COSMOS ** II

Evolution
– From Microbe to Man

(Origin of the Universe, Life and Man)

A Comprehensive Pre-Release
PRECIS

By

Gerald F. Pillay

2 Dec 2025
Singapore
(Celebrating my 91st Birthday)

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Explanatory Note

This precis is a self-contained summary of **Volume 4 in the series, Cosmos** II - From Microbe to Man**, which is being edited for release in early 2026.

It incorporates the preliminary conclusions of **Volume III – Cosmos*** III – Beyond Materiality?** which will be released after the above.

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About This Book

The object of the study series has been to understand the latest thinking on the origin of the universe, the evolution of life and where the latter is heading, and the role of man. (See Genealogy below)

The target readership is the mature and informed person ("man in the. street"), of whatever background, who wishes to add to or update his or her understanding of these front lines of human knowledge.

While the areas covered are technical, and technical terms cannot be avoided, the content is generally expressed in ordinary language. The author has wide experience reporting and explaining technical things to non-technical people.

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Genealogy of this Book

After my second retirement, and sundry other research work, I decided to do a roundup of the frontiers of science, moving onward on a piece by piece basis, and inevitably focussing on evolution. By professional habit (as a career administrator and consultant) I captured the outputs, and over the years released them as follows:

Volume	Title	Description
1	Quantum Mechanics, A Non-Technical Brief ISBN 978-981-14-9875-6 2020	Coinciding with the first quantum computers
2	Virus* The Biological Predator ISBN 978-981-18-3046-4 2021	Coinciding with and including a detailed coverage of Covid-19
3	Cosmos* The Physical Universe ISBN: 978-981-18-7401-7 2023	An historical survey of man's discovery of the universe. It summarises what we know today, and looks to the future. Coinciding with launch of the James Webb Space Telescope
4A (This work)	Cosmos* II, (Precis of) Evolution IBSN 2025	Covering the Origin of Life, Role of Man, and the Next Steps
4	Cosmos** II (under edit) Evolution - Microbe to Man IBSN (not yet) 2026 (due)	Covering the Origin of Life and Role of Man and Next Steps
5	Cosmos*** III (under edit) Evolution - Beyond Materiality? IBSN (not yet) 2026 (due)	Covering evolution beyond materiality

I have completed the work on both Cosmos** II and Cosmos***III, but the editing will take some time, as a lot is technical and needs checking for a "non-technical" person like myself. I thought therefore I would issue this Precis to capture the my overall findings fresh, and serve for easier digestion by others.

I have released the above as self-publications on the Internet at https://geraldpillay.wordpress.com/, and will do the same for those due.

All my publications, including the above, are also available at https://independent.academia.edu/GeraldPillay

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Dedication

To my grandsons
Christian Lowen Pillay
and
Derrick Ng

(I hope they read the main Volumes sometime.)

About Gerald F Pillay

(Extracted from Academia, at https://geraldpillay.academia.edu/)

Biography

Gerald Francis Pillay was born in Melaka on 2 Dec 1934. The family migrated to Singapore in 1949. He graduated with the B.A. Honours Upper II in Geography (1957) from the University of Malaya (then in Singapore).

Mr. Pillay served 33 years in the Singapore public service. In 1957, he joined the Administrative Service, rising to Deputy Secretary. In 1974 he was transferred to the newly-created Industrial Training Board as Secretary. In 1989, he retired as Deputy Director (Dy CEO) from the board, which has since become the Institute of Technical Education (ITE).

In 1989, he formed GFP Consultancy. He practised as a policy consultant in Technical Education (TVET)), serving international agencies such as the World Bank, UNESCO and ILO, employers and employers' organisations. In 1992-3, Mr. Pillay served on Botswana's Presidential National Commission on Education, nominated by the Singapore Government. He retired from practice in 2006.

HIS RECENT RESEARCH INTERESTS have been in the major frontiers of science and technology, probing the origin of things. He hopes next to explore the material-spiritual duality of human nature.

He releases these technical self-briefs on Academia.com, so far on "Quantum Mechanics" (2021), "Virus -The Biological Predator" (2022), and the "Cosmos - An Historical Survey and Exploration of the Future" (2023).

He has also e-published "the Chitty Melaka Story" (second edition) (2013) and "Japanese Conquest of Malaya and Singapore, 1941-2" (2019).(check Google).

Full CV available at "About Me" ,at the WordPress publications site.at https://geraldpillay.wordpress.com

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(Origin of the Universe, Life and Man)

(A Precis)

Object of the Study

The object of the study has been to understand the latest thinking on the origin and evolution of life, where evolution is heading, and the role of man.

The study looks for a grand design, if there be one. The study does so in the Frist Part by reviewing the pre-biotic development of the universe, which may be thought of as the preparatory phase. The study seeks to understand the processes by which the pre-conditions for life came to be distributed and located on planet Earth. In fact, the first question arising is whether this was unique to the Earth.

The study proceeds in the Second Part to trace the emergence of life in the single-cell prokaryote, and its progression to multi-cellular eukaryotes, to soft-bodied life, to animals and plants, and to Homo Sapiens.

The study proceeds in the Third Part to follow the further development of the latter, from early modern man to modern man, and finally to Man.

The study finally asks Quo Vadis? (what Next?), which will be addressed in the next Volume 5 - Cosmos*** III - Beyond Materiality.

(Editorial Note: For convenience, I use “man” (and its derivatives) to include woman, and I refer to the Supreme Being in the masculine. I make no apology.)

Pre-biotic Preparatory Phase

IN this part, unless the context otherwise requires:

“cosmos” means the universe and all that exists or may exist beyond it, known, unknown and conjectured, and unknowable.

“universe” means the physical world within time-space, including all biotic or living things

“pre-biotic” means before the emergence of life.

“metaphysical”, appertaining to all speculative thought relating to existence, being, reality, the origin and causes of things, and the purpose of man; and to knowing about these matters.

“philosophic”, the application of metaphysical (and related understandings) to what constitutes moral behaviour, a good life and the ultimate satisfactions of human existence.

“exoplanet”, planets found beyond our solar system, in orbit around other stars or as free-floating "rogue" planets.

Overview

The study finds that, spectacular and separate as they were, the many concatenated events in the universe, together, may be viewed in the light of the known end results as a single preparatory programme of stage-setting the conditions required to engender life.

It does not appear that the above was incidental, subsidiary or adjunct to some other purpose or objective of the development of the universe, or to have occurred by chance. On the contrary, the preparatory programme appears to be itself the primary purpose of the developing universe.

It would not be wrong to say that the universe was being set up to enable lfe according to the factors assembly therein - at the appropriate place and time.

We may add a qualifier. There are major areas within the universe still not understood. Among these are dark matter, dark energy, gravity, the apparently accelerating universe, and the time barrier. Therefore, as we progress, we shall be reformulating our understandings of the universe. However, as far as we can see, they will not change the facts as they happened. The pre-biotic preparatory activities did take place, enabling evolution of life. This study proceeds on that basis.

Unfolding of the Universe

Scientists have established that the whole of the universe is made up of the same matter, and the same physical laws of nature apply everywhere. This means in the first order of its development the universe created a common material base for different possible forms of life to emerge, subject to local conditions.

It is in the creation of local conditions that the preparatory programme excelled itself. Nothing could have been more spectacular or wide-ranging in the disposition of matter and local conditions than the modus operandi chosen, the grand opera of the big bang[1], followed by nucleosynthesis, the galaxies, the stars and the planets, the whole encapsuled in space-time.

The big bang contained the sum total of all the potential energy that drove, and still drives the universe. The universe expanded in space by a factor of the order of 1026 over a time frame of the order of 10−36 seconds. At the same time, the universe supercooled down sharply to 10-22 Kelvins. The primary purpose of the big bang was to install (or if you like “enspace”, my term) the universe.

But, whether by design or happenstance, when it initially attained the right temperature, pressure and energy level (of several million Kelvins) to perform nucleosynthesis, it first fused its payload of primeval matter, from quarks, protons and electrons, into atomic nuclei. Nucleosynthesis peaked at hydrogen, which was the lightest element, at one atom - with some spillover into helium, lithium and beryllium. Looking downstream, this represented some. 73% of all matter, and it would appear it greatly facilitated the subsequent build-up of the universe, while providing the fuel for energising the stars. All hydrogen atoms were created about 380,000 years after the big bang.

Progressing in stages, the universe first stretched out in giant filaments of hydrogenous gases, forming the cosmic web. As the latter cooled, the web formed the primary large-scale structures of the universe.

As things cooled further, galaxies began to form within the latter, again from nebulae of hydrogenous gases, accreting as star-clusters and giant stars. The first stars began to appear about 100 million years after the big bang.

With their gravitational collapse, the temperatures and pressures at the cores of these stars rose to fusion levels, in fact to levels above that initially achieved at the big bang, enabling fusion of heavier elements.

The fusion of hydrogen into helium, the next dense element, released a tremendous amount of energy. This was the start of stellar nucleosynthesis, which is the creation of new, heavier atomic

[1] - Scientists speculate how it occurred, whether from a singularity, a perturbation or hyper-inflation, for our purposes. It did occur..

nuclei from lighter ones. As the star continued to evolve and its core got even hotter, helium fused to form carbon, and subsequent fusion reactions created even heavier elements like oxygen.

Stellar nucleosynthesis went on to produce the rest of the elements. Under the energy released, the stars “lit up” and heated the universe for the first time, and we had the Cosmic Dawn, by roughly one billion years after the big bang.

Both carbon and oxygen, critical components of our biology, were made at this time. Nature further arranged it so that they got distributed to the universe when their stars terminated their life cycles in a supernova, by collision, assimilation, etc, aided by “stellar winds”.

Needless to say, as the stars spun on their axes and cooled externally, they in turn formed the planets from their loose material, offering an almost infinite combination of life-friendly conditions.

The materials also got distributed to the planets and other locations by lesser forms of transport like comets, asteroids, dust, debris, icicles and even “solar winds”, bringing complementary resources for life formation.

The net result of all the preceding was that the planets emerged as the practical locations for life as we know it on Earth to emerge, the only possible places where the right temperature ranges and other conditions could come together, depending on their orbit. These planets are said to be within the “habitable zones” of their stars.

It has been gestimated that there are 200 billion billion (6 sextillion) stars in the universe, and some 100 billion stars in the Milky Way alone. Even if we assume that there might be only one planet on the average per thousand stars in the Milky Way, we are looking at 100 million exoplanets. At one *per million,* there could be 100 habitable exoplanets in the Milky Way alone.

No new galaxies are being “born”, However, galaxies are still growing through mergers and collisions, and star formation continues. There have in fact been three generations of stars, our Sun belonging to the youngest generation.

On this basis, one might say the universe was pretty much set up to take on life in any number of places over a wide swipe of time, subject to local conditions. It is possible life may have emerged and died out many times before we even began.

Life is dependent on local conditions. These include the terrain, topography, tectonics and heating conditions, the availability and disposition of water, the atmosphere and climate – and importantly but not essentially to start off, the presence of organic compounds.

Water

We will end here by touching on two compounds, critical to life as we know it. The first is water (H2O). Oxygen was made in the stars, and therefore water only began to appear with the Cosmic Dawn. The oxygen had to disperse and unite with hydrogen in significant amounts to form water. They must be subjected to an energy charge for this to happen.. It is thought water was formed when dust and debris, also created by stars, passed through oxygen in hydrogen-filled space, delivering the necessary energy, forming icicles. Water was therefore first formed in deep space.

In time, it got delivered to the planets by bombardments of various kinds. Some scientists think the universe is saturated with water. It is thought the early Earth was a “water-world”. 71% of Earth is still covered by the oceans.

Carbon

The universe was about 200 million years old when the first stars began their fusion processes that created carbon, the fourth most plentiful element. Evolution chose carbon as the basis of its biology. All living matter is formed of organic compounds, which includes carbon.

Technically, an organic compound is a chemical compound containing carbon, covalently bonded to other atoms, most commonly hydrogen, oxygen, and nitrogen. Carbon has the ability to form very long chains of interconnecting bonds. This property allows the complexity and diversity of the organic molecules necessary to form the backbone of life.

