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THE EIGHT LAYERS OF OUR PLANET

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FOREWORD

I have been thinking for a long time about tackling a topic that underlies this book, but the invitation to publish from a publishing house to write something about the Ecosphere made me not delay it, because as an ecologist, I noticed that people in my industry are a bit coddled when it comes to tackling topics that go beyond ecological knowledge of ecosystems. In other words, with the approach of the higher levels of organization of living matter, which are now taken over and applied in other fields (and in our case, in ecology), that is, in the study of *landscape, ecobiome, ecozone and ecosphere*. Most geographies have written about them, and only tangentially biologists. However, ecologists deal with the functionality of interrelationships and seek to highlight the complex activity of different ecological systems. This is why I believe that it is imperative that these levels are also the subject of research by ecologists, levels which, until now, have not been seriously analysed from a systemic point of view.

Looking in the scientific literature, I noticed with surprise that at the level of the field "natural sciences" there are a multitude of classifications, in which the basic concepts are most often confused: for example, geosphere with toposphere, toposphere with troposphere, biosphere enters in geosphere, hydrosphere is divided into hydrosphere and cryosphere, and so on. Before setting off on the road, we will specify with what terms we work, then we will treat them more extensively, but according to the context of this work and at the right time.

Underlying our current thinking are two *"unorthodox"* premises:

Man is a being who appeared and evolved permanently on our planet, BUT who was "helped" from a certain moment by extraterrestrial beings who came to exploit terrestrial resources in their interest. They "created" humans because they needed slaves (which they made on biological material that they found on our planet using a series of genetic manipulations). That's who we are now. Genetically manipulated terrestrial beings. Doesn't sound too good!

The guiding information for all living and non-living processes at the planetary level is that produced by the living world. So, it's about biological information, which has appeared since the appearance of life on Earth, which has been constantly improving, reaching from a certain point to influence all the other types of information that non-living environments on the planet have. As a result, they are now under the control of biological information existing on a planetary level.

This paper addresses several aspects:

Presentation of the four non-living shells/spheres on the planet (toposphere) – atmosphere, hydrosphere, lithosphere and magnetosphere.

Presentation of the biosphere – the living shell of the planet highlighting the complexity it has reached.

Presentation of the ecosphere – the shell emerged by connecting the activities that take place between the living world and the non-living environment on Earth. Here, as a precursor to the ecosphere, the pedosphere is described, a shell existing only in the terrestrial environment, which was formed by the functional joining of living and non-living components on the planet, before the formation of the true ecosphere.

Presentation of the anthroposphere – a shell created by mankind for the purpose of subordinating the components and functioning of the ecosphere to a wide range of human interests, more or less material and more or less spiritual, all egocentric, using for this purpose the achievements of those parts of human consciousness that deal with science and technology. It now seeks to subordinate the planet to human information.

Much less will we refer, at the beginning and the end of the book, to the relations of our planet with the Solar System of which it is a part, and we will treat very succinctly, how we see the future of humanity and that of the anthroposphere.

Over the years I have had discussions with many colleagues. Thanks to them I structured the ideas we present in this work. The first, the one who shaped my current way of thinking and who instilled in me correctness and probity in research is Professor Nicolae Botnariuc from the University of Bucharest. The second is Professor Radu Codreanu, from the same university, who gave me a dictum: *„whatever you publish, write in such a way that you are not ashamed of it even after 10 years!"*

Others were colleagues from the two research institutes where I worked: the Institute of Biology and the Institute of Applied Ecology, both in Bucharest, and numerous colleagues from the two universities where I taught after 1990: "Ovidius" University of Constanta and "Lucian Blaga" University of Sibiu, as well as colleagues from the Society of Ecology in Bucharest and the Society of Hydrobiology in Bacău.

Lately I have collaborated more with a reputed ecologist who has worked all his life in the forestry field, Mr. Eng. Nicolae Doniță, because we have a similar way of thinking when it comes to living-non-living interactions at the levels of organization of living matter on our planet.

For the publication, my thanks go to my former student and PhD student, biologist Dr. Marian Tudor, director of the Danube Delta National Institute for Research and Development in Tulcea, who supported me and who made possible the publication and dissemination of this book.

I hope this introduction will stimulate your interest and we are open to any discussion about what is presented in it.

Prof. Univ. Emeritus Dr. Stoica Preda Godeanu,

Member of the Academy of Romanian Scientists

CONTENTS

1 CHARACTERIZATION OF THE SOLAR SYSTEM

1.1 Our solar system's place in the Milky Way Galaxy

The galaxy to which the Milky Way belongs is like a huge spiral, composed of several spirals. It has a diameter of over 100,000 light years and contains between 100 and 400 billion stars (Figure 1).

