Humans and their Nature

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By

Mariano L. Bianca

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PREFACE

Many researchers in different fields, such as philosophy, the sciences and religions, starting from the past to the present day, have devoted their attention to the study of human nature and the birth and development of the human civilization. All of the research activity has led us to understand many aspects of the human species, but up to now there have been so many other that we still lack any exhaustive explanation for and comprehension of.

We believe that different scientific fields will be able, in the near future, to formulate explanations to better understand human nature and civilization. Nevertheless, it will not be enough because many aspects of human life are not of a scientific nature, so it will be necessary to formulate philosophical considerations that take into account questions relative to the dimension of meaning, which can help to formulate a deeper grasp of the overall significance of the past, the actual and the future presence of the human species on Earth and within the cosmic space. These researchers will also be able to fully understand the complexity of an individual human life, of interpersonal relationships, social structures and the relations between human communities and nations.

At the same time, scientific and humanistic studies could be useful, from one side, to find solutions for many of the problems that have involved the actual human civilization as a whole, with the goal of a global amelioration. From the other side, scientific researchers in the genetic and genomic fields in particular could formulate the eventuality of an enhancement of the human genetic biology with an eugenics approach.

In this essay, too, we deal with human nature and civilization, adopting a multidisciplinary approach grounded on the scientific data formulated by paleontology, anthropology, neurophysiology, geology, evolutionary biology and genetics, and on the concept of *eventualism*, so that it allows the formulation of a global vision of Homo: its birth, evolution, and its present and future condition.

Chapter One deals with the cosmic and geological conditions that gave rise to Earth and the emergence of life from the first living beings to Homo sapiens. Chapter Two analyzes Homo's characteristics that have led to the development of civilizations with their negative aspects, such as wars, and the positive ones related to the complexity of societies and the breadth of human cultures. Chapter Three considers different ways in which societies are founded, from the origin of agriculture to the present era. Chapter Four examines Homo's role on Earth, its relationship with other living beings and the ecological conditions. Chapter Five presents some aspects related to the future of Homo, its survival, the conquest of space and the future social conditions with the presence of robots, cyborgs and artificial intelligence (AI) apparatuses. This futuristic scenario includes the enhancement of Homo with genetic engineering.

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CHAPTER ONE

FROM THE SOLAR SYSTEM TO HOMO SAPIENS

1.1. Premise

The nature of humans, their presence on planet Earth and their individual and community behavior are topics that have been investigated by many scientists. To formulate a complete analysis of Homo it is necessary to adopt a very broad perspective that involves not only Earth but the whole solar system. The presence of Homo on Earth is the result of cosmic phenomena that occurred even at a distance of many light years from Earth and allowed the formation of the solar system.

Even today, life on Earth depends on endogenous and exogenous causes. The former refer to terrestrial conditions and phenomena: an iron core, a mantle of matter in a fluid state (lava) that envelops the core and generates volcanic phenomena; a rocky crust, with its tectonic plates and its movements; different layers of the atmosphere made up of many types of gases, in particular hydrogen, nitrogen and oxygen which are peculiar to terrestrial life; and also a magnetic field, generated by the nucleus, which surrounds Earth and protects it from solar phenomena (flares and coronal mass ejections) and by radioactive waves coming from the cosmos, such as gamma waves.

The mass of Earth, with its physical-geological constitution, generates a gravitational force that attracts many cosmic bodies, first of all the Moon, and many others such as comets and asteroids.

The exogenous causes, however, derive above all from the way in which the Sun, Earth and the entire solar system (with all its planets and satellites) were formed. The Sun is not only the main source of energy for the planet but has the gravitational force that allows Earth's revolution around it. Furthermore, the current state of Earth is also influenced by the presence of the Moon which not only generates the tides (marine and terrestrial) but keeps its position and axis constant during its revolution around the Sun. Other influences come from the presence of some planets, particularly from Jupiter, and from larger cosmic phenomena occurring in outer space beyond the solar system. Earth is such because it is located in the solar system, which influenced its formation and still influences its current and future state.

Furthermore, Earth, compared to the Sun, is in that position which was called *goldilocks* by Stephen Hawkings, being neither too close nor too far from the Sun and this allowed its specific formation and, subsequently, the birth of life. Finally, it is important to note the position of the solar system within the Milky Way: a galactic zone that has allowed not only its formation but also its persistence over time, at least until the current cosmic era.

