted research to give an undeniable account of the birth of light which became one of the most important scientific discoveries on earth and helped in solving the problem related to understanding the development of the universe. As time flew, the gases condensed to form stars. Stars constituted the galaxies—like the Milky Ways. Galaxy is a system comprising of solar systems and stars. They are held together by gravity. In galaxies, vast empty spaces are present separating solar systems. Our earth and solar system together with presumably 200 billion stars form a galaxy, called the Milky Way. Solar systems orbit around the stars that form these galaxies. Within the galaxies, the spaces with intense gravitational pulls from which not even light can escape are called black holes. Such sections of space are also present elsewhere in the space.

British astronomers, Fred Hoyle, one of the greatest scientists of the twentieth century refuted that the universe was formed as a result of a single explosion. He was candid when he said, “It is no more likely that our world has evolved out of chaos than that a hurricane, blowing through a junkyard, should create a Boeing”. He wondered where the elements heavier than hydrogen and helium came from. The idea put forth was that inside the stars something was going on. The stars acted like nuclear reactors, something almost akin to an atom bomb exploding in slow motion but many billions of times more powerful and their nuclear waste created new elements. This became more coherently accepted by the scientists later on when studies were conducted on the light emitted by stars. On heating, each element emits light at a particular frequency. Let’s take sunlight

for example. When broken up into spectrum it breaks like a bar code, each colour corresponding to different elements, each of them has a specific colour. Based on this, different elements are identified. For example, hydrogen mainly emits red colour. The Hubble Space Telescope was launched by NASA in the year 1989 to discover the mysteries of an earlier universe. Very appropriately, they called it a window into space. The focus was to study the older stars if they are still making new elements. This was the most expensive telescope ever built but had several hiccups before it started working and doing photography. It was primarily possible by a heroic deed performed by the NASA team and their Astronaut Professor Jeff Hoffman, who carried out a fine repair work that took five days, reaching there in another space shuttle with telescope still in the space. Hubble telescope captured the final moments of a star's life, its explosion and release of gases, *cosmic dust interstellar nurseries* of newborn stars and dart pillars of *cosmic dust* millions and millions of miles long ready to span a new generation of stars and planets. The telescope also captured the tapestry of distinct galaxies in seemingly an empty patch of space, formed millions and millions of years ago while it also noticed some of the first galaxies created after the Big Bang. A large number of galaxies could be seen not known before. Hubble telescope testified what had been just hypothesised. The universe was still in the making. At one point the universe entered into what is generally called a super-creative phase. Then came a situation when the giant stars called supernovae exploded to create more elements which were not created till then. It was roughly a period of 500 million years that our universe had lived through and there were 13 billion years more to go before the appearance of humans on the face of the earth. The telescope saw the explosion of stars and supernovae, who are the creators of new elements, the array that we see today. It is therefore very pertinent to state that without the birth and death both resulting from the explosion, our planet would be dull, possibly might not have forged such a variety and shockingly we might not have been around. The making, however,

continues unabated. The fact, as stated by scientists, is that our lives in a real sense depend on the lives and deaths of stars.

The images snapped by Hubble telescope elaborated the aftermaths of the explosion of stars. It must have looked like some incredible and heavenly fireworks over an enormous span of time. Nebulae, giant clouds of debris thrown off by exploding stars, comprised of new atoms like gold, silver, zinc and lead. During its phenomenal services rendered for about 30 years, in addition to millions of pictures, Hubble has observed distant stars and measured the age of our universe. It has shed light on various mysteries of our universe. After such a successful service, Hubble has peaked in terms of how far back it is able to observe. One of Hubble's astounding observation came up in 2016, when it captured the image of galaxy GN-z11 found in the constellation Ursa Major, It was probably the most distant and currently the oldest galaxy observed by Hubble telescope. This galaxy is 32 billion light-years away. As rightly propounded by Edwin Hubble the universe is still expanding. Due to this expansion, the light from the high-redshift galaxy observed by Hubble telescope was 13.4 billion years in the past, just about 400 million years after the Big Bang. This is the maximum Hubble can observe and not beyond it. In fact, Hubble's capabilities are limited to the range of certain wavelengths of light. Galaxies are on the move; when they travel from one point to another in the space the wavelengths of its light are stretched due to constant expansion of space. By the time the light reaches Hubble it is stretched to a wavelength outside the viewing range of Hubble. It cannot observe anything stretched to near-infrared range. The relentless quest of the human mind grows and the paragon of science enriches by leaps and bounds. NASA is likely to substitute Hubble telescope with a more versatile version of space observatories, the James Webb Space Telescope (JWST) in the near future. James Webb once in action, will virtually substitute the Hubble which successfully added to the vibrant treasure of humans'