Interestingly enough, we know of no other element in our universe with this or similar capability. This is thought to pretty much narrow the possibilities of other life forms based on other elements, say iron. We are a carbon life-form.

All organic compounds are biological. They have each evolved to serve a biological function. Every living thing on Earth is a skinful of organic compounds.

Life itself functions through the structures and chemical reactions of organic compounds, and it evolves new organic compounds as needed. Thus, there are standard substances like proteins, carbohydrates, fats, and nucleic acids. Additionally living things make other organic compounds as "biological tools" and "molecular muscles" for specialised purposes. Among the latter are enzymes. These are functional as well as catalytical, serving to trap photons, transmit energy , breakdown food, remove waste, medicate and repair, and engineer replication. There are myriads of organic compounds.

I think myself of carbon's ability to enable us to make the next new organic compound as the first frontier of evolution.

Origin of Organic Compounds

New lines of enquiry have opened up in recent years exploring the possibilities that organic compounds may have been formed in space (like water) and transported to Earth in the inter-stellar exchanges. These and other complex molecules, like those found in meteorites, could have been delivered to early Earth from space, providing the raw materials for life to begin. Confirmation of this would mean, organic compounds are standard to all parts and planets of the universe, like water, simply waiting our discovery. They do not, however, explain how life got going, here or anywhere.

Aside from the evidence of transfer of organic compounds (and possibly microorganisms) from space, the standing theory of the origin of life on Earth is the primordial soup theory, which is the backdrop of our investigations in Part Two.

The thesis is that life on Earth arose from a mixture of inorganic compounds in the early oceans or atmosphere, which when energised by sources like lightning or UV radiation, formed simple but essential organic molecules like amino acids and purines. These molecules then combined to form more complex compounds, eventually leading to the first self-replicating life.

Researchers suggest these metabolic cycles could also have occurred in hypothermal vents on the ocean floor, where chemical reactions might be driven by geothermal energy. The further thesis is that the vented gases could have included methane, ammonia, water vapor, and carbon dioxide, which could have formed the organic molecules.

The Miller-Urey experiment[2] was a 1953 simulation of early Earth conditions that successfully produced amino acids from inorganic molecules by passing electrical sparks through a mixture of methane, ammonia, hydrogen, and water. The experiment demonstrated that the basic chemical building blocks of life could form through natural processes, establishing chemical evolution as a fundamental process of life formation.

In retrospect, the experiment focussed on creation of the organic compound, not life generation. The experiment demonstrated the (natural) formation of organic molecules, but did not show how these molecules would combine to form life. Various follow up experiment have been carried out since, generally upholding the finding of this experiment, but there is no report of any advance further.

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[2] - Conducted by Stanley Miller and Harold Urey at the University of Chicago, https://en.wikipedia.org/wiki/Miller%E2%80%93Urey_experiment

Up to 1828, it was thought that organic compounds could only be synthesised by the living bodies. Today, we can artificially produce a considerable range of organic compounds to supplement our health. It does not bely their biological character, but we are far from understanding how to make life.

What finally it boils down to is that the universe included provision for organic compounds as a preparatory step.

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PART TWO

The Saga of Evolution

Definitions

Unless otherwise required in their context,

“respiration” or “cellular respiration” is the process of extraction of energy. It is “aerobic” if done with oxygen, and “anaerobic” if done without oxygen.

“food” or “nutrients” means organic compounds consumed (broken down) to release their energy and raw materials

“consumption” means the breaking down of organic compounds.

“prokaryote” is any organism that lacks a distinct nucleus and other organelles due to the absence of internal membranes. There are two broad domains, namely archaea and eubacteria (bacteria).

“eukaryote” is any organism whose cells contain a nucleus and other membrane-bound organelles . There is a wide range of eukaryotic organisms, including all animals, plants, fungi, and protists, as well as most algae.

“Quantum leap” is a forward shift In complexity for which there is no scientific basis. In time, we have come to understand how most quantum leaps took place and even (from the results) why. The only two outstanding are: why was life started and why man acquired his intellectual capacities.

Overview

In Part Two, we capture in considerable detail what followed the preparatory stages, and what happened in evolution up to today. I find the best starting perspective to take is that we, man, are the current end-product of evolution; and this study seeks to trace what were the steps and processes that brought things together to make us what we are.

The saga of evolution emerges as a dramatic (the word that occurs to me is unquenchable) upsurge of life, on the stage of a tectonically turbulent planet, on the longest possible swathe of time, and with cycles of new growth, destruction, regeneration, quantum leaps and triumphs.

I make the point that we are the same micro-organism of yore that grew up, a future model of the same thing.

The Four Fronts

I find that evolution, after picking on carbon as the base substance for building our life-form and identifying Earth as the place to start things, proceeded with its purposes on four interacting fronts

.1 Firstly, establish a system to capture, store, unpackage and deploy energy.

.2 Secondly, invent a biochemistry (previously non-existent) that could work with organic compounds to make and fuctionalise the living organism.

.3 Thirdly, develop the necessary metabolism, that is the set of all chemical reactions necessary to sustain life and develop.

.4 Fourthly, be able to reproduce itself, and in doing so adapt and mutate as necessary, and thereby evolve.

Our proto-organism adopted a twofold strategy: a short life cycle and mass reproduction. This allowed for evolution on an exponentially increasing front, improving the chances of surviving the high rates of extinction in early Earth.

Rise of the Prokaryotes

The Earth was formed 4.56 billion years ago, and we have found the first evidence of evolution dating back to 3.8 billion years ago in the Archaean. The oceans had substantially formed, but the Earth's surface was still made up of continental chunks drifting about under the influence of magmatic currents heated from the core.

It is believed life started in the ocean, near a hypothermic vent. Neither the oceans nor the atmosphere at that time contained the levels of oxygen necessary to support life as we know it.

The Anaerobic Chemotropic Prokaryotic phase
(3.8 to 2.9 billion years ago)

Our first life was therefore an anaerobic prokaryote, a single-cell microorganism or entity.

Its first requirement was to obtain energy. Our proto-organism had initially to kick-start things with energy from an inorganic source, such as the surrounding rocks or minerals, by a process called chemolithotrophy. When this source was triggered by lightning or an electrical charge or heat, our prokaryote had its first "activation energy".

After much mucking around for hours, days, years, perhaps thousands of years, our proto-organism discovered "redox" Applying activation energy, this is the chemical reaction that knocked off an ion or electron from a (donor) substance (oxidation) coupling it with a further transfer of the same on to another (acceptor) substance (reduction).

Our prokaryote then proceeded to develop an Electr**on** Transfer Chain (ETC) applying the redox principle to transfer the electron (and its energy) via a series of intermediaries to a terminal acceptor. By a series of "reductions", this process created a "proton gradient" (of potential energy) at the latter. The terminal acceptor was then passed through a "molecular machine" or enzyme called "ATP Synthase" [3], which synthesised the energy to form ATP (adonise triphosphate) molecules (energy carriers). Voila, our prokaryote was in business.

Prokaryotes perform cellular respiration and ATP production across their cell membrane and in the cytoplasm. This is assisted by a structure called mesosome which are the infoldings of the cell membrane.

Donors were usually inorganic, the intermediates were organic, and the terminal acceptors either, usually inorganic compounds.

The next urgent task was to build a cell and make it function as a living entity (definition: it could reproduce). It established three sets of functionalities:(1) to breakdown and extract from the existing organic (and inorganic) compounds the nutrients and energy necessary to sustain life and tap more energy, (2) to build its different requirements, and (3) to operationalise the metabolic system. Then, our prokaryote went on to create a whole corpus of enzymes and biological tools to execute these functionalities.

Our prokaryote's primary requirement was for organic compounds. After further mucking around, it established four categories of organic compounds as its nutritional sources, namely (1) proteins for

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[3] ATPs are energy carriers, also the the unit of measurement of biological energy. When ATP releases a phosphate group to power cellular activities, ADP (adenosine diphosphate),is formed. It is then converted back to ATP through processes like cellular respiration, essentially acting as the "rechargeable battery" of the cell.

building, (2) carbohydrates (glucose) for food, and (3) lipids (fats for storage) and (4) nucleic acids. Additional requirements included minerals, water and vitamins, with which we not be concerned here.

Our prokaryotes initially got their organic nutrients from the external environment by absorption through the cell wall-membrane. Where the molecules were too large, they flushed out enzymes to break them down first. In time, they began to store supplies in excess to needs. Ultimately, this would be the basic practice of future generations, with the ingestion of food as the standard source.

Ongoing research suggess that prokaryotes very early started using chemosynthesis to fix carbon compounds from inorganic compounds, in particular carbon dioxide and hydrogen in the air – in fact establishing the pathway for carbon fixation in the future. (There is the suggestion the latter function may well have been a standard process in nature before the emergence of life, perhaps another preparatory step to enable it.) Carbon fixation has remained the ultimate source of food, in the absence of everything else.

I could get no firm source, but it is likely the early cyanobacteria had evolved pathways enabling the (future) Calvin Cycle as a third independent source of energy production, although at that stage they had no dire need to manufacture organic compounds additional to what was already available.

Among the earliest metabolic systems put in place was the anaerobic universal pathway glycosis, It critically converted glucose to extract ATP (but imperfectly), while releasing its payload of other raw materials. Other organic compounds were processed by other enzyme-tools to other intermediate stages for their purposes and/or fed into glycosis to extract their payloads. This was the primordial "consumption" (of food) function.

Central to all of the above was the metabolic system. This is the working system of an entity that keeps all its operations functioning in sync and coordinated towards the objectives of the entity. In the case of a biological entity this would be: to be alive, grow, repair, be in homeostasis, reproduce, adapt, and evolve. Even at that stage, the prokaryote had built up a considerable operational management load.

Finally, our proto-organism also needed a management information system to store data and organise, select and set its directions of advance. Our prokaryote created and installed two related systems[4] which also serve a second major function, the microorganism's building, repair and development system:

. (1) The first was the DNA system, housed in a nucleus. It stored all the genetic codes for an organism to develop, survive, and reproduce, in other wors the blueprints for building and operating the organism. DNA also accurately copied itself on reproduction so this genetic information can be passed from one generation to the next.

. (2) The second system was the RNA. A copy of the DNA instructions is made into a messenger molecule called RNA, which takes the message out of the cell's nucleus into the molecular machine ribosomes (of which there are many in a cell). Ribosomes read the RNA message and link amino acids together in the correct order to build a protein.

Our evidence is that our prokaryote took a billion years to evolve all of the above, and all that bio-engineering took place in a single cell of less than a micron. By then, our prokaryote would also have multiplied into the zillions and occupied much of the land as well as the water, over an almost infinite number of mutations.

Modern evidence shows that our prokaryotes split early into their presently recognised domains of Archaea and Eubacteria (Bacteria). The timelines of species divergence suggest that archaea diverged earlier: between 3.7 and 3.1 billion years ago, while bacteria diverged from common ancestral species between 3.2 and 2.5 billion years ago.

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[4] - Nucleic acids, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), carry genetic information which is read in cells to make the RNA and proteins by which living things function. The well-known structure of the DNA double helix allows this information to be copied and passed on to the next generation.

Archaean prokaryotes became specialised to extreme conditions, while bacterial prokaryotes represented the main line of the prokaryote. Therefore, in this study, we have focussed on the latter, and our descriptions relate to them.

The (bacterial) prokaryote was typically a single cell microorganism, measuring from 0.1 to 5 microns (one millionth of a metre). The limited energy available set the limits on their evolution. They stayed small to maximiser efficiency and replication, sacrificing speed of movement and size.

Typically, our micro-organism was enclosed by a cell wall on the outside and a plasma membrane on the inside. Together, they functioned as a two-way filter to intake external nutrients and in reverse to dispose of waste products. Some prokaryotes had flagella on the outer membrane for movement and linking up with others, eg. typically in colonies

Inside the plasma membrane was the cytoplasm, which consisted of a gelatinous liquid known as the cytosol. It was a mixture of colloidal protein and other molecules which included: enzymes, carbohydrates, small protein molecules, ribosomes and ribonucleic acid (RNA).

Prokaryotic cells had no internal membrane-bound organelles. The absence of a nucleus and other membrane-bound organelles differentiates prokaryotes from eukaryotes.