Therefore, to fully understand the presence and nature of Homo it is not sufficient to analyze its biology and the physical-chemical and geological conditions in which Homo sapiens was generated, but it is necessary to focus on the broader fundamental cosmic conditions to grasp the causes and the origin of the Homo species and its physical and, in particular, biological constitution.

In the following sections we will deal with the birth of the Sun, the solar system, Earth and life. Due to the limits of this essay, the descriptions will not be in depth and the data formulated by various scientific research studies will be accepted. The explanations of the processes that took place for approximately 4.5 billion years and the dating (including that of 4.5 billion years ago) are hypotheses, some of them supported by data, others by assumptions accepted by the researchers. In many cases in the scientific literature, with reference to these phenomena, there are different hypotheses and dating, sometimes conflicting, and here the most accepted ones have been chosen and, in some cases, even more than one hypothesis has been presented with reference, for example, to the birth of Earth, of life and its evolution.

As will be seen from reading the essay, current knowledge is still not only provisional but often also incomplete, but this is the only one we have at our disposal and it is accepted on a provisional basis while awaiting new scientific results. However, a large number of scientists from different disciplines are carrying out assiduous research and, often, from year to year data and hypotheses are modified; this does not mean that even at present it is not possible to have some knowledge of those processes that will be described. Geological and cosmological processes are correlated with each other in a hyper-complex way and, at the same time, occurred billions of years ago, so there are intrinsic difficulties in accumulating relevant data to describe them and even more so in formulating explanations for their occurrence. Therefore, current knowledge, even that presented in this essay, may not only be modified (in part or entirely) in the future but also overcome, and new data will be formulated with more reliable dating, descriptions and explanations than the current ones. In some cases, however, such as the birth of the Sun and the solar system, our knowledge (even in the future) cannot be definitive and perhaps never will be.

1.2. The Formation of the Solar System and of Earth

The solar system, one of billions of cosmic systems, was formed about 4.5 billion years ago by the gravitational collapse of a Milky Way nebula located in the Orion Arm. Perhaps the influence of the explosion of a nearby supernova caused the compression of the matter of the nebula inside it until it collapsed. This nebula, formed by cosmic dust and gas, began to rotate and heat up and started a process of aggregation by collision that generated the Sun and the eight planets and their satellites and a great part of the cosmic dust formed asteroids and comets that, in large part, are still in the Asteroid Belt between Earth and Mars, in the Kuiper Belt and in the Oort Cloud.

The Sun, despite being the largest cosmic object in the solar system (99.86% of the mass of the solar system), is a relatively small star compared to many others that populate the Milky Way and the entire cosmos such as Antares, Aldebaran, Betelgeuse and others.

The formation of the Sun, with its gravitational field, had a great influence on the formation of the solar system; however, the rocky planets (Mercury, Venus, Earth, Mars, the inner planets) and the gaseous ones (Jupiter, Saturn, Uranus, Neptune, the outer planets), with a large number of satellites, also played an important role during the billions of years of the formation of the solar system as observed in the current era.

The Sun, which is on average 149,957,870 million kilometers away from Earth and is a million times larger, is a cosmic body with a mass of approximately 1.9891 x 10^{30} kg, 99.86% of the mass of the solar system (330,000 times greater than the mass of Earth). The Sun rotates on itself and is made up of plasma in which hydrogen and helium are predominant.

At the center of the Sun is the nucleus that generates the Sun's energy; it is made up of gaseous hydrogen which, when subjected to high temperatures (15,000,000°C) causes the hydrogen atoms to fuse together, forming helium atoms (four hydrogen atoms generate one helium atom). In this process, it emits a large amount of energy in the form of photons that travel at the speed of light (299,792,458 meters per second, 1,079,252.849 km/h) and take eight minutes to reach Earth.

The photons generated by the thermonuclear reactions of the nucleus are transmitted into an area of the Sun which is called the radiative zone of approximately 7,000,000°C. This transmission of energy involves a zone called the convective zone and subsequently reaches the photosphere made up of plasma, and here it radiates outside the Sun in the form of light. The photosphere is surrounded by the atmosphere in which the energy produced by the nucleus tends to disperse from the Sun and photons can take thousands of years before reaching it and then diffusing into space.

Above the atmosphere there is the chromosphere, 5,000 km deep, with a temperature that varies from 5,000 to 10,000°C. Finally, there is the solar corona which extends for millions of kilometers into space and which has a temperature of 1,000,000°C (the one seen in solar eclipses). Electromagnetic processes are generated in the corona in the form of large magnetic arcs which often "break", producing flares and coronal mass expulsion which spreads into space and also reaches Earth. Although Earth is protected by its magnetic field, generated by its core, coronal mass ejections or solar flares can generate a lot of damage on Earth, particularly on artificial satellites and structures that rely on electronic equipment. The Earth's magnetic field is weaker at the poles so solar emissions of electrically charged ions can penetrate it, releasing energy into the atmosphere and, thus, polar auroras are generated.