space knowledge for over three decades. This observatory will be able to see what the universe looked like around a quarter of a billion years or possibly even 100 million years, after the Big Bang. Presumably, it was this period when the first generation of stars and galaxies started to form. The difference in the size of mirrors in Hubble and James Webb is conspicuous. Hubble had a 2.4 Metre-diameter mirror while James Webb will have a 6.5 metre-diameter mirror. The number of wavelengths that can fit in a mirror depends on the size of the mirror. A larger mirror allows a higher resolution. Interestingly, the James Webb with its capabilities can observe a small coin from 40 kilometres, a fact that speaks volumes of its breath-taking capabilities.

This may not be out of context to elucidate a rather more modern concept on the matter. However, this does not impart anything to demean the work done by the illustrious astronomers in the past. In the year 1964 Scottish physicist Peter Higgs and others laid out a theory on the advent of everything in the universe and thus the universe itself. It is the physical proof of an invisible, omnipresent field that provided mass to all matter right after the Big Bang. This forced the particles to coalesce into stars, planets and others in the universe. A model in quantum physics comprises a hypothetical, ubiquitous quantum field which is thought to give mass to all the particles in existence. This indeed explains why at all the particles have any mass. This field was named as Higgs field and the particle associated with it is called *Higgs Boson*. The existence of Boson is not yet proved, yet if it is assumed that the *Higgs Boson* does exist, its mass can be inferred on the basis of the effect it would have on the properties of other particles and fields. The *Higgs Boson*, later on, came to be known as *'God particle'* also, probably due to the pious belief that the God is omnipresent, is pervasive and runs the 'entire' show in the universe. In layman's language, it is the *Higgs Boson* which is responsible for the existence of everything—be it of any shape, size and function, if just present in the universe.

The name came into existence in 1993 from a book on the topic. In order to fill in the gap, particularly for those new to the subject, one resolutely needs to comprehend what 'Boson' has to do so with Higgs particle. The name Boson was coined by Paul Adrien Maurice Dirac, an English theoretical physicist. Boson is one of the two classes of particles, the other being 'fermions' and is doggedly bonded to commemorate the contribution of Satyendra Nath Bose, an Indian Physicist and Professor at University of Calcutta and Dhaka, who developed Bose-Einstein statistics which theorises the characteristics of elementary particles. The *Higgs Boson* is an elusive particle since its inception. In fact, no experiment has observed the *Higgs Boson* to confirm the theory. *CERN*, a multination organisation after conducting experiments like A Toroidal LHC ApparatuS CMS combine *(ATLAS)*, the general particle detector on Large Hadron Collider *(LHC)* claimed to have observed a new particle in the mass region. This is consistent with the Higgs particle. ATLAS is one of the four experiments at LHC at *CERN*. *ATLAS* is aimed to answer the fundamental questions like what the basic building blocks of the matter are and what the fundamental forces of nature are. It also aims to understand if there is an underlying symmetry to our universe. With the colossal magnitude of the cost and the utility of research, *CERN*, the European Organisation for Nuclear Research and an acronym for *Conseil Europeen por la Recherche Nucleaire* is the most appropriate establishment to undertake such experiments. The reference is probably incomplete if the name of Francois Baron Englert, the Belgian theoretical physicist who shared the 2013 Noble Prize in Physics jointly with Peter Higgs for their work on "theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles", which recently was confirmed by the *CERN*'s *LHC*.

Scientists have also propounded theories about the death of the universe. One hypothesis propounds when the universe will run out of steam and stop expanding and as a result every star, planet, galaxy

and the supernovae, every atom will start collapsing, culminating in a super-dense pinpoint, called the “Big crunch”. Scientists like Saul Perlmutter have studied if the universe was still expanding. By focusing to study the explosion of Type 1a supernovae and by comparing the dates and positions of supernovae, stretched over space and time, it is calculated if the expansion of the universe is slowing down. Interestingly it is observed that it is not slowing down at all. So another theory, diagonally opposite to the previous one was propounded. The universe, everything included may rip apart due to the expansion to the ultimate limit. Ultimately, it is presumed that the universe will be dark, empty and probably lifeless.