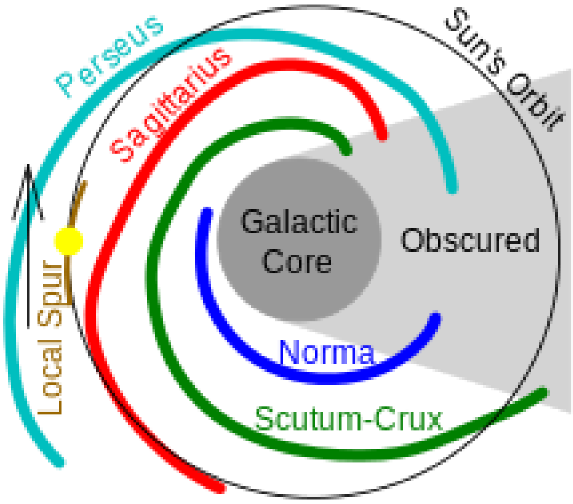

Figure 1. Location of the Solar System within the Milky Way (https://en.wikipedia.org/wiki/Formation_and_evolution_of_the_Solar_System)

Our solar system resides in one of the arms of the galaxy's outer spiral, the Orion arm. This is a small arm, located about 26,673 ± 8 light years from the center of the galaxy. Its rotational speed is 250 km/sec, so the cosmic year (the time our solar system makes a detour around the center of the galaxy) is 220-250 million years. Its orbit is almost circular. The closest solar system to us is Proxima Centauri, which has a red dwarf star about 4.2 light years (4.0x1013 km) from Earth in the constellation Centaurus.

1.2 Brief overview of the Solar System

The planetary system created by the sun, which is the solar system to which our planet belongs, is composed of a star – the Sun – and numerous larger and smaller celestial objects arranged on a disk that circulates in approximately the same orbit, on more or less circular trajectories around it (Figure 2). They are the 8 planets, around which gravitate 214 natural satellites (called moons), plus 5 small planets with 9 moons around them, but also billions of smaller solid bodies, called asteroids, cosmic dust, etc. Along with these from outside our solar system, they come from cosmos, in very long orbits that intersect the trajectories of solid bodies and orbit around the sun in different directions, a series of comets (Zeilik *et al.,* 1998; Sagan, 2013; Pater *et al.,* 2015).

Our solar system is part of the galaxy called the Milky Way and is discoidal in shape. It has at its center the Sun, which represents 99.85% of its solid mass and produces, through nuclear fusion, hydrogen and helium. From this sun, going to the periphery of the planetary system, lie two distinct zones of planets. The nearest ones make up the inner solar system and consist of 4 rocky planets, composed mainly of rocks and various metals. These are Mercury, Venus, Earth and Mars. An asteroid belt follows. Beyond it is the outer solar system, made up of 4 other planets, which are very large (giant): the first two are constituted mainly by hydrogen and helium: they are Jupiter and Saturn. The next two, Uranus and Neptune, ice planets, which are made up mostly of water, ammonia and methane. All 8 planets orbit the sun in almost circular orbits and are in an ecliptic plane relative to the sun (Brandner, 2011; Zeilik *et al.,* 1998; Sagan, 2013; https://www.britannica.com/science/solar-system).

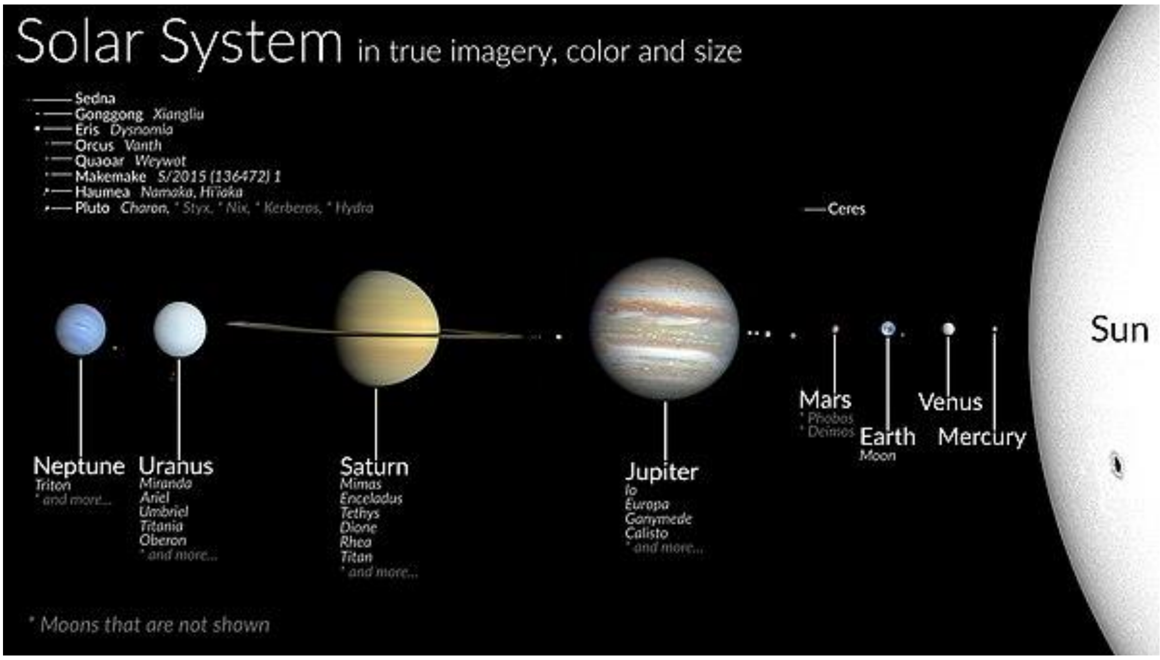

Figure 2. Diagram of our Solar System
(https://www.google.com/search?client=firefox-b-d&sca_esv=583328628&q=sistemul+solar&tbm)