Finally, the Sun has what is called the heliosphere which extends for millions of kilometers and marks the space in which the influence of the gravitational force of the Sun (and the photons that it spreads into space) expands.

It is believed that the Sun still has a lifespan of 5.4 billion years, in which time the hydrogen resources within it will run out and a process of core collapse will begin. At the same time, the hydrogen will still burn in the outermost part and, in this way, the Sun will increase its surface which will gradually cool down because the thermonuclear processes of the nucleus will no longer take place (in about seven billion years).

The Sun will become what is called a red giant and will have a diameter 256 times greater than its current one. This will cause the Sun to incorporate Mercury, Venus, Earth, and perhaps even Mars, which will be volatilized. This great expansion could generate its implosion and, in this way, the Sun will transform into a white dwarf: a small star with a high concentration of mass.

In the solar system, in addition to the eight planets, there are 146 satellites and if we consider the Asteroid Belt (between Mars and Jupiter) and the Kuiper Belt (beyond Neptune) and the Oort Cloud at the edge of the solar system (made up of comets), the celestial objects amount to several million.

Earth was the result of these cosmic processes and its survival is due, first, to the existence of the Sun and then also to that of other planets, satellites and asteroids, including Jupiter, which with its gravitational force plays a significant role in maintaining Earth in its current spatial position: not very close to the Sun like Mercury, with its hot surface temperature, and not as far away as Uranus with its very cold temperature: both cannot support life.

The Sun is the primary source of the current warming of Earth which has allowed the formation of life with the presence of hydrogen, oxygen and carbon, which are fundamental for the existence of terrestrial life.

In this cosmic condition, the largest bodies, based on their increasing gravity, not only attracted others, enlarging them further (growth processes), but collided with each other, thus generating very different planets. For a few billion years, the planetary formations influenced each other and, in this way, the entire structure of the solar system changed to become the current one. In these processes, an important role was played by the formation of Jupiter with its very big mass, which determined the current state of the solar system.

The formation of Earth and its transformation over time is correlated with Earth's gravitational field that was formed during the period in which it fully achieved its geophysical structure and which influenced the way in which the planet formed. Over billions of years, gravity has influenced every aspect of Earth and also the rise of a particular form of life that evolved 4.4 billion years ago.

The current Earth is the result of the formation of its gravitational field and, at the same time, of those cosmic processes of the nascent solar system and it underwent a profound transformation when a celestial body called Theia, with a mass more or less equal to that of Mars, collided with it, hitting it laterally and not in the center and this modified its geological and spatial state and its axis (it inclined by about 23°, compared to the perpendicular to the ecliptic plane) and, thus, also its revolutionary motion around the Sun. In this cosmic collision, the Earth incorporated part of Theia (and its load of metals) and at the same time a part of Theia was dispersed into space and was attracted by Earth's gravity and, thus, a disk of matter began to form around Earth which generated the Moon which, due to the gravitational attraction of Earth, began to revolve around it and around the Sun at the same time.

At that time the Moon was very close to Earth, but over the next billions of years it began to move away from Earth up to the current distance of about 380,000 km which is increasing by a few centimeters every year.

The Moon has always played an important role in the Earth-Moon system; in addition to the phenomenon of marine and terrestrial tides, it stabilized the inclination of Earth's axis and slowed down Earth's rotation speed and therefore the rotation period. The inclination of the axis of rotation together with the rotation around the Sun produced the alternation of the seasons.

The formation of Earth is believed to have occurred, like that of the other planets, around 4.5 billion years ago, more or less at the time of the formation of the Sun, and from that period up to today Earth underwent many transformations in addition to that generated by its impact with Theia.

At the time of its birth, Earth was made up of agglomerates of numerous metals, gases, radioactive material and rock (which already belonged to the nebula), in a state of fusion generated by high temperatures related to the radioactivity of many of its constituents. Furthermore, this state of fusion was also influenced by continuous impacts with other celestial bodies (meteorites and comets) which increased its mass and, therefore, its gravitational force as well.

Earth is the largest of the rocky planets (Mercury, Venus, Earth, and Mars) and is third in distance from the Sun (after Mercury and Venus).