After the Big Bang and passage of almost 9 billion years, the universe had all the necessities for life now in place. The universe was not artless anymore; it has now grown into a vast complex of billions of galaxies and innumerable stars. Silently in a corner in Milky Way, an enormous amount of dust and gas started accumulating which comprised the rich debris left over from one of the supernovae. When this debris reached the critical mass, it began to burn brightly. Consequently, a star was born, the sun, our own star. What was left over, formed a disc of swirling debris that orbits around the new star. The gas and debris that make up this disc collide and is pulled together by gravity. More and more dust and gas get supplemented to make it bigger and bigger and thus the planets are formed. Our earth is one of them. In the following 500 million years, the planet generated a canopy of gas around it, the atmosphere.

The solar system consists of a star, such as the sun and the objects like moons, asteroids, comets, rocks, dust and meteoroids affected by its gravity. The solar system we refer to by this very name and the one known to mankind is constituted by the sun together with its planetary system, which also includes the earth. There are eight planets, in addition to the sun in the solar system. They differ a great deal from one another. There are inner planets Mercury and Venus, closest to the sun; mysterious Mars; accompanied by

Jupiter, Saturn, Uranus, Neptune and the only planet that harbours life in an unimaginable variety of forms, our Earth. Mercury, Venus, Mars and Earth are terrestrial planets whereas Jupiter, Saturn, Uranus and Neptune are Jovian planets which have no solid surface and are gas giants.

What we know of the solar system, elucidates that the solar system is the one of which our earth is a part. Our solar system is just one specific planetary system, a star with planets orbiting around it. There may be more planetary systems present outside our solar system. There are about 200 billion stars in our own galaxy including the sun and earth. As regards the moon, it is the only natural satellite of our earth. Some known planets outside our galaxy are *HD 40307*, with eight times greater mass and gravitational pull. Another is Kepler-16b. It is fascinating to understand that this one is said to orbit two stars. There is *Trappist-1*, a planetary system that comprises as many as seven planets similar to the size of our earth. Although the universe encompasses both the solar system and galaxies, the actual size of the solar system is extremely hard for a human brain to truly comprehend in terms of scale. Life on earth largely owes its existence to the sun. Sun is crucial to virtually what we come across every day during the entire life span on the planet earth. The solar system has the sun at the centre with the earth orbiting it. The heart of the solar system is occupied by sun, where it is by far the biggest object, holding 99.8% of the solar system's mass and is about 109 times the diameter of the earth. The size of the sun can be understood by the prognosis that a million earths could be lodged in it. Due to its extreme gravitational force, all the planets started orbiting around it. The notion of a heliocentric solar system, with the sun at the centre, was possibly first suggested in the Vedic literature of ancient India, which often refers to the sun as the "centre of spheres". Later on, this came to be known as heliocentric. Some interpret Aryabhatta's writings in Āryabhaṭīya as implicitly heliocentric. A prominent school of western thinkers give credit to

Polish mathematician and astronomer Nicholas Copernicus, who in his book *"On the Revolution of the Heavenly Spheres"* propounded that the planets orbited around the sun and not Earth. In terms of size and distance respectively, if the sun is as big as a tennis ball, the earth would be the size of a sand grain, located almost 8 metres or 26 feet apart.

Moon is a natural satellite of our planet and fifth-largest among the moons in the solar system. Our planet's wobble is stabilised by the presence of the moon which stabilises our climate. It has a very thin atmosphere, called the *Exosphere* and is located about 385,000 kilometres away. Some planets in our solar system have one or more moons. The moon that we see somersaulting every clear night, mesmerising the humans is a natural satellite of our earth. Mars has two, and Jupiter has as many as 50 known moons, with 17 more awaiting confirmations. Saturn has 53 known and nine awaiting confirmation. Uranus has 27 whereas Neptune has 13. We comprehend more of our moon in our strides ahead.

The evolutionary history of life on earth is an extremely ambiguous spectacle which has been baffling the anthropologists, the geologists, biologists and has given rise to various schools of hypotheses. It is truly intriguing, obviously for many reasons. Our recent ancestors have been mute witnesses to the extinction of many species in the wild and growth of many others. Just after its inception, the planet earth had a very high temperature. Majority of the surface of the earth was covered by hot boiling lava, the molten rock material. Following 600 million years planet earth gradually cooled, during which innumerable meteoroids and asteroids kept on hitting the earth surface. One school of scientists believe that these meteoroids and asteroids brought minerals and water along with them. The set of scientific work, in the field of paleoenvironment, palaeontology, the ongoing process of global warming and climate change have altogether provided enough support to interpret that the life did not ascend all at once. Life emerged and became extinct

many times on the planet. It did not occur all at once, undertook the journey to acquire the present form and its inhabitants. However, the last time it took birth, maybe 4.5 billion years ago, has not perished since then and is thriving. By any magnitude of logic, the evolutionary approach looks more reasonable which, in fact, is supported by adequate pieces of evidence also.