Prokaryotes reproduce by binary fission. There was no central brain. We may note some of their processes:

, (a) The sourcing, production and application of energy.
. (b) The breaking down and re-synthesising of organic compounds
. © The fixation of carbon and storage of food
. (d) The management of the reproductive processes
. (f) The maintenance, homeostasis and movement processes.

We must make the point here that as we move forward with each new mutation and species, the old ones continue, usually with specialisations and improvements. Thus, the original anaerobic prokaryote and their successors are still very much around today. Scientist say however that 99% of al. past species have gone extinct.

The Non-Oxygenic Photosynthetic Prokaryote Period
(3.4 to 2.3 billion years ago)

The first dramatic **turning point** began when our prokaryote came within range of sunlight, probably on the ocean shores. The atmosphere continued to be devoid of oxygen. The world was still anaerobic.

With their biochemistry set, one day they came up with a pigment which captured a photon of sunlight (albeit in the infra-red range), which has since been named “bacteriochlorophyll”. Not long after, they incorporated it into a new Photo System 1 to produce energy on a regular basis. Marrying this with redox and the ETC, they produced the first big turning point in evolution, the photosynthetic energy capture system. This resulted in a significant but still limited leap in the availability of energy, among other things limited to daylight and the performance of the terminal acceptor used.

Current evidence is that this event predated the split into the domains Archaea and Eubacteria, and before the latter develop the Cyanobacteria. The new system continued to use various hydrogenous inorganic compounds as electron donors and electron acceptors, but not (yet) water.

The energy breakthrough was the defining achievement. It enabled our prokaryote to fully build itself up. Critically, it enabled our prokaryote to create the enzymes, chemical pathways and routines which in the end enabled it to switch dependence from anaerobic photosynthesis to oxygenic photosynthesis and in time to its own organic compounds as the prime source of energy.

The Oxygenic-Photosynthetic Prokaryote Period
(2.4 to 1.8 billion years ago)

We follow the evolution of the bacteria as it formed the main line of advance. Somewhere as early as around 2.9 billion years ag, the cyanobacteria became a lead species.

The next turning point, executed by the cyanobacteria, was oxygenic-photosynthesis. This began to happen around 2.4 billion years ago. It was in essence to adopt water (H2O) as the electron donor. The underlying chemistry proved to be quite simple. When The water (H2O) was oxidised by an appropriate reducing agent, it released an ion of hydrogen (H+) (an electron) as energy, and produced pure oxygen (O2) and hydrogen oxide (H2O) as end products. Hydrogen oxide remained as the oxidated residue, and oxygen was released into the atmosphere as a by-product. Needless to mention, water yields the highest release of energy. In this context, energy means electron (or ions thereof).This would change the world.

After much experimentation, our prokaryote settled on the enzyme NAD (nicotinamide adenine dinucleotide), or one of its variants, as the first electron acceptor. It designed the special enzyme NAD as a biological carrier of reducing equivalents, i.e. it could accept and deliver electrons. In that sense, it functioned as a coenzyme. NADP was the reducing version and NADPH the oxidising version. The latter is the only known oxidiser that can split water. If it had not invented this enzyme, the world would be without oxygen to this day!.

To ramp up the supply of the energy, our prokaryote modified bacteriochlorophyll, finally making what we name today as "chlorophyll," the same used by plants. It was capable in a number of variants of trapping sunlight across the full visual spectrum, and it was installed it in a newly designed Photo System II .

Light reactions occurred in two interdependent systems, primarily in Photosystem II but also via the earlier Photo System I. Light energy absorbed by Photosystem II caused the formation of high-energy electrons (H*) which were transferred along a series of acceptor molecules (NADP) in an electron transport chain to Photosystem I, whence they ultimately flowed to their points of usage. Photosystem II simultaneously obtained replacement (reloads) electrons from oxidising water molecules using the oxidiser (NADPH), resulting in their split into hydrogen ions (H+) (electrons) and oxygen atoms. This happens at an oxygen-evolving complex (OEC) within Photo System II , also known as the water-splitting complex, a biochemical cluster.

The electrons are ultimately transferred to Photosystem I, which, after further light excitation, drove the reduction of NADP+ to NADPH, another crucial energy carrier.

Photosystem II produced the proton gradient that drove the synthesis of ATP by ATP Synthase, while Photosystem I delivered it the reducing power in the form of NADPH.

The increase in energy availability was quantum in scale. The immediate effects were twofold: (1) vast increase in prokaryotes and (2) vast increase in oxygen. The problem was the oxygen was poisonous to the anaerobic prokaryote.

It led to the Great Oxygen Event (GOE), at which stage, around 1.8 billions ago, the oxygen levels had risen to about 10% of Present Atmospheric Levels (PAL). Scientists estimate that about 90% of all prokaryotes died.

As a consequence, the oxygen diminished. By around 1.6 billion years ago, we had the Great Oxygen Crisis (GOC), when oxygen levels fell to around 1% PAL.

Boring Billion Years
(1.6 to 0.5 billion years ago)

The ensuing million years became known as the "Boring Billion Years". On the surface, nothing much happened evolutionarily. But it allowed our prokaryotic ancestors the time to struggle for survival and the emergence of the eukaryote

Recovery of the Prokaryotes

Firstly the prokaryotes created the enzyme defences against the harmful effects of oxygen, particularly a toxic by-product of oxygen called “reactive oxygen species”(ROS). This meant the survivors could and would continue to produce oxygen. This proved to be vital to re-supplying the atmosphere for the future.

Secondly the prokaryotes were able to adapt themselves to an oxygenic environment while remaining anaerobic. Realising that oxygen was one of the most versatile, energy-loaded and chemically-friendly (bonding) substances, they decided to incorporate it in their bio-engineering.

A cardinal change was oxidative phosphorylation, the upgraded energy production system in which **oxygen became the terminal acceptor**. It produced some 38 ATPS (per module of glucose) with the end product of water. This became the basis of aerobic respiration, which would become fundamental characteristic of all eukaryotes, animals and man. I have not seen it said so, but our prokaryote’s invention of aerobic respiration must be accounted as vital a contribution (sine qua non) to evolution as DNA/RNA. What came after were mainly changes in the mechanisms.

It may be recalled that oxygen is produced by the prokaryote in the production of energy from sunlight by splitting water (ie anaerobic oxygenic-photosynthesis). Up to that point, the prokaryotes took the oxygen off the air. Scientist estimate, these prokaryotes used up 10% of their own oxygen production, and released the rest to the environment

It is thought that prokaryotes began experimenting with oxygenic-respiration (ie aerobic respiration) from an early stage, even as they were being decimated, with some success. The front-runners achieved “facultative capability” (able to switch), and the early eukaryotes inherited it from them. As the re-oxygenation began, the eukaryotic evolution could take place.

Cellular respiration, which breaks down organic compounds to produce ATP, may be anaerobic or aerobic. This process occurs in stages, including glycolysis in the cytoplasm, followed by the Krebs’s Cycle (or citric cycle) followed by oxidative phosphorylation. The presence of oxygen as the final electron acceptor is what makes the process "aerobic". This was inherited by eukaryotes.

Likewise, prokaryotes developed the process of building organic compounds from carbon di oxide in the atmosphere, eventually known as Carbon Fixation, and this too was inherited by the early eukaryotes. This process is non-oxygenic.

Emergence of the Eukaryotes

Single-cell Eukaryote

Scientists theorise that the first eukaryotes were formed through endosymbiosis, a process where a single-celled host, likely an ancient archaeon, engulfed another bacterium (inclusive of its various processes). This engulfed bacterium survived and evolved into the eukaryote’s mitochondrion, (plural: mitochondria). Over time, this beneficial relationship led to a symbiotic partnership, resulting in the first complex eukaryotic cell. Later, some eukaryotic lineages acquired other symbiotic bacteria, such as cyanobacteria, which evolved into chloroplasts, allowing for photosynthesis. Carbon fixations was portably acquired in the same way.

The early eukaryotes were still single-celled. With their increased energy resources, they grew up to 10 to 100 microns, Besides a cell wall, cell membrane and cytoplasm, which they inherited from the prokaryotes, they became defined by a set of new and more sophisticated organs:

. (1) Mitochondria:

This is a double-membrane-bound organelle (mitochondrion, singular) that houses and performs cellular respiration. Eukaryotes will progressively develop the extraction of energy from stored organic compounds to become the main source of all thr energy requirements, with the mitochondria becoming the "powerhouse of the cell".

Cellular respiration involves a series of reactions, including glycosis, the citric acid (or Kreb's) cycle and oxidative phosphorylation, all of which take place in the mitochondria.

Mitochondria have their own DNA and play a role in other cellular processes like storing calcium. The number of mitochondria in a cell varies; some cells may have just one, while others may contain hundreds. The acquisition of mitochondria was the critical step, allowing for a massive increase in the energy available to the cell.

.(2) Chloroplasts.

A chloroplast is a double-membraned organelle that hosts the oxygenic-photosynthesis function inherited from the prokaryote, converting light energy into chemical energy (ATP) to make food, etc. It contains the green pigment chlorophyll,

The chloroplast also hosts the Carbon Fixation process inherited from the prokaryote ancestor, which converts (fixes) carbon di oxide from the atmosphere in the form of organic compounds for respiration and. storage, using the Calvin cycle. The enzyme that fixes carbon is Rubisco

In time, the above two functions will be combined together in plants, known simply as "photosynthesis" and forming the crucial component of the Carbon Cycle and base of the food chain.

(3) Nucleus

It is the presence of a nucleus that distinguishes an eukaryote from a prokaryote, The nuclear envelope is a double-membraned structure that separates the nucleus from the cytoplasm The nucleus is the control centre of a single-celled organism. It coordinates the cell's activities by controlling gene expression, which determines the proteins that are made.

It contains the cell's genetic material (DNA). It protects the DNA chromosomes, regulates access, and is responsible for DNA replication, transcription into RNA, and RNA processing.

The nuclear envelop acts as regulated gateways for molecules to move in and out. It transcribes the DNA into various types of RNA, which then exit the nucleus through the nuclear pores to be used by the cell to make proteins.

(4) Endoplasmic Reticulum (ER)

This is a network of membranes involved in protein and lipid synthesis, and includes the Golgi Apparatus, which modifies, sorts, and packages proteins and lipids for transport. It is contiguous with the outer membrane of the nucleus.

It is clear that the eukaryote made some very critical breakthroughs in evolution. First it established respiration as an alternative to sunlight as the source of energy supply, making this function diurnally independent and under its full control, Second, it installed its own organic compound manufactory, releasing the eukaryote from hunting around for food. Third, these factors extended the range of its mobility and multi-cellular specialisation. Fourth, the increase of energy at its command enabled it to grow and attain higher levels of life organisation and mobility, eventually intellectual capability.

For good measure, the eukaryote retained oxygenic-photosynthesis to provide the supply of oxygen, which had become indispensable. In fact the eukaryotes re-oxygenated the atmosphere after the Great Oxygen Crisis (GOC), continuing to main it at 21% with plant-life. By the period 700-541 million years ago, the planet began to experience the Neoproterozoic Oxidation Event (NOE).

The emergence of the eukaryote took place alongside the recovery of the prokaryotes during the "Boring Billion Years". Fortunately, tectonic and atmospheric conditions were stable.
The oldest unambiguous single-celled eukaryotes have been found in rocks from about 1.65 billion years ago

Multi-cell Eukaryotes

The next step was the multi-cellular organism, as organisms began to share functions.

The earliest evidence of multi-celled organisation actually comes from prokaryotic organisms, like cyanobacteria, that lived 3 to 3.5 billion years ago. These organisms formed colonies, but lacked the specialised, differentiated cells of true multicellular eukaryotes

The first organisms that were clearly multicellular were algae. The earliest has been found in Gabon, Africa around 2.1 billion years ago. . The first definitive evidence of multicellular eukaryotic life comes from fossils of photosynthetic algae dating back approximately 1.63 billion years. These ancient, multi-celled filaments were discovered in northern China in 2024 and are considered the oldest undisputed examples of multicellular eukaryotes. The earliest known sexually reproducing organism was a red alga found 1.2 billion years ago.