Beyond the orbit of Neptune are other icy cosmic objects, called trans-Neptunians, which make up Kuiper's belt and 4 plutoid planets: Pluto, Haumea, Makemake and Eris. Up to the limit of the sun's magnetic attraction is the solar wind. The gravitational limit of the sun extends up to 1-2 light years and is also the area where comets that make oval-elongated paths travel in very long periods of time. Satellites called moons orbit all planets, or there are solid dust particles and other larger solid particles. The only planet that has a thick gaseous atmosphere and on which water is liquid is planet Earth, the only planet on which life exists. So far, neither in our solar system nor in other planetary systems have been definitively detected life forms. As a result, our planet seems to be unique in the universe known so far to humans.

1.3 Origin, formation and evolution of Solar System

From what is known so far, our solar system appeared 4.55-4.56 billion years ago, through the gravitational condensation of a fragment of a solid molecular cloud that was about a few light years in diameter and began to condense under the action of a shock wave caused by several supernovae in the vicinity. These caused denser areas, with a diameter of 7,000-20,000 astronomical units and a mass slightly larger than that of the current sun, but whose composition was similar to its own, meaning its mass contained 98% hydrogen, helium and traces of lithium. The rest of its content, 2%, consisted of heavier elements resulting from the mass of other nearby stars that had exploded when they became supernovae.

As a result of the nebula's rotation and the frequency of collisions between atoms, a very high kinetic energy was generated, which in turn produced heat. Over a period of approximately 100,000 years, gravitational forces, gas pressure, magnetic fields, and the rotation of this cloud of microparticles led to the contraction and flattening of the nebula, forming a protoplanetary disk in the center of which a warm and dense protostar formed, initiating the fusion of hydrogen.

Most of the original cloud clustered in the center of this area, forming the current Sun. After about 50 million years, the temperature and pressure increased so much that hydrogen fusion started, creating a new source of energy that resisted gravitational contraction until a hydrostatic equilibrium was achieved; This marked the beginning of the transition of nuclear fusion from hydrogen to helium (it is still at this stage of evolution).

It appears that the initial nebula, being disk-shaped and composed of gas and dust, led to the formation of protoplanetary disks arranged around the central protostar, which in turn gave rise to the planets, their moons, asteroids, and other small bodies in the current solar system. There has been a continuous succession of collisions between various concentrations of matter, followed by cataclysmic collisions, which have not ceased to this day, playing a major role in the evolution of our Solar System.

Furthermore, the positions of the different planets have changed; this phenomenon continues to be the primary driver of the evolution of our solar system.

Modern astronomical analyses have established that our solar system consists of two subsystems: an inner solar system, referred to as the rocky system, and an outer solar system, referred to as the gas system.

The inner solar system is composed of materials with higher condensation temperatures than those required for methane and water to transform into liquids. These materials consist of chemical compounds characterized by a high level of solubility: iron, nickel, aluminum, and various silicates, elements that constitute the current planets Mercury, Venus, Earth, and Mars. They are small and grow very slowly by attracting smaller solid bodies circulating in space, which reach these planets through gravitational attraction. As they grow, the size of these planets also increases, and they slowly approach the Sun due to gravitational attraction.

The gas solar system is beyond the zone where the material is cold enough for volatile matter to remain solid. Here lie the gas giant planets, which are richer in hydrogen and helium. Currently, the four planets in this category, Jupiter, Saturn, Uranus, and Neptune, concentrate 99% of the mass of matter orbiting the Sun. They have low pressure, which accelerates particles on their orbits, reduces their movements toward the Sun, and possesses numerous satellites. It is now considered that the appearance of the solar system differs greatly from its initial state. In the early period, there were between 50 and 100 solid bodies the size of Mercury orbiting around the planets. They collided frequently, shattered, and then fused with the planets of the inner solar system. The current Moon of Earth emerged from such a giant collision. (https://www.astronoo.com/en/articles/characteristics_of_planets).

Between the terrestrial and gas giant planets lies the asteroid belt. Initially, there was enough material here to form two or three Earth-sized planets. However, because the planet Jupiter is nearby, the movement of the solid bodies formed accelerated, causing them to collide forcefully with each other. As a result, they formed an asteroid belt instead of creating a larger planet. Some of these asteroids migrated towards the inner solar system, leading to meteor showers, while others moved towards the icy outer solar system, especially towards Jupiter.

During this period, Earth received an abundant amount of water (approximately 6×10^{21} kilograms). It is possible that this water was brought from the cold regions of the solar system, most likely from Jupiter's moon system.

The cold giants Uranus and Neptune were initially formed near Jupiter and Saturn but later migrated towards the outer solar system over several hundred million years.

Because these planets are very large and their gravitational attraction is very strong, the orbits of the outer planets began to elongate/ become more elliptical. In contrast, the terrestrial planets in the interior maintained nearly circular orbits. During this time, meteor showers intensified for 4 billion years (whose craters on our Moon and Mercury are still visible today). Astronomers believe that life appeared on Earth about 3.8 billion years ago, shortly after the reduction of the great asteroid bombardment.