The mass of Earth is approximately 5.98 x 1024 kg, almost 6,000 trillion tons. With the acquisition of cosmic matter it increases by 107 kg/year. With reference to their weight, Earth is made up of the following elements:

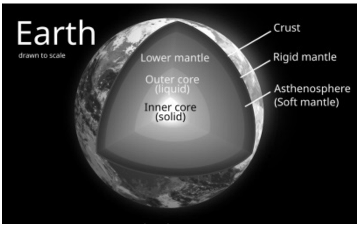
iron (32.1%), oxygen (30.1%), silicon (15.1%), magnesium (13.95%), sulfur (2.9%), nickel (1.8%), calcium (1.35%), aluminum (1.4%), and other elements (1.2%).

Since its formation over billions of years, in addition to the impact with Theia, Earth was also subject to many transformations within itself.

The heavy elements began to aggregate, forming a ferrous core at its center and, at the same time, the surface began to cool, forming what is called the lithosphere, of which its crust is part. In the course of evolution, up to the current period, Earth was formed from different overlapping layers, like an onion skin. The external one, called the lithosphere (5–120 km deep), is formed by the crust and the upper part of the mantle. The crust, in particular, made up of rocky material and metals, is 5–10 km deep in its oceanic areas and 30–70 km in its continental areas.

Below the lithosphere lies the mantle in a fluid state (from 35 to 2900 km) and made up of rocks and metals in the molten state.

The mantle covers the core from 2,900 to 6,300 km. The nucleus is liquid (outer mantle) and viscous (inner mantle) in nature and is made up of 88.8% iron to which 5.8% nickel and 4.5% sulfur are added. The nucleus is in a state of fusion, with temperatures ranging from 3,000 to 6,000°C. These temperatures are probably generated by the decay of radioactive elements such as uranium and thorium which became part of the Earth during its formation, acquired from the gravitational collapse of the solar nebula and by the supernova explosion that impacted the solar nebula.



Structure of the Geosphere

The lithosphere, composed of the Earth's crust, including the oceans, and the upper part of the mantle, floats on the upper part of the mantle (which consists of partly molten rocks) which is very hot and behaves like a fluid. The convective movements of the mantle, due to the rotation of Earth, fragment the crust, generating tectonic plates (continental and oceanic) and favor their movements.

The tectonic plates are lighter and cooler than the mantle, hence (according to Archimedes principle) can float on the mantle. The tectonic plates shift, therefore the terrestrial surface is always moving, generating continuous collisions that generate land fractures which cause earthquakes of differing intensity and, frequently, volcanic eruptions. Then the so-called *subduction process* is formed, in which a plate shifts under another, raising the land of the last.

Earth's great mountain ranges, from the Alps to the Andes and the Himalayas, were often formed through the process of subduction in which one tectonic plate pushes against another and slides under it, raising its terrain and (thus) generating mountainous chains; on Mount Everest (8,800 m altitude), for example, fossils of primordial ocean animals have been found because Everest was originally located in the ocean.

From the beginning, the process of the movement of the tectonic plates generated the first super-continent, (perhaps around 750 million years ago), called Rodinia, which later divided into smaller continents (Laurasia and Gondwana) and from here another process of agglomeration that formed Pangea which (about 290 million years ago) generated smaller continents, which are the ones that still exist.

In the current era, Earth's crust is made up of 6 continents (Africa, America, Asia, Europe, Oceania, Antarctica), 4 oceans (the Atlantic, Pacific, Indian and Antarctic) (78% of the crust), 12 plates of which the main ones are: the Eurasian, Indo-Australian, Philippine, Antarctic, Pacific, Cocos, Juan de Fuca, North American, Caribbean, South American, Scottish and African.

The Earth's surface is characterized by extensive volcanic activity which derives from the movement of plates which, when generating fractures (faults) in the crust, allow the escape of lava material from the mantle which, in turn, is fueled by the continuous activity of fusion of the ferrous core.

Volcanic activity generated the initial atmosphere and, thus, water vapor over billions of years led to the formation of oceans which (perhaps) were also enriched by the ice brought by comets and asteroids that fell to Earth.

In addition to the lithosphere, which is made up of rocks even in the molten state, the Earth is made up of other spheres.

Around Earth there is a wide and thick atmosphere that divides the planet from the rest of the cosmos and is made up of 78% nitrogen, 21% oxygen, 1% argon and other gases such as hydrogen and carbon dioxide (CO_2). The atmosphere, up to 10,000 km high, is divided into the following zones. The troposphere constitutes three-quarters of the atmospheric mass and is located 8 to 14.5 km from Earth's surface. Above it, up to 50 km high, there is the stratosphere and, even higher, the mesosphere (up to 85 km above Earth's surface), the thermosphere (up to 600 km) and, finally, the exosphere which separates Earth from space which is not terrestrial.