The Home Stretch

Evolution of Animals and Plants

Timecope

4.567 billion years so (bya)
The Earth was formed

4.2 to 2.9 bya (1.3 bys)
The first generation prokaryotes
(archaea and eubacteria)

2.9 to 1.6 bya (1.3 bys)
The second generation prokaryotes (rise of cyanobacteria)
First generation unicellar eukaryotes

1.6 to 0.5 bya (1.1 bys)
Rise of multi-cellar eukaryotes)
Facultative prokaryotes
Edicaran biota

541-538 bya
CAMBRIAN EXPLOSION

538 to present mya (0.5 bys)
HOME STRETCH

Environmental Conditions

The Cambrian Explosion marked the beginning of the Home. Stretch. The oceans covered 71% of the planet, very much like today. The supercontinent Gondwana had just broken up (500 bya) and would form Pangea (355 bya), which in turn would break up (175 bya) to form our present continents. All pre-Cambrian life was microscopic and lived in the oceans. The land was barren.

Generally, the planet was unstable. It was tectonically active, as it cooled. There continued to be magmatic flows and thermal eruptions. The atmosphere warmed and cooled (in fact depending the strength of photosynthesis in the ocean at the time), which in turn triggered glaciations. The latter then reduced the water levels of the oceans, and so on. There were also extraneous events, like a meteorite landing in Mexico.

Our eukaryotes had to fight against heavy odds, ferociously reviving, restarting, improving their specifications, and pushing in new directions each time after each five major extinction events

Proliferation of Life

After 3.7 billion years of prior development, with aerobic cellular respiration, oxygenic-photosynthesis and carbon fixation on board, our eukaryotes were poised on the starting line to proliferate life and take evolution to the next stage as represented by the emergence of man.

Our front-runners relied on multiple strategies, including adaption, diversification, mutationnd rapid growth, for quick response to changing environments, including toxic defence:

.1 Self reliance in the production of energy (aerobic cellular respiration + photosynthesis)
.2 Self-reliance in the supply-lines of food (including carbon fixation)
.3 Muli-cellular specialisation, organisation of functions and central control (individualisation)
.4 Increase in size, mobility, dexterity,
.5 High replication, adaption and mutation (short-life-cycle and proliferation of families and species)
.
Our eukaryotes occupied the Earth in the zillions and were poised across a broad front, stacked with the necessary energy.

The single cell eukaryote continued to evolve. The new frontiers of evolution were the animal and plant kingdoms. The prokaryotes that had re-generated themselves continued to grow and develop. Altogether they have continued to multiply and fill the earth

Taxonomy

Taxonomy is the science of classifying living organisms into a hierarchical system based on shared characteristics. The result is that we have all living things today grouped under a Three Domain-Seven Kingdom System. The domains are (1) Archaea, (2) Bacteria and (3) Eukarya - animals, plants and all other eukaryotes, The classification system further breaks these down into seven ranks from broadest to most specific: Kingdom, Phylum, Class, Order, Family, Genus, and Species.

Our current Earth's population of living things is reflected in Table 1:

Table 1*
Three Domain- Seven Kingdom Classification[5]

Domain	Kingdom	Description	Phyla[6]	Families	Genuses	Species
Archaea	Archaea-bacteria	Single-celled prokaryotes that often live in extreme environments	18-23	27		NA
Eubacteria	Bacteria	Single-celled prokaryotes that live in more common environments	10	300	3,433	NA
Eukarya	Protista	Earliest single-celled eukaryotes, including protozoa and algae	45	250	NA	36,400
	Chromista	Photosynthetic eukaryotic microorganisms (with chlorophyll), including many algae	8	180	NA	27,500
	Fungi	Heterotrophic (non-photosynthetic) eukaryotic microorganisms, including. mushrooms, yeast, molds, etc.	8	550	10,468	611,100
	Planta	Multicellular eukaryotes that create their own food through photosynthesis (autotrophs)	14	400=750	28,724	296,1800
	Animalia	Multicellular eukaryotes that ingest others	31	6,000	239.033	7.770.,000

[5] - https://www.researchgate.net/figure/Estimated-total-number-of-species-on-Earth-in-the-seven-kingdoms-of-life-29-30_tbl1_363252151 (main source)
[6] - The full standard taxonomic (or family-tree) classification of living things is: Domain, Kingdom, Phyllum, Class, Order, Family, Genus, and Species.

		organisms for food (heterotrophs)				

*. Estimates of Archaea and Bacteria are only of known, with large proportions unknown. All figures should be taken as indicative. Sources vary widely.

In terms of both the number of species and the number of individual organisms, insects are the most numerous (ants). However, if considering all life, microscopic organisms like bacteria and tiny plankton may be more numerous.

The estimated total figure for all **species** for all the three domains is 10.1 million. Of this eukaryotes make up 8.8 million, while the two bacterial domains make up 1.3 million. There are many more species of eukaryotes than the bacterial group. Of the latter, bacteria proper are estimated to comprise 93% while archaea make up the small balance. No breakdown is given for the bacterial domains vis-a-vis their marine component.

So far, as at 2022, only some 2.16 million species of eukaryotes haven identified including 0.95 million animals, leaving 87% still unknown. Each year, about 13,000 more species are added to the list of known organisms. Figures for the bacterial domains are not available as yet. One research group suggests that 86% of the species on land and 91% in the ocean still await description.

The figures in the table above are intended to show that, with the Cambrian Explosion, evolution focused on developing Animalia as the front end. Planta evolved, supported by aerobic eukaryotes and bacteria, to maintain the oxygen environment and provide the food supply. Animalia evolved rapidly developing various functions and capabilities to combine into that superb free-ranging creature called Man, who in turn has transferred evolution onto the intellectual plane.

There have been many, many, many more species of animals than of plants or all the other eukaryotes put together. In a evolving situation, new species replace those that go extinct, with a net increase.

Edicaran Biota
(635 to 541 million years ago) (mya)

The Boring Billion Years terminated with two major “Snowball” glaciations which covered the whole globe with ice, the Silurian and the Mannion from 715-635 mya.

The Ediacaran period took place from 635–541 mya, over a spell of some 84 million years. This period saw the emergence for the first time of eukaryotic biota of larger, soft-bodied organisms that represent some of the first clearly multicellular life forms.

The biota were both animal and plant (or proto-forms of these). The former included sponges, cnidarians (jellyfish, anemones), worms and vendobionts. The latter included algae and lichens. They were typically enigmatic tubular and frond-shaped, mostly sessile organisms, lacking independent motive capability. This rapid diversification of multicellular life has been attributed to the increases in oxygen content. The oceans became better oxygenated after glaciation.

The Edicaran biota flush was a global event. Oxygen-consuming multicellular eukaryotes became ubiquitous and widespread. Initially they were restricted to deeper, colder waters that possessed the most dissolved oxygen. Metazoan (animal) life gradually expanded into warmer zones of the ocean as global oxygen levels rose. Plant life came after animal life because they mainly reached sunlight later when they neared the shore-lines. The Edicaran biota was largely swamped by and went extinct in the Cambrian Explosion.

Cambrian Explosion
(541- 525 mya) (20 mys)

The Cambrian Explosion” was the event that began the Home Stretch, the upscaling of Earth’s bio-population to its present levels of diversity, complexity and development. It was a global event that took place from 541 to 525 mya, lasting a mere 20 million years.

It was primarily a massive diversification of animal life, with many new species and forms evolving rapidly compared to the periods before and after. It resulted in the appearance of most major animal phyla, including arthropods, molluscs, and chordates, and the evolution of hard body parts.

One of the earliest groups of arthropods, trilobites were among the most successful of all early animals existing in the oceans, also brachiopods (animals in shells)..

The period saw the appearance of many features common in modern animals, such as exoskeletons, segmented bodies, and complex body plans. The Cambrian saw the development of a complex food web with the emergence of predation as a way of life.

The Cambrian biota was primarily confined to the shallow sea margins. The land and the ocean depths were largely devoid of life, although some early land bacteria may have existed in moist sediments .

Plant life had not yet evolved. The Cambrian flora was little different from the Ediacaran. The principal taxa were the marine macro-algae Photosynthesis was carried out by bacteria and algae-protists, which populated the shallow seas

Up to the Cambrian Explosion, all plant and animal life was **microscopic** and invisible to the naked eye, neither on land nor in the oceans.

The Cambrian period ended in the Andean-Saharan Himantian glaciations around 485-445 mya, with significant but not total impact on the burgeoning life.

Phanezoic era

(538 - 120 mya) (418 mys)

The Phanezoic Era which followed means the “Visible era”, marking the transition to visibility of life on Earth, starting with the Ordovician.

Ordovician Period
(485-442 mya) (41mys)

The Ordovician was a time, lasting about 41 million years, in which many groups still prevalent today evolved or diversified. This process is known as the **Great Ordovician Biodiversification Event (GOBE).**

The Ordovician is known for its diverse marine invertebrates, including graptolites, trilobites, brachiopods, and the conodonts (early vertebrates) . A typical marine community consisted of these animals, plus red and green algae, primitive fish, cephalopods, corals, crinoids, and gastropods. The trilobites were gradually replaced by arthropods.

A group of freshwater green algae, the steptophytes, began to colonise the flood plains and riverine zones giving rise to primitive land plants.

By the end of the Ordovician, Gondwana had moved from the equator to the South Pole. The glaciation of Gondwana resulted in a major drop in sea levels, killing off all life that had established along the coasts. The glaciation caused an “icehouse[7] Earth” leading to **the Ordovician-Silurian Extinctions (@ OS)**, Some 60% of marine invertebrates and 25% of families became extinct.

Silurian period
(443.8 to 419.2 million years ago) (22 mys)
Devonian period
(419.2 to 359 million years ago (61 mys)

One important event in this period was the initial establishment of terrestrial life, in what is known as the **Silurian-Devonian Terrestrial Revolution.**

[7] “icehouse” means ice caps at both poles

It was a period of rapid colonisation and radiation of land plants and fungi on dry land. Diversity of plants increased greatly, comparable in scale and effect to the explosion of animal life during the Cambrian. The appearance of vascular plants allowed plants to gain a foothold on land. The first trees and seeds evolved

Arthropods were the apex predators. Fully terrestrial life evolved, including early arachnids, fungi, and centipedes. The first amphibians appeared and fish diversified and occupied the top of the food chain.

Vertical growth of vascular plants allowed for expansive canopies to develop, forever altering the plant evolution that followed. The Devonian witnessed the widespread greening of the Earth.

Earth's second Phanerozoic mass extinction event (a group of several smaller extinction events), occurred in the late Devonian, ended 70% of existing species. The **Late Devonian Extinction Event** primarily refers to a major extinction occurred around 372 mya. Overall, 19% of all families and 50% of all genera became extinct. A second mass extinction occurred 359 mya, bringing an end to the Devonian. Some consider the extinction to be as many as seven distinct events, spread over about 25 million years, with massive loss of biodiversity.

Carboniferous period
(359 to 299 mya (60 mys)

The Carboniferous is the period during which both animal and plant life were well established on land. The early half is sometimes referred to as the **Carboniferous Explosion.** The average global temperatures were exceedingly high; and oxygen levels were as high as 30% of the atmosphere, the highest ever.

Tropical swamps dominated the Earth, and the trees grew to greater heights and number. Their remains were left buried, which created much of the carbon that became the coal deposits of today.

The most important evolutionary development of the time was the amniotic egg, which allowed amphibians to move farther inland and remain the dominant vertebrates for the duration of this period. The period is sometimes called the Age of Amphibians.

The first synapsids (proto-mammalians) and sauropods (which include modern reptiles and birds) evolved in the swamps.

Throughout the Carboniferous, there was a cooling trend, which led to the **Perm-Carboniferous glaciation** and the **Carboniferous Rainforest Collapse.** Gondwana was glaciated as much of it was situated around the south pole. The late half of the period experienced glaciations, low sea level, and mountain building as the continents collided to form Pangaea.

Permian period
(299-252) (47mys)

At the beginning of this period, all continents joined together to form the supercontinent Pangaea.