The evolution of the outer solar system seems to have been continually influenced by supernovae in the vicinity of our solar system. They underwent spatial alterations due to the solar wind, as well as interstellar clouds through which our solar system's orbit passes in its circulation through the Milky Way Galaxy.

Regarding the asteroid belt zone, after the meteorite bombardment on the inner planets, collisions between the asteroids composing it continued and still occur today.

All planets in our solar system have one or more satellites (moons). They can originate from various collisions with other celestial bodies (the Moon is the result of a collision of another planet - Theia - with Earth, Charon with Pluto), from capturing large asteroids (Deimos and Phobos by Mars, or Triton by Neptune), or they may have formed similarly to the parent planet around which they orbit today (the moons of Jupiter and Saturn).

It is possible that some of the moons of distant planets are even gravitationally captured objects from outside our solar system (the moons of the last two planets are small, with eccentric orbits and random inclinations) (https://en.wikipedia.org/wiki/Formation_and_evolution_of_the_Solar_System; https://www.google.com/search?client=firefox-b-d&q=solar+system+wikipedia).

1.4 The Sun and the Planets of the Solar System

The Sun

The Sun is a small yellow star of spectral class I (Figure 3). It formed from matter expelled by the explosions of supernovae. It consists mainly of hydrogen and helium, but it possesses a very small ammount of other metals derived from older stars of the Milky Way. This metallicity is crucial because it facilitated the formation of the inner planets of our solar system. (Sackmann et al., 1993; Whitehouse, 2005).

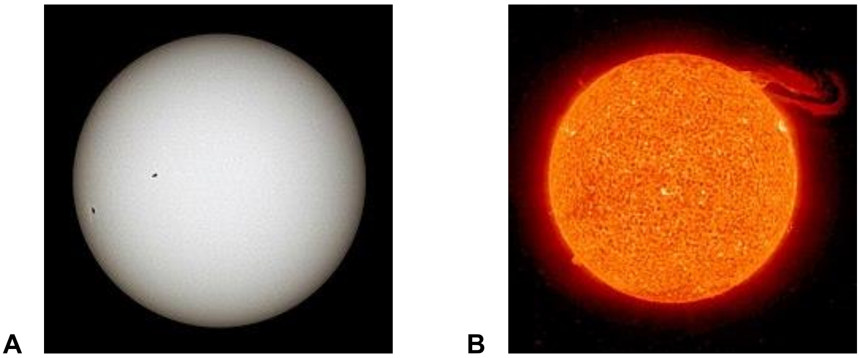

Figure 3. **A**. The Sun in true white color (https://en.wikipedia.org/wiki/Solar_System); **B**. The Sun photographed during an important solar eruption, represented in false colors https://fr.wikipedia.org/wiki/Syst%C3%A8me_solaire)

The Sun has a high density which allows continuous nuclear reactions to take place, with an energy output of 4 x 10^{26} watts, distributed into space in the form of electromagnetic radiation. At its surface, the Sun has a temperature of 5.570^0 K, reaching several million kelvins at its core. The Sun emits light and a continuous stream of plasma particles, including protons, electrons, and alpha particles, forming the solar wind. This solar wind moves at a speed of 1.5 million kilometers per hour. The solar wind creates the heliosphere /interplanetary medium. Activity on the Sun's surface (solar flares) and emissions of coronal mass ejections result in a continuous variation in the intensity of the solar wind, which is responsible for magnetic storms. The solar wind and solar flares eject immense amounts of matter from the Sun into space. The solar wind is the cause of the formation of comet tails as they move through space.

The heliosphere partially protects the solar system from the flow of high-energy interstellar particles (cosmic radiation). The planets also defend themselves from this radiation by their own planetary magnetic field. Table 1 shows the main characteristics of the planets in our solar system.

Inner planets

All four planets (Figure 4) constituting the so-called terrestrial inner planets have a dense, rocky composition and a solid surface, exhibiting craters caused by impacts with other celestial bodies. Their crusts feature large fissures (rifts) and display volcanic phenomena. They have a solid crust, a semi-liquid mantle, and a liquid core that is still in fusion. Three of them (Venus, Earth, and Mars) also possess, to varying degrees, an atmosphere.

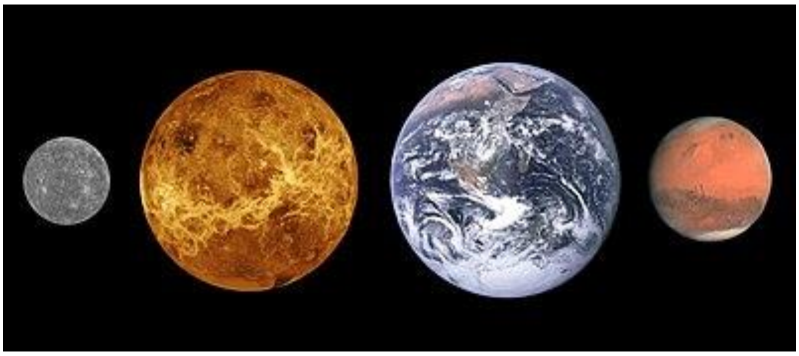

Figure. 4. Comparative photomontage of the size of telluric plants in our solar system. From left to right: Mercury, Venus (radar image), Terra (Earth) and Mars (https://fr.wikipedia.org/wiki/Syst%C3%A8me_solaire)

Mercury

Planet Mercury is the closest planet to the Sun, with a diameter of 4878 kilometers. It has no natural satellites and is entirely covered in impact craters. At its center lies a very large iron core. Its outer mantle is very thin. Mercury has a revolution period of 88 days and a rotation period of 59 days. Mercury has a rotational eccentricity of 0.2 (which is 12 times greater than that of Earth), making this planet rotate most prominently. The planet Mercury is practically devoid of an atmosphere, which allows it to have no protection from the destructive action of meteorites attracted to it. In space near the mercury crust there are rare atoms of oxygen, sodium and potassium, as well as hydrogen and helium atoms from the solar wind.