The hydrosphere, on the other hand, is made up of the water present on the planet: oceans, lakes, rivers, aquifers and atmospheric humidity. Of all Earth's water, 97% is contained in the oceans and fresh water is only 0.023% of the total. The hydrosphere, which is the largest surface of Earth, is constantly changing in the water cycle: rain from the atmosphere falls on Earth's surface and forms aquifers, rivers, seas and oceans and partly evaporates, forming the atmosphere, and so the water cycle restarts.

The fourth sphere of Earth is the biosphere which is made up of all living organisms: plants, animals and unicellular living beings found on Earth's surface or in the oceans.

The cryosphere is that part of Earth's surface which is covered by water in its solid state: glaciers, the regions of the South Pole and the North Pole, snow covers of the land, seas, lakes and rivers, permanently frozen ground (permafrost) or during certain periods of the year.

Finally, Earth has a *magnetic sphere*, or *electromagnetic shield*. This magnetosphere, generated by the rotation of Earth's ferrous core, envelops it and protects it against that part of the flows of solar radiation (flares and coronal mass ejections) and cosmic rays (coming from extra-solar space) which would have a negative effect on the planet and (in particular) on the living world.

1.3. The Origin and Evolution of life

The cosmic processes that allowed the formation of the Sun, the solar system and Earth, with its geophysical evolution, were the prerequisites for the origin of life on Earth.

There are still several hypotheses on how life formed on Earth and among them there are two relevant ones: a) the extra-terrestrial hypothesis and b) the terrestrial hypothesis.

The first hypothesis holds that organic macromolecules, transported by comets and asteroids, fell to Earth in its primordial soup consisting of a mixture of liquid water in which are present inorganic salts and simple chemical compounds based on carbon, hydrogen, oxygen, nitrogen and other compounds, such as amino acids, carboxylic acids and polymers, and inorganic compounds such as ammonia and carbon dioxide (NH_3 and CO_2). From this, the first living terrestrial cells were formed.

The second hypothesis states that life on the planet originated, without external contributions, in the period in which the physical-chemical conditions for the formation of the first organic molecules were generated and, in particular, when the oceans were formed in which the first unicellular (prokaryote) and later multicellular (eukaryotic) organisms developed.

The origin of life on Earth can be dated to within a period between 4.4 billion years ago, when liquid water formed on Earth's surface, and 3.8 billion years ago when the first unicellular living beings arose in the primordial oceans. The formation of the primordial oceans was caused by the physical cycle of CO_2 which was released into the atmosphere by volcanic eruptions which transported the magma of Earth's mantle which contained water (perhaps transported by the many impacts of asteroids and comets) to the surface and, therefore, with the vapor released from the volcanoes, the primordial clouds were formed and (subsequently) the water vapor fell back to the earth in the form of rain, increasing the formation of the oceans. At the same time, this process generated the atmosphere, with the presence of CO_2, which was subsequently deposited on the ocean floor in the form of limestone.

The original and fundamental process for the birth of life was the one that generated those organic compounds that linked together to form the structure of DNA and RNA from which all living beings and species that inhabited Earth were born. The first stage in the origin of life, therefore, was the formation of simple organic molecules, such as amino acids and nucleotides, which are the building blocks of life whose fundamental constituents are: methane (CH_4), ammonia (NH_3), water (H_2O), hydrogen sulfide (H_2S), carbon dioxide (CO_2) or carbon monoxide (CO), and phosphates (PO43).

Some researchers believe that the first organic cells were formed with the presence of hydrothermal springs in the oceans or, better yet, in pools of fresh water near, and influenced by, terrestrial thermal springs in which there was little movement of water. Hence, they did not disperse the chemical substances but, on the contrary, they could meet and join. It is also claimed that the constituents of life, such as nucleotides and nucleic acids, were formed in the presence of cyanide sulfates. From this comes the hypothesis that cyanide came from the impacts (on Earth) of cosmic bodies that contained cyanide or chemical compounds with cyanide that allowed the bonds between the fundamental chemical constituents of life.

These first unicellular, prokaryotic living beings later underwent an even more relevant (but still not entirely explainable) process. Prokaryotes joined together to form eukaryotic cells, in particular multicellular ones, that is, chains of cells whose genetic content was in the nucleus of each cell and protected by a membrane.