The land mass was very dry during this time, with harsh seasons. The Carboniferous Rainforest Collapse left behind vast regions of desert within the continental interior.

Amniotes rose to dominance in place of their amphibian ancestors. The Permian witnessed the diversification of two groups, the synapsids and the sauropsids (reptiles). The first conifers evolved, and dominated the terrestrial landscape.

The Permian ended with the **Permian-Triassic Extinction Event** (251 mya). It lasted under one hundred thousand years. It was the largest mass extinction in Earth's history and was the last of the three (or four) crises that occurred in the Permian.

It was the Earth’s most severe known extinction event, with the extinction of 57% of all biological families, 83% of genera, 81% of marine species and 70% of terrestrial vertebrate species. It was also the greatest known mass extinction of insects. Eventually, some 95% of all life on Earth disappeared.

The scientific consensus is that a major cause was the flood volcanic eruptions of basalt that created the Siberian Traps, which released sulfur di oxide and carbon di oxide, resulting in acidifying the oceans, and causing high global temperatures.

It took well into the Triassic for life to recover from this catastrophe, and on land, the ecosystems took 30 million years to recover. The extinction event saw most lineages of primitive synapsids becoming replaced by more advanced therapsids.

Mesozoic era

(252 – 66 mya)

This era is known as the **Age of the Dinosaurs**, spanning most of the Triassic, Jurassic and the Cretaceous, some 186 years in all.

Triassic period
(252 to 201 million years ago) (51 mys)

At the dawn of the Triassic, ocean plankton communities transitioned from ones dominated by green archaeal-plastidans (prokaryotic) to ones dominated by endosymbiotic algae with red-algal-derived plastids (eukaryotic).

On land, groups of insects flourished, like mosquitoes and fruit flies, and the first crocodilians evolved, Dinosaurs first appeared in the Mid-Triassic, and became the dominant terrestrial vertebrates, occupying this position for about 150 or 135 million years, until their demise at the end of the Cretaceous. The first mammals also appeared but would remain small—less than 15 kg (33 lb)—until the Cenozoic

Climatic change however resulted in a large die-out known as the **Triassic–Jurassic Extinction** event. Many archosaurs (excluding pterosaurs, dinosaurs and crocodymorphs), and almost all large amphibians became extinct, as well as 34% of marine life, in the Earth's fourth mass extinction event.

Jurassic period
(201 to 145 million years ago) (56 mys)

The Jurassic lasted 56 million years. The Jurassic climate was tropical and much more humid than the Triassic, as a result of the large seas appearing between the landmasses.

On land, dinosaurs and other archosaurs staked their claim as the dominant race, with theropods at the top of the food chain. Archosaurs rose to rule the world. The first true crocodiles evolved, pushing the large amphibians to near extinction. The first true mammals evolved, remaining relatively small, but spreading widely.
.
Conifer forests made up a large portion of the forests. In the oceans, plesiosaurs were quite common, and ichthyosaurs flourished. This epoch was the peak period of the reptiles. The Late Jurassic saw the first avians, evolved from small dinosaurs.

The increase in sea levels opened up the Atlantic seaway, which has grown continually larger until today. The further separation of the continents gave opportunity for the diversification of new dinosaurs.

There was a relatively minor **Jurassic-Cretaceous extinction** event at the end, killing off some 34% of biological life.

Cretaceous period
(145 to 66 million years ago) (79 mys)

The Late Cretaceous spanned 34 million years, and saw an expansion of seaways. It featured a cooling trend that would continue in the Cenozoic. Seasons came back into effect and the poles got seasonally colder. Eventually, the tropics were restricted to the equator and areas beyond the tropic lines experienced extreme seasonal changes in weather.

The Early Cretaceous saw d a decline in diversity of sauropods, stegosaurs, and other high-browsing groups, Dinosaurs still thrived, as new taxa such as Tyrannosaurs, Ankylosaurs, Triceratops and Hadrosaurs dominated the food web. Mammals continued to expand their range.

Flowering plants, possibly appearing as far back as the Triassic, became truly dominant for the first time. Birds became increasingly common and diversified.

At the end of the Cretaceous, the Deccan Traps and other volcanic eruptions were poisoning the atmosphere.

It is thought that a massive **asteroid** (10-15 km in size) smashed into Earth some 66 million years ago, creating the Chicxulub Crater, in an event known as the **Cretaceous–Paleogene (K – Pg) extinction** event, the fifth and most recent mass extinction event. Some 75% of the plant and animal species of the Earth. life became extinct, including all non-avian dinosaurs. The destruction was caused mainly through the lingering impact winter which halted photosynthesis in plants and plankton.

Cenozoic era
(66 to now mya) (66mys)

-Paleogene period (including the Palaeocene, Eocene & Oligocene epochs)
(66 to 23mya)),
- Neogene period (including the Miocene and Pliocene ages)
(23 to 2.58 mya), and
-The Quaternary period (including the Pleistocene and Holocene ages)
(2.6 million years ago to now.)

In the short 66 million years following the K-P Extinction event, the Cenozoic saw the emergence of man. I tried to find a clear front runner among the survivors of the K-Pg Extinction who became man, but found no inputs. It seems they all started from scratch depending on their environment and opportunities.

Palaeogene period
(66 to 23mya)

The Palaeogene is the period when the continents moved into their current positions. India collided with Asia 55 to 45 mya creating the Himalayas, and Arabia collided with Eurasia closing the Tethys Ocean and creating the Zagros Mountains around 35 mya..

In the Palaeocene epoch, the climate was hot and humid with lush forests at the poles. There was no permanent ice and sea levels were around 300 metres higher than today. This continued until the **Palaeocene-Eocene Thermal Maximum** around 55 mya.

Around 50 mya, Earth entered a period of long term cooling. This was mainly due to the rise of the Himalayas. Around 35 mya, permanent ice began to build up on Antarctica. The cooling trend continued in the Miocene, with relatively short warmer periods.

The Late Eocene epoch saw the rebirth of seasons, which caused the expansion of savanna-like areas, along with the evolution of grasses.

The end of the Eocene was marked by the **Eocene-Oligocene Extinction Event** occurring between 34 and 33.mya. It was marked by large-scale extinction and floral and faunal turnover, although it was relatively minor in comparison to the large earlier mass extinctions.

The Oligocene epoch lasted 11 million years and featured the further expansion of grasslands which had led to many new species to evolve, including the first elephants, cats, dogs, marsupials and many other species still prevalent today.

Neogene period
(23 -2.58 million years ago)

In the Miocene, kelp forests evolved, encouraging the evolution of new species, such as sea otters. **Apes evolved into 30 species**. Many new plants evolved: 95% of modern seed plant families were present by the end of the Miocene.

The Pliocene saw dramatic physiographic-climatic changes. The Mediterranean Sea dried up for several million years, because ice ages reduced sea levels, The isthmus of Panama was formed and the Arctic region cooled leading to the glaciations of the Quintenary Ice Age. Climatic changes accentuated the savannas, the Indian monsoons, deserts in central Asia - and the beginnings of the Sahara desert. Grasslands shaped the evolution of birds and the mammals that fed on them.

By the Pliocene, mammals came to occupy almost every available niche, and some grew very large, attaining sizes not seen in most of today's terrestrial mammals. The **Australopithecus** evolved about 8 to 9 million years ago in Africa, beginning the human branch.

This epoch was full of mammals both strange and familiar, from mastodons, mammoths, three-toed horses and sabre-tooth tigers to marsupials, whales and primates.

Quaternary period
(2.58 million years ago to now)
Pleistocene epoch
(2.58 mya to 11,700 year ago)
Holocene epoch
(11,700 years ago to now)

The Pleistocene lasted from 2.58 million years This epoch was marked by ice ages as a result of the cooling trend that started in the Mid-Eocene. There were at least four separate glaciation periods marked by the advance of ice caps as far south as 40° N in mountainous areas.

Africa experienced further desertification which resulted in the creation of the Sahara, the Namibian and the Kalahari deserts.

Many animals evolved including mammoths, giant ground sloths, wolves and sabre-toothed cats. The genus **Homo** evolved about 2.8 million years ago, and **Homo Sapiens** therefrom about 50,000 years ago.

The Holocene epoch is the present, starting from 11,700 years ago. We are in an inter-glacial period. The first cradle of civiliisation began about 8,000 years ago..

PART THREE

Evolution of Man

Definitions

Unless the context otherwise requires,

“moral” means that which is right or good (as against wrong or bad) in relation to the individual’s well-being, the collective welfare and/or the safety of the species.

“moral code” is commonly used to describe the set of behavioural precepts and norms sanctioned by society, while “ethics” relate to approved behaviour in specific areas, eg. the professions.

“religious domain”, appertains to the teachings and practices of a religion, generally including the spiritual activities of its followers. While here “spiritual” refers to any human interaction with the paranormal or unknown.

“reality”, that which exists, physical and non-corporeal.

“Non-corporeal”, that part of evolved **reality** which is **not physical,** such as information, knowledge, systems, data, history.

“Identity”, a non-corporeal reality.

“reason”, embraces the total range of man’s abstract thinking abilities.

“knowledge” sum total of all relevant information appropriately organised, stored and retrievable.

“information” relevant human constructs of knowledge (facts) from processing data

“data” raw sensory or informational inputs

“information gap”, that which lies beyond man’s ability to perceive or obtain.

Human Ancestry

On the physical side, the practice of bi-pedalism (walking upright) when in “terrestrial mode” marked the beginning of our evolution (as apes). From their earliest evolution most if not all animals have had a “brain “ of some sort, eg. the planarian flatworm. An increasing brain size marked the progressive evolution of our bi-pedalling brethren. They were also distinguished by two other features, namely they used objects (stones) as tools, and they began to live increasingly as a social group.

Humans are descended from apes (super-family Hominoidae) who first evolved 25-30 million years ago in the Miocene, within which was the ancestral line of the great apes (Hominidae). Along the way, several branches split out from the latter, first the gibbons (Hylobatidae) about 14 to 18 million years ago, then the orang-utan (Pongo) in the same period, then the gorillas (Gorilla) 8-10 million years ago, and finally the chimpanzees and bonobos (Pan) around 7–4 million years ag. The time-modified ancestral line (Hominin) went on to evolve man.

Following their split with chimpanzees and bonobos, the hominins diversified into many species and at least two distinct genera. All but one of these lineages are now extinct, except Homo sapiens – representing the genus Homo.

The earliest members of Homo share several key traits with Australopithecus who evolved in Africa in the Pliocene. The earliest record of the genus Homo is the 2.8 million-year-old specimen from Ethiopia and the earliest named species are Homo habilis and Homo rudolfensis which evolved by 2.3 million years ago.

Homo erectus evolved 2 million years ago and was the first archaic human species to leave Africa and disperse across Eurasia. Homo erectus also was the first to evolve a characteristically human body plan, and is our direct ancestor..

Homo sapiens emerged in Africa around 315,000 years ago from the descendants of Homo erectus that remained in Africa. Homo sapiens migrated out of that continent, gradually replacing or interbreeding with local populations of archaic humans. They began exhibiting behavioural modernity about 160,000–170,000 years ago.

Early modern human (EMH), or Anatomically modern human (AMH), are terms used to distinguish Homo sapiens species that were anatomically consistent with the range of phenotypes seen in contemporary humans today.

A parallel group, also extinct, were the Homo Neanderthalensis who emerged in Europe and West Asia around 430,000 years ago, and included the Homo Denisovans (around 285,000 years ago) The two (together with related tribes) are called “archaic humans”. They overlapped with the Homo Sapiens and there was significant inter-breeding with the latter.

The Cro-Magnon refer to Early Modern Humans who lived in our world at the end of the last ice age (ca. 40,000–10,000 years ago). They lived alongside Neanderthals for about 10,000 of those years. They are now also extinct.

Homo sapiens evolved from the genus Homo habilis, very broadly between 50,000 and 12,000 years ago (the beginning of the Holocene), ushering in the Upper Palaeolithic Revolution

Transition to Modern Man

The Palaeolithic age, or Old Stone Age, began approximately 3.3 million years ago (before the genus Homo) with the first use of stone tools, and continued with Homo sapiens until about 10,000 to 12,000 years ago, the end of the last ice age. At first, the latter were hunters and gatherers.