From a geological standpoint, this planet is inactive. The absence of atmosphere and its proximity to the sun result in a significant temperature variation across its surface: in the sunlit region, temperatures can reach up to +427 degrees Celsius, while in the dark region, temperatures drop sharply to -183 degrees Celsius.

Venus

The second planet, Venus, is very similar to Earth in terms of its size (0.815 times Earth's mass). It has a thick mantle of silicates, a mass surrounding a metallic core. Its atmosphere is 92 times denser than Earth's and is composed of 96% carbon dioxide (which has led to a strong greenhouse effect). Its surface temperature is around +462°C. The planet is covered with a dense/opaque layer of clouds made of sulfuric acid, which reflects visible light. It is suspected that liquid water once existed on its surface, but currently, the terrestrial environment is desert-like, covered with rocks. Venus experiences continuous volcanic activity and has its own geological processes. The planet lacks a magnetic field, and its atmosphere is constantly affected by solar wind. The terrain of Venus is relatively flat, indicating very young geological zones (only a few hundred million years old). Its thick atmosphere protects it from meteorite impacts, and volcanic activity is relatively low.

Venus orbits the Sun in 224.7 Earth days on an almost circular orbit and has a rotation speed around its own axis of 234 Earth days (thus rotating very slowly). Its rotation is retrograde (rotating opposite to the other planets - the sun "rises" in the west and "sets" in the east). It also lacks its own moon, but there is a dense disk-shaped ring of dust in its circumstellar orbit.

Terra (Earth)

Terra is the largest and most massive planet (with a diameter of 12,756 kilometers) and possesses the highest density compared to the other planets in our solar system. It is the only planet known to support life, orbiting around the sun in 365.256 days (known as the sidereal year) and completing a rotation around its own axis in 23 hours, 56 minutes, and 4 seconds (known as the sidereal day). Its rotational axis is tilted at 23 degrees, which determines the existence of seasons (Figure 5).

Figure 5. Planet Earth (Terra) and Moon (their dimensions are on the same size scale) (https://fr.wikipedia.org/wiki/Syst%C3%A8me_solaire)

Earth has a satellite, the Moon, which rotates almost synchronously with the planet and is the largest satellite of any of the terrestrial planets. It formed as a result of a gigantic impact between a proto-Earth and another planet (Theia - which was about the size of planet Mars - approximately 4.54 billion years ago) (Canup, 2001) (Figure 6). This impact led to the formation of ocean tides and stabilized Earth's rotational axis. As a result, even today, Earth is accompanied in its orbit around the sun by a fine cloud of cosmic dust.

Figure 6. Artist's impression of the gigantic impact that led to the formation of the Moon (https://en.wikipedia.org/wiki/Formation_and_evolution_of_the_Solar_System)

The outer shell of the planet (lithosphere) is composed of various tectonic plates that move several millimeters per year. Approximately 41% of its surface is covered by liquid water, forming oceans, seas, lakes, and rivers, while 29% of the Earth's crust surface is dry and represented by continents and islands. In polar regions, these landmasses are temporarily (especially in winter) or permanently covered with solid water (ice).

The internal structure of planet Earth is geologically active. It has a solid inner core and an outer liquid core made of iron, which generates the Earth's magnetic field. Above this core is a mantle composed of silicate rocks, which form the tectonic plates (they are unique to a planet in our solar system).

Planet Earth has an atmosphere that is completely different from that of other planets, as it has been profoundly modified due to the existence of living organisms; currently, it contains 21% oxygen. This has raised the average temperature of the atmosphere by 33 Kelvin, and as a result of the greenhouse effect, its average temperature is 15 ^{0}C, allowing for the existence of liquid water throughout the planet.

Mars

Mars is a planet about half the size of Earth and Venus, with only one-tenth of Earth's mass. It orbits the sun once every 687 days, with a daily rotation of 24 hours and 39 minutes. Its axial tilt, which is five times greater than that of Earth, allows for similar seasonal cycles to those on Earth, but it results in a hyper continental climate. In summer, temperatures rarely exceed +20-25°C at the equator, dropping to -120°C in winter at the poles.

Mars has a thin atmosphere primarily composed of carbon dioxide.

Its surface is desert-like and reddish due to abundant hematite or iron oxide. The planet is marked by numerous craters and impact basins, as well as volcanoes, rifts, canyons, valleys, dune fields, and polar ice caps. Mars hosts the tallest volcano in the solar system (Olympus Mons) and the deepest canyon (Valles Marineris). These geological structures indicate past geological and hydrological activities, although current activity is limited to occasional landslides and rare volcanic eruptions with lava flows. The planet lacks a global magnetic field.