The first living organisms (in the strict sense) were formed on the ocean floor or in pools of fresh water and were living beings like the current bacteria and archaeal bacteria (archaea). This process should have happened 3.8-3.9 billion years ago, at the beginning of the pre-Cambrian period. At that time, the atmosphere probably contained water vapor, ammonia, methane, hydrogen, hydrogen sulfide and carbon dioxide.

Eukaryotic organisms (plants and animals), however, developed later, starting around 2.7 billion years ago. The oldest fossils on the ocean floor date back 500–600 million years.

In fact, before the birth of living organisms, the first organic molecules were formed and this process lasted more than three billion years before the first unicellular ones were formed, such as bacteria and viruses, proto animals and (later) the multicellular ones from which all living beings developed. The multicellular ones, which played a fundamental role in the evolution of life compared to the unicellular ones, being more complex (made up of many cells), could have had a greater chance of survival.

Many conditions led to the rise of life. First of all, there was the geophysical-astronomical condition of the formation of Earth, its place in the solar system and its distance from the Sun. To these conditions are added the rotation of Earth, the revolution around the Sun, its specific gravity and the inclination of 23, 27° of its axis with respect to the perpendicular to the plane of the ecliptic. This last condition seems to have been caused by the collision of Theia and (subsequently) the formation of the Moon which, with its gravity, allowed the maintenance of this inclination and, therefore, also of the alternation of the seasons during the revolution of Earth around the Sun.

Even the formation of other planets, in particular the gaseous ones and especially Jupiter, supported the maintenance of Earth in its current position and that in which the first organic cells were formed.

For terrestrial life, all those characteristics that are specific to Earth are involved. First, its geophysical structure: its iron core in the solid state, the mantle in the viscous state, the upper part of the mantle and the crust (lithosphere) floating on it. From this geophysical condition, the tectonic plates and continents were formed, which transformed over billions of years from Rodinia to Pangea and from this to the current state of the different continents, the ocean floors and all the mountain chains.

Added to these variables are the vastness of the oceans, glaciers and glacial poles, and the volcanic and seismic activity. Life would not have evolved if other variables had not been involved: the production of oxygen and CO_2, photosynthesis, forestation, the alternation of the seasons, the formation of a dense atmosphere and the magnetic shield (the magnetosphere), generated by the terrestrial solid ferrous core, they play the role of protecting the Earth from solar activity as well as from cosmic radiation, such as gamma rays, coming from various cosmic events and from other stars (including supernovae).

All these variables and conditions have ensured not only that life originated on the planet but that it could be maintained for at least three billion years with a continuous evolution of living species: from the original multicellular ones (eukaryotes) up to the current ones, Homo sapiens included.

At the time of the formation of the first unicellular cells (prokaryotes), made up of carbon and hydrogen, it could not be foreseen that these cells could bind together, generating increasingly complex multicellular organisms (eukaryotes) from which all living beings derived in the millions of years they inhabited the planet including dinosaurs, and later, birds and mammals, which also include humans.

After the process of the formation of multicellular organisms, the latter became increasingly complex and from the oceans, or from pools of water, they spread to the land and into the atmosphere. With a few exceptions, they did not possess the energy necessary for their survival: *they were heterotrophs*. *Heterotrophy* consists of the endogenous lack of energy and the search for energy sources that possess physical-chemical substances which, if introduced into the organism, generate energy fundamental for survival.

In order to survive, these multicellular organisms had to obtain energy from their environment, be it marine (even from oceanic volcanoes, as the so-called extremophiles still do today), terrestrial or atmospheric.

Heterotrophy is that character that has marked the evolution of life on Earth, speciation, the relationships between the animal and plant world, and the inorganic world, and all the relationships between living species.

The first multicellular living beings can be divided into two classes: a) those that did not possess motility and b) those that possessed motility.

The first multicellular organisms did not have the ability to move (as happens today for stromatolites and extremophiles, which obtain energy without moving from the site where there is an underwater volcano, or even for coral reefs) so their energy was obtained (directly) only from the surrounding environment in which they lived. Among those on the ocean floors there were: a) stromatolites formed by residues of cyanobacteria already present in the Pre-Cambrian (Archeozoic, three billion years ago) and corals that can reproduce in the form of fractals: repetition of the same elements; b) extremophiles who lived near oceanic volcanic springs. These types of multicellular animals without motility are still present in the oceans today.