The Upper Palaeolithic Revolution which occurred around 40,000 to 10,000 years ago was a period of rapid cultural and technological change. This era saw the development of advanced tool-making, the creation of sophisticated art and symbolic objects, and the establishment of complex social structures and long-distance trade networks. While some see it as an abrupt "creative explosion," others debate whether the changes were a gradual evolution, influenced by a combination of biological, cultural, and environmental factors .

The Mesolithic was or Middle Stone age, was the period roughly from 10,000 to 4,000 years ago which marked the shift from the purely nomadic hunter-gatherer to the settled agricultural communities of the Neolithic. Towards the end of the period, some cultures began the initial stages of domesticating plants and animals, leading eventually to settled farming. Some began forming more permanent settlements, which would develop into villages and eventually cities in the Neolithic .This era saw the first evidence of systematic burial practices, the use of decorative adornments made from shells and bones, and early forms of large-scale stone construction.

The Neolithic, the final phase of the Stone age, was marked by the development of farming, which allowed for permanent settlements and a shift from a nomadic hunter-gatherer lifestyle to one of agriculture and animal husbandry. This period saw major innovations such as the domestication of plants and animals, polished stone tools, and the creation of pottery.

The invention of farming was a central development, leading to the cultivation of crops like wheat and barley, leading to the construction of more permanent structures like longhouses and surplus-to-need economics.

The Neolithic period began at different times in different parts of the world. It is believed to have started in the Fertile Crescent around 8000 years ago, where agriculture, writing, and organized religion were first developed .

The end of the Neolithic period also varies significantly by region. It was marked by the introduction of metalworking, and is often considered to have occurred around 4500–2000 years ago. Man moved into the Copper and then the Iron age, by which time they were largely civilised communities.

Cradles of Civiliisation

The earliest humans communities grew into complex societies from around 7000-5000 years ago and were defined by the emergence of urban centres, organised governance, surplus food production, and specialised labour.

Key characteristics included writing systems, monumental architecture, social hierarchies, and religion playing a crucial role in unifying populations and legitimising power. These societies arose in areas with geography favourable to intensive agriculture, leading to population growth and economic stability . They grew from states, to countries, to empires, and to civilisations.

The earliest was Sumer in Mesopotamia. The other cradles of civiliisation included Egypt, China, India, and (less known) the Olmec civilisation in Mesoamerica and the Norte Chico civilisation of Peru.

Modern Man

Behavioural modernity is a suite of behavioural and cognitive features that distinguish modern man from other AMHs, hominins and primates.

Frontiers of Modernity

I see modern man emerging in three dimensions: (1) facultative (or intelligence) development, (2) societal development and (3) moral development.

Most scholars agree that modern human behaviour can be characterised by a number of “human universals” in facultative development. These include abstract thinking, planning depth, symbolic behaviour (art, ornamentation), music, and dance, scale in exploitation of resources, and the development and application of technology, These attainments pre-suppose the acquisition of language and writing.

Collectively, man has built up and shares a comprehensive knowledge structure incorporating two streams, the empirical and the deductive or metaphysical. Individually, besides his own reservoir of the preceding, man is equipped with his own bank of experiential knowledge, and his own emotions and passions.

At the societal level, there has emerged the social and legal framework, evolving towards statehood, division of labour and craftsmanship evolving towards social hierarchy, and trade and economics evolving towards urbanisation. The family has remained the unit of the community and society.

At the morality level, there has been increasing order and personal and collective responsibility for the family, the community and the state. This has been accompanied by increasing education as well as self-awareness of the individual’s responsibilities in his choices and decisions in the exercise of free will.

But, moralists also generally. agree that man is both self-gratifying and caring. There is a sense that while evolving his desirable societal attributes, man has not yet completely lost some of his primitive instincts of survival. While on balance, his overall moral performance has been good, man needs to watch this front.

At some point, man is deemed to have become civilised. Among other things, this is measured by the increasing unification of peoples as one society, sharing their Intellectual heritage and technology, and living (as peacefully as possible) within a common set of ideals, standards and aspirations.

I tend to think man's future evolution lies in his civilisation, in his further development in the above dimensions, perhaps critically in the moral sphere.

Religious Development

From the beginning, man has grappled with a sense of awareness of the unknown, variously populating a non-corporeal world and worshipping the same through religion. Overall, the historical record of this activity shows a significant role in his social and moral evolution, For convenience, I call the sum total of all man's such doings his "religious" experience.

Religion itself is a composite. It is an institution in the societal domain providing forms of worship and spiritual caring for it adherents. At core is its theology, which may include revelation. This lies across the domains of metaphysics, and generally relates to understandings about the supreme being, his role in creation (evolution) and the role and duties of man.

Religion has been taken advantage of by leaders, even abused by tyrants, to control the population, based on fear of the unknown and punishment for misdeeds. As the mysterious and misinformation got cleared away, this domain has contributed many important qualities to the matrix of human life. Besides the moral code, they include the right to life, equality, justice, and fairness. In human terms we have spiritual qualities like kindness, charity and love. Afterlife, a feature of some theologies, also can add continuity, depth and meaning to man's otherwise short existence.

A 2020 survey showed that world-wide 75.8% of the world's people believe in God a with about 24.2% identifying as unaffiliated to religion8

There is a place for all these in the further evolution of man, and religious development is a domain to look to in the future.

Evolutionary Status of Man

Turning Point

The Homo sapiens stands at the apex of the biological evolution that began on Earth. Some 19 species of the genus Homo came down the line with him but have all gone extinct, leaving him the dominant species on the planet. He is the most advanced outcome or product of this biological evolution. He exercises de facto hegemony over all other life forms, and is at the top of the food chain.

With the largest brain so far of any animal (1,300 cm), he has total mastery not only of himself but of his physical environment. He has an extraordinary set of intellectual and qualitative faculties. Among other things, he can self-drive himself through different emotional states from self-gratification to desire for the common good. And lastly, he is endowed with the free will to do so. Man is today in a position to change the course of evolution.

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[8] Pew Research Center. https://www.pewresearch.org/?gad_source=1&gad_campaignid=22378837192&gbraid=0AAAAA-ddO9FGpwSW1hDk0vLJJWOXUHmUb&gclid=CjwKCAiA55rJBhByEiwAFkY1QKbDlavh8mcdTshb9FN7mYviCZnLNsD6Z4wlBW7myIBh-_sfaAhouBoC9ssQAvD_BwE

The preceding represent a quantum leap for which there was no prior preparation. It is a **turning point**. it raises the question whether man is in fact the intended terminal objective of evolution or whether evolution intends that hereon he discover and determine his own (and evolution's) destiny.

Each man is a person. Each person will have different behavioural responses to the real world. it is thought he is responsible and accountable for his whole life, and if his individual actions fail moral scrutiny, he can square out and make amends over a life-time.

The individual human is thought to have a totally new quality, namely **identity,** referred to by some as his "soul". Identity is an incorporeal reality that exists, manifests itself in decisions, commands the body through the brain, and resides in the mind. It is identity that provokes the issues of life after death, reincarnation, etc.

By incorporating identity into man's being, evolution has brought into existence a non-corporeal component to the universe of the human, making it a frontier of further development.

Purpose of Man

Every human action has three levels of application and fulfilment: (1) personal objectives, (2) societal objectives, and (3) the further evolution of the species. In most situations, the second and third go together and may be treated as one.

Th best human actions are those in which all three levels are in sync. The best human person assumes responsibility and adopts the most favourable norms of attainment and behaviour for each, and acts accordingly, and further influences the collective to do the same. Where the majority of the latter do, the species is saved, while the person is said to have achieved the most desirable personal satisfaction.

The preceding suggests that the destiny of the species is hereon no longer set and ordered by the evolutionary process. It is in the hands of the individual, taking decisions in the interests of himself and the collective. In fact it seems he has a responsibility to do so.

However, it seems contrary to "common sense" that, after establishing a new mental plane and endowing man with abstract thinking to master the universe, it does not matter (to evolution) whether man pushes himself further or destroys the Earth and himself. The very same abstract thinking tells us that man's purpose is to take evolution forward, whether to the stars, beyond time and space, and even to discover the unknown, perhaps even beyond materiality.

What of those who exercise free will contrary to the best interests of evolution, as against those who do? Issues of punishment and reward arise, and the further question whether these extend beyond the temporal to the afterlife.

Achievements So Far

To appraise where we could be heading, it is meaningful to look at what man has achieved so far.

In the Knowledge sphere

We have united and institutionalised our efforts, achieving a collective mountain of knowledge
.- In the physical sciences, we understand matter from the sub atomic to the cosmos.
.- In the biological sciences, we understand evolution and living organisms, from microbes up
.- In the psychological and sociological sciences, we have studied individual and social behaviour,
.- In the "earth sciences", we have studied the complete Earth history and anthropology of man
.- In the philosophical disciplines, we have studied existence and identity, mortality and immortality.
.- In the metaphysical domain, we have studied existence, reality, knowing and casualty, including our intellectual faculties themselves,
.- In In the theological domain, we have studied the existence and nature of a creator, including human accountability, and
In the religious sphere, we have studied belief systems, myths and revelation,

Man has inter alia developed our moral and ethical codes, and accumulated much **wisdom** in the process, ie. how to live well.

In the Technology sphere

.- With the computer, the internet and telecommunications, we have transformed mankind into an integrated society, functioning globally as one.
.- We have substantially mastered our living environment (except the climate)
.- We have conquered the air, the sea and space
.- We have mechanised, automated and robotised our work process and food production
.- Our medical and educational services are all high-tech.
On the obverse side
.- We have not (yet) conquered death (if we do, we shall have other problems.)

In the Information sphere

.Man is today an information-based or knowledge-based species. The cutting edge of evolution is no longer biological but information

Our brain capability will increase rapidly by hitherto unimagined scales by technological inventions such as the quantum computer.

In the Social and Political sphere

.- We have taken concrete steps towards and institutionalised world consultation, cooperation, international law and world government,
.- And, for the first time, we have global, if not sector, peace.
On the obverse side,
.- We also have Incredible weapons of mass destruction

Shortcomings

Morality

Moralists have found that individuals in this world are from to time driven by a common set of failings, the most prominent of which are pride or vainglory, envy, wrath, sloth, avarice, greed, and inordinate sexual desire or concupiscence. Where they dominate, they become passions, overriding good sense and caution. Where they become obsessive, they become vices. Hate is a passion that can drive a person even to self-destruction.

As against the preceding, moralists point out that the larger part of humanity do control these passions by the practice of the virtues, namely prudence, temperance, fortitude, diligence and justice. Combined with the positive emotions, like love, kindness, generosity, etc, they foster the high character attained by most of humanity.

So far civilisation has progressed far ahead and may yet survive. By and large, a man's responsibilities, relationships, rewards and resources remain in balance.

Other Dangers

The evidence in this review so far suggests that our human destiny will be tied in with three factors:

.- (i) How far we go in science and technology (physical and biological) without crossing human limits or creating uncontrollable means of our own destruction

.- (2) How well we structure and manage our civil society, including enforcement of our laws and ethics, without resorting to wars.

.- (3) The standards of behaviour of the people, which is closely related to their espousing and practising some kind of moral code

Our Record

Wars and Conflicts

In our time, peoples have come together with nationalist or ideological aspirations to wage war or cause societal subversion on a global scale. Perhaps our greatest achievement is that we survived the 20th century.

Driven fist by territorial aggrandisement and then by race superiority ideology, one country launched two world wars and exterminated six million people. World War II was the largest and most violent military conflict in human history. It was a technological war, dominated by new generation aircraft, battleships, submarines and radar, and ended with the world's first "WMDs" (weapons of mass destruction). Official casualty sources estimate battle deaths at nearly 15 million military personnel and civilian deaths at over 38 million.

Driven by dialectic materialism (an evolutionary ideologic travesty) and led by megalomaniac political leadership, the communist revolutions near crippled the world, Any attempt to estimate a total number of killings under communist regimes depends greatly on definitions, ranging from a low of 10–20 million to as high as 110 million if one includes all nine countries and deaths from famines, gulags, deportations, etc. China alone top scored with 66 millions and the USSR with some 20 million[9].