Mars has two small moons – Phobos and Deimos – which may be captured asteroids. They orbit synchronously, always presenting the same face to the planet. Measurements suggest that Phobos will gradually disintegrate, while Deimos will move away from the planet.

The first asteroid belt

Asteroids are small bodies within the solar planetary system composed of irregularly shaped minerals, ranging in size from a few hundred kilometers (much smaller than the dimensions of planets) to microscopic dust.In our solar system, there are two asteroid belts (Figure 7).

The first is located between the orbits of the planets Mars and Jupiter, at 2.2 - 2.3 astronomical units from the Sun, while the second, the Kuiper belt, is located at 30-55 astronomical units from the Sun and is 20 to 200 times more massive, although it has a much lower asteroid density.The first asteroid belt, between Mars and Jupiter, formed from the primordial solar nebula as a group of planetesimals that, under the influence of the planet Jupiter, gained very high energy and collided violently many times, so that about 99.9% of their mass was lost in the first hundred million years of the history of our solar system. Many of them were attracted to the inner solar system (as presented above), becoming meteorites on these planets. It is considered that the meteorite belt is still the main source of meteorites that fall on Earth.The meteorite belt consists of 1-2 million asteroids larger than 1 km in length (only a few of them exceed 100 km in diameter). They are not very close together now, as evidenced by the fact that many space probes sent from Earth have passed through this asteroid belt. Depending on their chemical spectrum, they can be grouped into carbonaceous (type C), silicate (type S), and metallic (type M) asteroids.

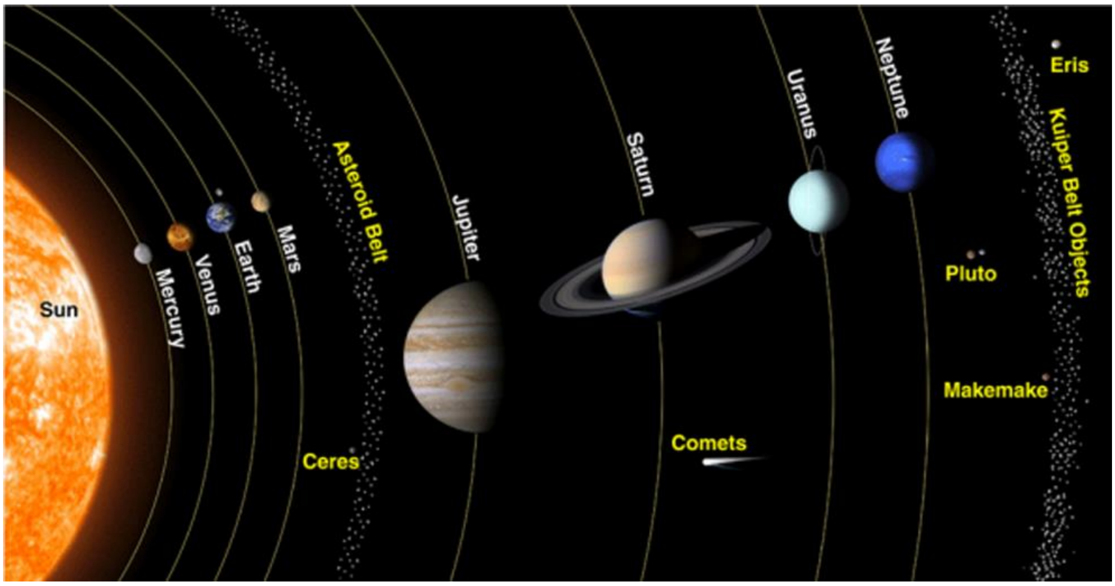

Figure 7. Schematic of the two asteroid belts and the two Trojan asteroids of the planet Jupiter (https://www.google.com/search?client=firefox-b d&sca_esv=583317652&q=the+two+asteroid+belts&tbm=isch&source)

Outer Planets/ Outer Solar System

Beyond the aforementioned asteroid belt is a region where giant gas planets and their natural satellites meet, as well as numerous comets with short rotation periods, including the Centaurs. Beyond them lies the region of trans-Neptunian objects, which extends to the Kuiper Belt. The outer planets are composed of water, ammonia, and methane; they are located below the freezing limit of these gases; therefore, they appear to be solid (Figure 7 and 8).

Here are four large planets - Jupiter, Saturn, Uranus, and Neptune - which account for 99% of the material mass rotating in the solar planetary system. The first two, Jupiter and Saturn together constitute the equivalent of 400 times the mass of Earth, while the other two, Uranus and Neptune, together constitute the equivalent of 20 times the mass of Earth.