The world of life continued to evolve until 500–600 million years ago, in the Cambrian, in which much more complex, multicellular organisms were formed that crawled on the ocean floor, or were equipped with limbs that allowed them to move around the environment to search for sources of energy.

Motility was a fundamental step in the evolution of living beings on Earth. Among these living beings with Cambrian motility, called trilobites, their fossil remains can be remembered.

Dickinsonia—Fossil of a living being with motility (ocean floor, Australia, 550 million years ago)

The behavior of motility (although useful on its own) was not efficient, so it was necessary to have *sensors* that allowed the detection of energy sites. The trilobites must have already possessed sensory organs useful for detecting energy sources and the evolution of living beings also passed through the evolution of sensory organs which became increasingly complex.

All heterotrophic living beings possess the following characteristics that allow them to survive in a given habitat.

A) a body made up of biological matter
B) the ability to move in their habitat (limbs, legs, wings, tails, claws, etc.), even if not everyone has it, for example, stromatolites and corals
C) sensors suitable for searching for energy sources with movement
D) an apparatus for introducing researched (and found) natural substances into it (mouthparts, proboscises, etc.)
E) a gut that chemically processes substances found in the environment
F) an apparatus for expelling substances not used to generate energy
G) a sexual (or other similar) mode of reproduction
H) tools for defense and attack (natural weapons)
I) a neuronal structure, whether very simple or complex, that regulates all vital functions
L) the DNA and RNA that possess the information necessary for the replication and generation of a specific living organism.

These characteristics mean that every living being can maximize the success of its survival; however, as still happens today, the purpose of living beings is not their survival but their possibility of reproducing, so surviving means living to reproduce. In this sense, *sexual reproduction* (even of other types) has been the purpose not only of every animal but also of every living being on the planet (animals and plants).

Sensors of all types, which evolution has generated from multicellular living beings, have the following functions:

— can detect natural sources from which to extract energetic substances that can be chemically manipulated to generate the energy necessary for survival.

— can detect other living beings (conspecifics and predators), including plants, and the global and particular conditions of an ecological niche. Without sensors, living beings could not survive and the plan of evolution would not have developed. The sensors were created for these goals and, therefore, they must be such as to allow reliable knowledge of the environment, i.e., corresponding to the structure of the environment.

The formation of visual sensory organs (eyes) was a further crucial step in the evolution of living beings from the Cambrian, about 540 million years ago, until today.

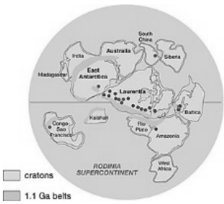
The sensors have two characteristics: adequacy and reliability. A sensory representation is said to be adequate if it conforms to the bodily structure of a living being and is advantageous for achieving a goal. In this way, for example, the adequacy of a sensorial/neural representation referring to the reaching of a prey is measured; in the brain of a cheetah, for example, a representation of a Thomson's gazelle in the savanna is formed. It is adequate if the cheetah can manage to reach the gazelle and prey on it (even if this action is often unsuccessful). A sensory representation is said to be reliable if it contains information that corresponds to the status of the environment.

Life on Earth was formed thanks to those characteristics which allowed the formation of the planet from its origins up to that period in which the first organic cells, pre-prokaryotic, prokaryotic and eukaryotic, were formed. It took a few million years to reach this condition: from an abiotic to a biotic Earth. An equally large number of years were necessary for life to evolve so that multicellular organisms became dominant and unicellular organisms were preserved until today (microbes, viruses and bacteria).

From the original trials, from around 4.4 billion years ago, life reached 500–600 million years in which, in the Cambrian, the explosion of life began which evolved with the formation of hundreds of species, many of which disappeared, giving way to others which (in several cases) originated from the evolutionary process of the previous ones.

All the evolutionary processes of life occurred in parallel with the many geophysical, chemical and cosmic transformations that the planet underwent in the period of its complete formation and subsequently, of its surface in particular.

Life originated thanks to many transformations of Earth's surface and beyond: the formation of the atmosphere and its physical-chemical composition, its oceans, the magnetosphere, the ozone layer (caused by the steam coming out of the volcanoes and from the release of oxygen by the stromatolites during the process of photosynthesis) and from the tectonic plates which shaped the surface in different ways over the course of a few million years, with the formation of the continents and the terrestrial and oceanic mountain chains. Earth went from having the presence of a single continent (Rodinia and then Pangea, Paleozoic and early Mesozoic) to the current one with 6 continents and 12 tectonic plates. Later, the planet also appeared as a large ball of snow and ice (the Snowball Earth, Proterozoic) and, subsequently, the surface temperature rose and Earth became a planet made up of large oceans and large mountain chains. In addition to continental drift, the resulting seismic and volcanic activity played a fundamental role in these transformations.