In the last three quarters of a century there has not been another world war. This is not to say we have been living peacefully.

The Cold War lasted from 1945 to 1989, and has left a legacy of nuclear missiles. Even today, believe it or not, there are some 12,100 nuclear warheads, mostly shared by US (5,748) and Russia (5,580). They in turn have some 1,479 and 1,509 respectively strategically deployed at any one time on nuclear submarines, intercontinental ballistic missiles, heavy bombers and forward bases. The other countries with nuclear warheads include China (500), France (290), UK (225) India (172), Pakistan (170), Israel (90) and North Korea ((90).[10] Despite valiant efforts to disarm, the nuclear threat remains the greatest danger to the survival of mankind.

There has always been some war or conflict going on. Data collected by the Uppsala University in Sweden[11] identifies 285 distinct armed conflicts having taken place since 1946.

One research group, the Global Peace Index (GPI), estimates that some 13.5% of the world's GDP is going into armament and war, 92 countries are currently involved in conflicts beyond their borders, and 110 million people are either refugees or internally displaced due to violent conflict. [12] Not to be outdone, we have inter alia the Russian invasion of Ukraine, and Israel doing battle with Palestine.

It takes great faith to believe that human nature will improve as we grow more civilised, as would appear to be the position taken by evolution if it believes we shall survive. The philosophic stream however points out that man is inherently capable of and does exercise the necessary virtues to do the right thing

Destruction of the Planet

The highly developed human species uses proportionately much more energy (including the brain), requires much more territorial space, and therefore consumes far more natural resources per individual than other species.

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[9] -https://en.wikipedia.org/wiki/The_Black_Book_of_Communism
[10] - https://www.armscontrol.org/factsheets/nuclear-weapons-who-has-what-glance
[11] - https://ucdp.uu.se/downloads/index.html#armedconflict
[12] - https://www.visionofhumanity.org/highest-number-of-countries-engaged-in-conflict-since-world-war-ii/

A growing group of scientists argue that the current age of man should be described as the Anthropocene Epoch, and began in the year 1950, which is when human activity started to have a significant impact on the planet's climate and ecosystems.

Around 10,000 years ago, some 57% of the world's habitable land was covered by forest. We have lost one-third since, half in the last century. Scientists estimate that only about 5% of the environment remains unaffected by humans, in floral and faunal terms.

The current rate of extinction of species is estimated at 100 to 1,000 times higher than natural background extinction rate. We could be losing from 1,500 to 10,000 species a year from microorganisms up. Biodiversity loss and species extinction have accelerated to the point that human activity is either on the cusp of or has already produced a 6th mass extinction

This has been accentuated by the rise in pollution, in carbon dioxide (57%), methane (10%) and other “greenhouse” gases. Unless checked, the world’s temperature will cross the critical threshold of 2 º Celsius above pre-industrial levels, in 10-15 years. The ice-caps are already melting, despite the fact that we are supposed geologically to be in the Holocene ice age.

There are signs of biological instability. The human body is becoming susceptible to increasing stress and aberrations. We have cancers and mental disorders. Most alarming, we have the emergence of viruses, by nature predatorial, that diversify rapidly and multiply almost infinitely in human hosts, who are almost indefensible against them.

Mankind has developed close to limits to the point of adversely affecting the planet and evolution. This has to be taken into account in considering the future of the human race.

Life extension (and immortality) will acerbate over-crowding in the short run. In the long run, they will require population control if technology fails to find the additional resources necessary, including extraterrestrial habitation.

Evolutionary Frontiers

Societal Development.

Humans began to recognise the full extent and oneness of their species after the explorations and colonisations that followed Christopher Columbus in 1492. And the front-end soon began to function as a global community sharing their culture, including their languages and religion. The period was characterised by the struggles of the colonial powers for territory and raw materials. At home, they faced social revolution due to the widening gap between the rich and poor.

The scientific revolution which began in the 17th century transformed man’s capabilities intellectually, in terms of his mastery of the environment, and in unifying the peoples of the Earth as a single community. It also more clearly separated the known from the unknown and unknowable.

Mankind has since developed an essentially unified civil society or civilisation while respecting and fostering national and cultural differences. We are an educated species and are able to access the different streams of knowledge and their institutions, whether scientific, philosophical, religious or traditional, with equal openness. Mercifully most people can communicate in common languages that have become international.

Fortunately, the world is now networked by a growing number of co-operating international institutions and associations, whether for education, research, professional development and surveillance. or jointly managing our technological and supplies infrastructure. The multinational industries also cement our countries, where they were once primarily exploitative.

Finally, after two world wars, we have a declaration of human rights which enshrines the sanctity and freedom of the individual, and we have a UN system that governs us in common domains, sets the necessary ethics in relevant areas, and even arbitrates in an international court of justice.

The UN has done great things in health, education, trade and economic development, the foundations of our civil society. It is sufficient to look at the outstanding role the World Health Organisation (WHO) played during the recent Covid-19 pandemic, to appreciate the critical role of the UN system in our future survival.

However, an even closer look will reveal how inadequate the present system still is. Given the scale of our advances in (and the increased dangers of) our sciences and technologies, the whole UN is overdue for a complete revamp. They do not have authority within national boundaries. They have no enforcement powers, only limited “peace-keeping” roles with voluntary forces. They would be powerless to stop a nuclear war if one erupts between two super powers today.

If evolution has cast its lot with the individual human for its future, then the individual human must be able to exercise his choices within a framework of civic freedom. Of the two global systems tried out, democracy permits the better exercise of choice. On a hopeful note, the world collectively is leaning towards democracy as the standard political format for countries, according to the World Forum on Democracy, electoral democracies now represent 120 of the 192 existing countries and constitute 58.2% of the world's population.[13] However, the practice of democracy is still flawed in many countries. Of the seven countries with the largest populations in the world, totalling 51.3%, only China, 17.39%, is not a democracy.[14]

Finally, the distribution of income is another indicator of progress towards universal equality. The World Bank data for 2022 gives only 39 countries out of a total of 177 countries (22.0%).with a per capita GDP of $25,000 or above, the criterion of a developed country. Some 53 had less than USD 3,000. The distribution of Income and wealth within countries is another matter. Income inequality is at the heart of aberrant human behaviour. The hopeful note is that countries are increasingly tempering the extremes of capitalism with socialist policies, and vice versa.

The Technological Front

The European Space Agency (ESA) ‘s astrometry spacecraft (satellite) Gaia has already mapped and catalogued 1,7 billion stars in and around the Milky Way, The James Webb Space Telescope is currently looking at the universe some 200 light years from the big bang. We have already fond some 5,0600 ex-planets that could support life. Voyager 2 is currently 20 light-hours in space.

Man has been to the Moon. We have remotely been surveying Mars for some years, and our proto-type starship has made its first successful (reuseable) take-off and landing on Earth. All we need is to re-invent quantum physics to get round the time barrier, and we shall be poised for the first step to long range space and extra-terrestrial habitation

Today, a scanning transmission electron (STED) microscope has reached resolutions down to 0.5 nm (50 picometres) level and can provide magnifications of up to 10,000,000. Today, we can magnify our original prokaryote (of 1 micron) one 100 times.. At the quantum level, we are studying the boson, the gravity carrier, the last unknown frontier of space, and quasiparticles that are transparent in photons.

We have gone into the second quantum revolution with nanotechnology. We are now employing quantum mechanics to alter the quantum face of our physical world. We can create states of quantum coherent or entangled matter and energy that are not likely to exist anywhere else in the universe. These new man-made quantum states have novel properties of sensitivity and non-local correlation which defy our logic.

An equal revolution has taken place in biology and biotechnology. We know the complete architecture of a virus. We can trace our heredity through DNA to our first common ancestors. We have

[13] - https://www.coe.int/en/web/world-forum-democracy
[14] - https://www.worldometers.info/world-population/population-by-country

unravelled the complete genetic code of the human being. Technically, we are near to be able to clone ourselves. In biotechnology, scientists are talking of nanomedicine, ie diagnosing and delivering medication at nano levels even possibly using nano robot doctors.

We have replicate the nuclear fission of the Sun. We have 620 nuclear reactors supplying energy all round the world. We are on the point of launching fusion reactors, replicating the even more powerful process of nucleosynthesis that fuelled the primeval expansion of the cosmos and provides the energy of the stars.

The Information Age

The development of the Information Technology (IT) is perhaps the most profound directional change to evolution brought about by technology. Homo Sapiens have evolved into an information-based species.

As the decisions he makes have more and more to do with the external world of his own construct, the more he is dependent on information and more processed information, and less and less on the physical inputs of his senses.

A typical human today is a knowledge-worker. He is highly “instrumentalised” even in his daily life, checking his smartphone or computer for stock prices or talking (giving instructions) to a robot or his car to carry out a function. All automated functions are information based.

We have now multiplied our data processing and computing powers and our memory banks zillionfold. The world’s libraries and transactional records are substantially digitised, enlarging our span of the understandable. All the information we need is stored or accessible somewhere on-line and can be downloaded by anyone with a smartphone. This enables us to help to think with wider spans of information and in further depth in the abstract, to take better decisions and manage our civilisation more efficiently.

With Artificial Intelligence (AI) programming of our existing computer capabilities (for example the top 500 supercomputers today in tandem) we can interrogate our data resources, simulate, and programme extensive and intensive information analysis beyond the wildest imagination. .

We are already proto-typing the quantum computer, which is geometrically more powerful, with IBM’s Osprey with 433 qubits in the lead. The technology is still shaky. With Artificial Intelligence (A!) married to a quantum computer we shall be able to re-write quantum mechanics and GPS the Milky Way (at least), and when we get there we shall also have our favourite books and operas with us.

Human limitations

Reproduction and Growth

If man has a single overall responsibility, it is to replicate or reproduce himself. If he does not (by choice) do so, it could be said that he (a woman) has failed in his (her) primary evolutionary mission.

Mankind will soon reach a critical point in growth. By human intervention (birth control), the global total fertility rate (TFR) had declined from around five children per woman in 1950 to 2.2 in 2021. The replacement level is widely considered to be 2.1 children per woman. Over half of the world's countries are already below the replacement level.

The world’s population, now 8.7 billion, will peak in the early 2084 at 10.3 billion, and thereafter decline. Other things being equal, this a signal of species senility, not to mention extinction. Unless it is intended that technological man take him to quite new levels of existence, man is engaged in a form of self-assassination by not reproducing himself.

At this stage man is engaged in various endeavours (technologically) to prolong life, and even go immortal. The last would be a way of species survival. I can see a whole lot of problems though, if he does not also achieve a positive net reproduction rate.

Human Imperfectability

Mankind goes forward with the expectation that with increasing civilisation man improves as a moral creature. Education and understanding will "improve" the individual. By giving man free will, evolution is banking on this.

The mis-exercise of free will can be managed and secured against by controls within social development, by inter alia the moral code and the ethical and legal frameworks. The internationalisation of the world is an essential goal, to ensure peace and the equable distribution of resources and well-being. Education, equal income and equal opportunity are the foundations of good society.

By and large, man's responsibilities, relationships, passions and actions remain in aggregate balance. The situation however is a managed one. The debate still on whether man himself is improving.

The Way Forward

To some people, the findings of science indicate extensive evidence of design in the evolutionary saga, which pre-suppose the existence of a creator or prime mover, and suggest some purpose to the universe and the evolution of man, To others, the explanations for the design lie wholly within the universe and in the happenings themselves, and only remain to be found, without invoking an external creator or prime move. Yet others go further and take the position that there is nothing (no being) beyond this universe. I have also found it said that the so-called design of evolution is only the ex post facto cumulative route taken following the most favourable opportunities (chances) offered at each step, following the (chance) occurrence of the big bang.

For myself, I have found the pre-biotic and the biotic programmes constitute a single evolutionary event. I have not come across any suggestion that the two parts are unrelated

From this study, I find that there is a unifying direction and purpose combining the pre-biotic and the biotic stages of our evolution. Evolution has been a single programme in two parts which brought about the existence of man as we have him. Evolution worked to a series of overall algorithms, with the widest possible choices at each point, using the opportunities presented along the route. They allowed for corrections, adaption and mutations, and seizing new advantages as they arose. The originating impulse was to generate life. I am open as to at which stage man in the form of ourselves emerged as the likely prototype, possibly after the split of the genus Pan.