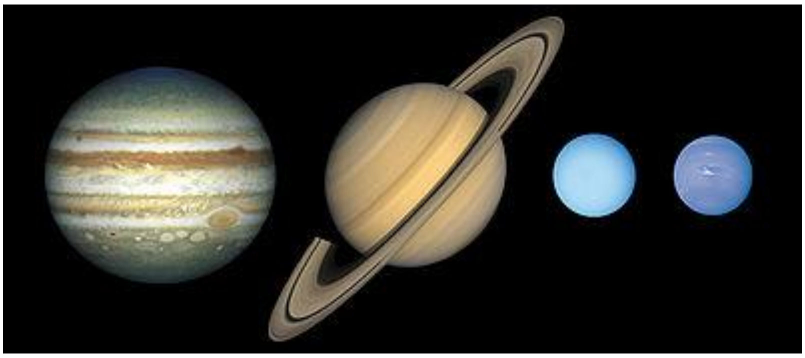

Figure 8. Comparative photomontage of the size of the giant planets in our solar system (from left to right): Jupiter, Saturn, Uranus, and Neptune. (https://fr.wikipedia.org/wiki/Syst%C3%A8me_solaire)

The four giant planets possess a ring system around which their moons/natural satellites orbit. Compared to the moons of the terrestrial planets, they are much more numerous. For example, Neptune has 14 natural satellites, while Saturn has 82 satellites. Although these giant planets do not have a solid surface, they still possess iron or silicate cores whose volume is several times that of Earth's mass.

Jupiter

Jupiter is about 317 times the mass of Earth, with a diameter of 143,000 kilometers. Its orbital period is approximately 12 years, while its rotational period is just under 10 hours. It is primarily composed of hydrogen and helium, with traces of ammonia and water vapor, but it has an undefined rocky solid core in its interior. The heat within Jupiter generates violent winds (reaching speeds of 600 km/h) that traverse the upper layers of its atmosphere, creating bands across different latitudes ; these bands are separated by even more turbulent zones. This phenomenon creates several semi-permanent features, such as the Great Red Spot. Jupiter has a strong magnetosphere, driven by an electric current in an interior layer of metallic hydrogen, which creates one of the most powerful magnetic fields known in our solar system (exceeded only by the energy from solar flares and the polar auroras of this planet). Although the temperature at Jupiter's cloud level is -153°C, it gradually increases towards the planet's center.

Jupiter has 83 natural satellites/moons arranged in the Jovian ring. The four largest ones are Ganymede, Callisto, Io, and Europa, which have geological similarities to terrestrial planets. This planet profoundly influences both the system of terrestrial planets and the asteroid belt.

Saturn

Saturn has a composition of the atmosphere and a magnetosphere similar to Jupiter but smaller in scale. Its volume, entirely gaseous, is 60% smaller than that of Jupiter, and its diameter at the equator is 121,000 km. Its orbital period is 30 years, while its rotational period is 10 hours and 33 minutes. Saturn has a thinner, calmer atmosphere capable of forming polar auroras. Air currents can reach speeds of 1800 km/h. Saturn has a prominent ring system, easily visible even with simpler optical instruments. It is composed of ice particles and cosmic dust. These rings formed approximately 100 million years ago and contain the largest number of natural satellites. The largest moons are Titan (which has its own atmosphere) and Enceladus (where geysers, cryovolcanism, and possibly microbial life have been observed). Saturn has a rocky core made of silicates and iron, overlaid with hydrogen (which transitions from solid to liquid to gaseous from the center to the periphery) mixed with helium.

Uranus

Uranus is the smallest ice giant planet and is equivalent to 14 times the mass of Earth. It has an equatorial diameter of 51,000 km, an orbital period of 84 years, and a rotational period of 17 hours. Because the planet's axis of rotation is in the plane of its orbit, it appears to roll through space. The north and south poles of the planet are located in the equatorial plane. Therefore, its magnetosphere gives the impression of twisting like a drill bit as the planet moves along its elliptical orbit around the Sun.

Like the other outer planets, its atmosphere is composed of hydrogen, helium, and contains traces of hydrocarbons. This atmosphere is the coldest of all the planets in the solar system (reaching -224°C) and presents a layered cloudy structure.

The planet's surface is composed of volatile water, ammonia, and methane, while its crust is also made up of these gases but in solid form, mixed with other solid materials. Uranus is almost devoid of relief features, and winds on its surface reach speeds of 900 km/h.

Uranus has a system of 13 narrow rings, with 27 natural satellites. The most important ones are Titania, Oberon, Umbriel, Ariel, and Miranda.

Neptune

Neptune is slightly larger than Uranus (equivalent to 17 times the mass of Earth) and has an equatorial diameter of 49,500 km. It is the outermost planet in the solar system with the highest density mass. It has an orbital period of approximately 165 years and a rotational period of just over 16 hours.

Neptune has an atmosphere similar to that of Uranus (composed of hydrogen, helium, and traces of hydrocarbons, with water, ammonia, and methane in ice form). The weather conditions on the planet are active and observable. Similar to Jupiter's Great Red Spot, Neptune has the Great Dark Spot. Winds on this planet reach speeds of 2100 km/h, and the surface temperature is around -218°C.

Neptune has a weak and fragmented ring system, with 14 natural satellites discovered and several small moons and Trojan asteroids originating from the Kuiper Belt. The largest satellite is Triton, where liquid nitrogen geysers have been observed. It is the only moon in this group of planets with a retrograde orbit.

In Table 1, we summarize the main data regarding the large planets in our solar system.