Rodinia

Pangea

Life managed to continue by adapting to these transformations of the planet and to other cosmic events such as the fall of (more or less) large asteroids on the planet. This adaptation led, on the one hand, to the extinction of many living species (see the table below) and, on the other, to the evolution of those that survived and the birth of many others.

4.4 billion years: first macromolecules — amino acids and nucleotides
3.6 billion years: simple cells (prokaryotic)
3.4 billion years: stromatolites that generate oxygen (photosynthesis)
2 billion years: complex cells (eukaryotes)

1 billion years: multicellular organisms
570 million years: arthropods (ancestors of insects, arachnids and crustaceans).

The evolution of living beings has not stopped until today, but starting from the Ordovician period there have been mass extinctions, or decreases in biodiversity, which have slowed down the process of the evolution of living species and (at the same time) directed it toward the realization of new species.

The first mass extinction occurred in the Ordovician-Silurian period (450 million years ago) in which there was a lowering of the ocean levels and a glaciation that caused the death of many species that lived in the ancient oceans, such as coral brachiopods and trilobites. Also, in the following period, the Devonian (375 million years ago), it is believed there were real extinctions or (at least) less biodiversity, which lasted for many millions of years (perhaps even 50 million) and which affected 82% of the living species of that era. In this case, some researchers assume that the cause of the lower biodiversity was caused by the fall of numerous asteroids on Earth.

A real mass extinction would also have occurred in the Permian-Triassic period (250 million years ago) and would have been the largest in the entire history of living beings, perhaps caused by large volcanic eruptions. Perhaps as many as 96% of species became extinct, as did 50% of all living marine animal species. Even in the following periods, the Triassic-Jurassic, several mass extinctions occurred due to the fall of asteroids or (perhaps) to climate changes. Finally, the best-known mass extinction occurred in the Cretaceous period, 65 million years ago, which caused a profound change in the evolutionary process of terrestrial life. This extinction was caused by the fall (into the sea near the Mexican Yucatan peninsula) of an asteroid of at least 10 km in diameter, which fell at a speed of 30 km/s, causing a large crater and an enormous mass of gas, dust and matter. This event generated a rapid change in the atmosphere, causing large accumulations of clouds which blocked solar energy for many years, resulting in a significant drop in Earth's temperature and the quantity of oxygen; hence, a great destruction of the plant life which (in turn) no longer offered sustenance to large herbivores and, therefore, also to carnivores. All marine, terrestrial and aerial dinosaurs became extinct, but only small mammals were saved and this allowed the resumption of life and its evolution until today. The following table illustrates the percentages of species that have become extinct in different geological eras.

millions of years	era	percentages of extinct species
430	Ordovician	84–85%
360	Devonian	79–83%
250	Permian	95%
200	Triassic	79–80%
65	Cretaceous	70–76%

To conclude this section, it is useful to underline that life on Earth has been generated and has evolved strictly according to the conditions of the planet, so that eventual changes in some of these conditions could have generated the extinction of the whole life on Earth. For such a reason, it is difficult to think that Earth's living beings could have survived on cosmic objects with different conditions, including gravity.

1.4. The Origin of Hominids and Homo Sapiens

We must go back to the Oligocene and Miocene periods, in which it is believed that the first ancestors of the Homo genus were born. The human family tree could reach the Oligocene with *Aegyptopithecus zeuxis* which dates back to 33–34 million years ago. In the following period, the Miocene, the *Proconsul*, the *Dryopithecus* and the *Kenyapithecus* would derive from the *Aegyptopithecus zeuxis* (from 23 to 14 million years ago). A subsequent step in the family tree would be represented by *Ramapithecus* (12–8 million years ago) from which two branches would derive: that of the current anthropomorphic apes (chimpanzees, gorillas, orangutans and bonobos) (Hominoidae) and that of the genus of hominids (Hominidae) which includes, in addition to humans (Homo sapiens), the African anthropomorphic apes, gorillas and Pan with two species, *Pan troglodytes*, the common chimpanzee and *Pan paniscus*, the bonobo or pygmy chimpanzee.

Among these hominids there was also the genus *Australopithecus* that lived between 5.4 and 1.2 million years ago, with several species including: *Australopithecus africanus*, *robustus*, *boisei* and *afarensis*, 3–3.5 million years ago.