The future lies with us. Our primary objectives are three-fold and pretty clear: (1) well-being of the individual, (2) welfare of the our society, and (3) perpetuation of our species. We could add two others: namely (4) live longer and (5) preserve the planet.

We have a set of facultative skills to work with, generally embraced in the terms reason or abstract thinking. This operates in two modes (1) the empirical and (2) the deductive. There is a (3) third faculty beyond reason, awareness of the unknown, which is accompanied by other arcane faculties (not present every one) like clairvoyance, mysticism, and extra-sensory perception, generally grouped as phenomena within the religious domain.

The Scientific Frontier

In our first mode, we have mastered our universe. By our science we have a comprehensive understanding of how it is constituted and works, both the physical the biological and both at the cosmic and the sub-atomic levels.. By our engineering technology we have exploited the planet's resources and mastered its physical laws. By our medical sciences, we have enhanced our biology. By our information technology, we have converted man to be information-based, amplifying his intellectual capacities. We are already in space

The scientific situation is itself changing. The potential of AI in quantum computing is incalculable. A new quantum theory that breaks the time barrier would enable man himself to travel into outer space.

From today's perspective, that is quite plausible, and represents our first frontier of evolution, our physical home.

The Metaphysical Frontier

In. our second mode, man has probed and queried whether there exists a beyond, beyond the universe, and if so the boundary lines between the two, and who may reside there. It seems clear that man is endowed is by evolution with the vision to ask these questions, even though the speculated reality lies beyond the information gap for him to know. One answer seems to be that the deductive (reasoning) ability is part of the set evolved to deal with his empirical activities and he has no business asking about the unknowable. My reaction is that we have in fact been endowed with this extended capability, and there must be some purpose or intention that we use it. Again, the only meaningful purpose is to help work out our and the specie's destiny. The ultimate valid question along these lines is whether man is intended to evolve beyond materiality.Hence the study looks at this option.

The central issue is who, if anyone, created the universe (evolution) and why. The parallel issue is why was man created.

The problem has been compounded for metaphysicians by the fact that man has had an awareness of the beyond since his earliest days, which crystallised through his religious practices into a belief that there is a supreme being or higher order of existence, including the purposes of man. Historically it was thought that religion would fade away with scientific and philosophic development, but this has not happened.

The Religious Domain

This study therefore finds religion to be a sector of emerging rather than decreasing importance as part of man's evolutionary scenario.

From his first conscious moments, he has been surrounded by an unknown world, which he naturally feared. Everything he could not explain he ascribed to parties unknown and supernatural, generally inhabiting a non-corporeal or non-physical domain. In time, these were conceived of as of a higher and more powerful order of beings, both benevolent and capricious. . Good things happening got ascribed as favours and rewards bestowed, and bad things vice-versa as disapprobations and punishments. Man proceeded to worship and supplicate them, instituting religion. In time, the conception of a supreme being emerged.

Every cradle of civilisation developed its own religion. In the early stages, leaders used religion as a societal tool for power, to control and cement cohesion. With intellectual development, much of the early mambo-jumbo and superstitions disappeared and theology developed. As a result the metaphysical issues emerged more clearly. And today, they have taken their place in their respective religions and the intellectual pursuits of man. Some religions have enjoyed revelation, and they have developed dogma.

My focus has been strictly on the metaphysical. Even with my limited approach it has proved to be substantial, so that I shall be reporting the substance of it in a separate Volume 5 – Cosmos III *** Beyond Materiality? to appear in 2026. Here, I can only highlight some salient perceptions.

Role of Religion

The Abrahamic religions subscribe to a supreme godhead, of varying attributes: omniscient, omnipotent, immortal, morally perfect, creator of the universe and man, and arbiter of the latter according to his moral code, in other words divine. The Dharmatic religions on other on the other hand conceive of Being as transcendent and immanent in the universe, of which man is a part through re-incarnation according to the morality of his life. Traditional Chinese culture recognises Huangdi, their godhead, the Mandate of Heaven to govern the peoples, and an afterlife with ancestor worship. In a world crowded with folk-deities, their philosophic focus has been less on the metaphysical and more on social order and a proper way of life.

Modern Western philosophy emerged from the Greco-Roman and Christian cultures. It is the mainstream within which metaphysics has taken shape, among the other current secular disciplines of philosophy. One main line of thought seems to be that man can by the use of his intellect establish a credible probability in the existence of a prime mover or supreme being, and that it is reasonable to believe in him. But the knowledge gap is there and it requires faith to do so. One further line of thought is that the latter must be given (or revealed) from above. The term commonly used for the supreme being or prime mover is God.

Fortunately, modern civilisation took an important turning point when it went separated religion from politics. As a result, religion today, although substantially institutionalised, is essentially an individual matter. However, overall, religion's contributions to man's civilisational ideals and his moral and ethical development have been substantial, some would say pivotal - in the democratic free-world if not the communist world..

Religions today are responsible institutions and in their own way as concerned with the future of man as the scientist. There is much metaphysical work being done by them that can be drawn into the picture. There is much in the way of spiritual experience still to be scientifically examined. ("spiritual" meaning reported personal man-to-God relationships).

This study finds it is pivotal than man must decide one way or another whether there is a supreme being, etc or not.

On this basis, my conclusion is that we should proceed to extract and evaluate all the information (of metaphysical relevance) we can from man's religious experience. We need to come together. We owe it to ourselves to close the information gap as far as we can go, even if by definition we cannot bridge it. The scientific, philosophic, sociological, academic and religious communities need to come together in joint research on this front – in addition to. their own work. We need not get involved in comparative dogma.

Perhaps a first step might well be to have an agreed list of data we want and how they are to be gathered and quantified. There are historical records and there is new research. There are the physical and the behavioural data sets. There the normal and the para-normal dimensions. And there is theology and revelation. We are looking for clues whether man's future lies beyond materiality.

If evolution has been heading man towards a non-corporeal existence, as there is much evidence to suggest, then our next immediate (metaphysical) step is acquiring extra-rational muscularity and extra information .

If we can extract (and share) from man's religious experience commonly agreed information, I wound say we could be edging more than a few concrete steps towards strength our reason base, and closing the information gap.

Perhaps the first fact staring us in the face is that, according to various surveys, about three quarters of mankind believe in a supreme being. We need to go into that in exhaustive detail, including the meaning of believe. The most comprehensive survey is that of the WIN-Gallup International 'Religiosity and Atheism Index' 2012[15] (of 57 countries), which found that 59% of people declared themselves as "religious", 23 % as "not religious" and 13% as "atheists".

Whatever information package we extract from the above exercise, the mere fact that it represents added or new or refined collective information previously unavailable and now commonly agreed means that we shall be better placed to postulate our questions and focus nearer the truth, ie ask better questions. It does not mean we will be able to answer ourselves. To the extent the result debunk earlier misinformation and mistaken views, the exercise will have improved the total understanding of things. There will still be a gap, albeit a more focussed one. Man will ultimately have to believe something, even that there is nothing to believe.

15 - https://www.scribd.com/document/136318147/Win-gallup-International-Global-Index-of-Religiosity-and-Atheism-2012

It will then be left to the parties concerned, including the religions, to take their stands as to what they believe, in the light of the common information now available, and make whatever adjustments they wish to their disciplines and their practises. The difference now will be that everyone will be doing so from the same platform of information, so that for one thing they will understand one another better.

Fundamentally, in a free society, the individual decides what his metaphysical and religious understandings are and what to believe. Happily, in our world, we have religious freedom, and a man can pursue what he wishes, or have no religion or no belief at all. He guides his moral life accordingly. For guidance, society lays down an agreed moral code Ultimately, society and the species proceed on the aggregate of the collective beliefs and decisions of the individual. I do not foresee much change from this status quo, except that everyone in future will be better informed, understand each other btter, and hopefully will take the best possible decisions.

Beyond Materiality

Our technological development has near outstripped our purely physical existence. In the longer term, our home could be in space. But moving the species out would be another ball game, as against just travelling around. For the present, our objectives must remain surviving on the Earth, living longer better lives, and safeguarding all its other inhabitants.

But man has already evolved beyond the Earth’s capability to sustain our civilisation. Man has in fact transferred our species to become an information-based life form. In every dimension, we are now dependent on information technology (IT). We even artificially manufacture much of our food. Some say we could even be close to being out of control, with quantum computing and artificial intelligence (AI). It would not be wrong to say that today man is largely non-corporeal. He has evolved beyond materiality.

Among other things, the possibilities of a longer technologically-based life and or life after death will be of increasing interest, here or in space.

Closing Remarks

To date, the primary metaphysical question remains open. Is there any world beyond ours, including the prime mover, deities, devis, spirits and whatever has been imagined by man up to now. We shall need to narrow the information gap in our last major fronter, ie. the religious domain, as suggested. Whatever the outcome, I feel we must keep this option open: as Louis Armstrong says “is you is” or “is you isn’t”.

My own feeling is that if evolution is working toward another quantum leap, it would most likely be in the direction of the non-corporeal. My feeling is that we shall progressively acquire enhanced, perhaps additional, intellectual faculties. We shall then know and believe what we need. We should be there by the time we move into space. We should have a clearer picture of things by then.

Meanwhile, let us move on technologically. And manage our collective morality as best we can to stay in business and not go extinct.

I close the study with a high sense of optimism about further study of the religious domain. On the one hand, on the religious side, I found in Teilhard de Chardin[16], the distinguished scientist-priest, the kind of convergent visionary we need, who caused a stir among his fellow Jesuits by identifying his Omega Point as both the ultimate objective of human evolution and the apex of his religion. At the same, on the secular side, there are many advances on many fronts at different levels, and I can do no better than reproduce the following Google AI generated summary as an indication:

16 - https://en.wikipedia.org/wiki/Pierre_Teilhard_de_Chardin

"Main advances in metaphysics include new approaches to established questions such as the mind-body problem, causation, and personal identity, and a renewed focus on topics like physical cosmology, the nature of physical laws, and the metaphysics of modality (possibility and necessity). Other advances include shifting from purely unchanging concepts to understanding the reality of changing things , a process sometimes called the "new metaphysics".

As I see it, we have awesome information technology to deploy. And the already well-laid metaphysical platforms look like the best common ground for solid forward footholds. The key is quantum-level AI programming, with their potential of multi-layered assembly and interrogation on cross informational and cross-religious fronts.

We should remember that with a convergence of effort, we could get breakthroughs from both sides. Thus, a major religious leader recently issued an encyclical stressing the safeguarding of the environment as a moral responsibility. And there is this delightful 1953 story of Arthur C Clarke, entitled "The Nine Billion Names of God" The traditional Tibetan wisdom believed that once all the nine billion names of God had been discovered, the purpose of existence would be fulfilled, and the universe would end. Some monks decided to hire two programmers to programme the newly invented computer to do just that. One day, not long after, it was found that everything had disappeared.

It is also known that evolution can make serious mistakes. Mammalian reproduction for instance is thought to be among the most sophisticated bio-engineering systems developed by evolution. When imported into the human, we had woman, designed as the ultimate in caring motherhood to raise its most precious creature, man. And then, it went on to endow her with the same (some say better) brains as man, and free will – with a touch of vanity. As a result, women today operate on the basis of equality with men and see it as their duty to manage the world before reproducing babies. In consequence, the human reproduction rate has dropped abysmally low and the race will be shrinking by the turn of this millennium, when all the women in the underdeveloped countries join their front-end sisters, Reproduction is the fundamental tool of evolution. It is hard to see how evolution can reverse this mistake. The stakes are very high. They include what happens to the species in the long term. As usual, it will be left to the men to sort things out.

We need new thinking, new vision, and like the eukaryotes of old, new synthesis and new courage. Undoubtedly we could use a quantum leap or two. Somewhere in the Late Jurassic, there were dinosaurs (archosauria) . When one of them was told his descendants would one day fly like birds, he said :"That would be a quantum leap". We are in the same position as the dinosaur, except that we can work out some of our options and influence how we shall evolve.

END

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