Table 1. The main data regarding the large planets in our Solar System (http://google.com/Tableau+comparatif+simplificate+des+planetes, modified)

	Mercury	**Venus**	**Earth**	**Mars**	**Jupiter**	**Saturn**	**Uranus**	**Neptune**	**Earth's Moon**
Main distance from Sun (million Km)	58.7	108.2	149.6	227.9	778.4	1426.7	2871.0	4498.3	149.6 (0.396 from Earth)
Period of Revolution (d-days, y-years)	88 d	224.7 d	365.21 d	687 d	11.9 y	29.5 y	84.0 y	164.8 y	27.3 d
Period of Rotations at Ecuator (d-days, m-minutes, s-seconds)	58.6d	243d	23h 56m 4s	24h 37m 23s	9h 50 m 30s	10h 14m	10h 49m	16.4h	23.7d
Inclination of the axis	0^0	178^0	23.5^0	24^0	3^0	27^0	98^0	~ 30^0	
Escape velocity (Km/s)	4.3	10.4	11.2	5.1	61	36.7	22.4	25.5	
Natural satelits	no	no	1	2 (Phobos, Deimos)	67 (principals Io,Ganimedia, Io, Europa)	62 (principal - Titan)	27	14	
Mass (Earth=1)	0.06	0.82	1.00	0.11	317.83	95.16	14.54	17.15	
Equatorial Diameter (Km)	4,879	12,104	12,756	6,794	142,984	120,536	51,118	49,528	
Density (g/cm)	5.4	5.2	5.5	3.9	1.3	0.7	1.3	1.8	
Temperature (Average, ± ^{0}C)	169 +463 -172	462 +482	15 +56.7 -89,2	-63 +37 -113	-163	-189	-214	-225	
Albedo (reflexion coefficient)	0.055	0.61	0.34	0.15	0.52	0.42	0.45	0.54	
Moons	0	0	1	2	95	83	27	14	
Atmosphere (in %)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
CO_2	-	96	-	95	-	-	-	-	
Nitrogen	-	4	78	27	-	-	-	-	
Oxygen	42	-	21	-	-	-	-	-	
Hydrogen	22	-	-	-	89.8	96.3	82.5	80.0	
Helium	6	-	-	-	10.2	3.2	15.2	19.0	
Sodium	22	-	-	-	-	-	-	-	
Other	8 Almost non-existent	- H_2SO_4 +CO_2	1 + water	2.3 Violent wind	methan,water, etan,amoniac, violent wind	0.5 methan, amoniac	2.3 metan	1.0 methan violent wind	
Relief	Mountains, canyons, volcanoes, with ice at the poles	Greenhouse effect	Very varied Mountains, canyons, volcanoes, seas and oceans, with ice at the poles	Mountains, valleys, craters					Mountains, valleys, craters
Surface composition of the planets	rocks of regolith, silicate, sulphur	rocks of regolith, silicate,	70.8% water, rocky of organic carbon, silicon compounds, sulphur	Rocks, water ice, silicate, regolith, iron-acide	Ice of hydrogene and water	Ice of hydrogene, helium and water	Ice of hydrogene, helium and water	Ice of hydrogene, helium and water	Rock of regolith, silicon compounds, sulphates
Planetary core	Iron dominant core, With craters	Iron-nikel dominant core Since water	Rich in mineral salts: iron, nickel, sulphur, carbon, potassium, vanadium, chromium, tantalum	Iron dominant core, sulphur, potassium, liquid core	no lithosphere Rock and ice core of metalic hydrogene	No lithosphere Metalic core of hydogen and helium	no lithosphere no water Metalic core of hydogen and helium	no lithosphere no water Core of hydogen and helium as ice	With many craters

Other planets that are part of the solar system

Following astronomical research conducted at ground-based observatories as well as those located on artificial satellites, and aided by artificial satellites sent into space by the U.S.A. and the former U.S.S.R. for comprehensive studies, formations larger than asteroids have been identified, which have been named pseudo-planets (Figure 7). Among these, we mention Pluto, Makemake, Haumea, Quaoar, and Orcus, each of which has its own moon (https://www.google.com/search?client=firefox-b-d&q=solar+system+wikipedia)

They are also referred to as trans-Neptunian planets and do not affect our planet in any way.

The Centaurs

Centaurs are small icy bodies, similar to comets and asteroids, orbiting between Jupiter and Neptune, with orbits that oscillate between the aforementioned planets. Some of them have a comet-like tail and can barely fit into either of the two categories of celestial bodies. Their orbits are chaotic and unstable. They are captured by the outer icy planets of our solar system, originating from the Kuiper Belt, and there may be a very large number of them (possibly over a million).

Comets

Comets are small celestial bodies, usually several kilometers in diameter, typically composed of ice. They move around the sun on highly eccentric orbits, with perihelion within the inner solar system and aphelion beyond the orbit of Pluto. When they approach the sun, under the influence of solar wind, they begin to sublime and ionize, leaving behind a long tail of gas, dust, and water vapor (forming the so-called comet tail). If the comet is bright enough, it can be observed even with the naked eye. Comets can approach Earth at intervals of tens, hundreds, or even thousands of years. The most well-known are Halley's Comet (visible approximately every 200 years – with a frequency of 75-76 years) and Hale-Bopp Comet (every few thousand years). Comets that frequently approach the sun gradually lose their tails and, considering they are made of ice, eventually disappear.

In our solar system, it is estimated that there are several thousand comets (some believe there are over a billion).

1.5 Characterization of planet Earth and the Moon

Earth

Earth (Figure 9 and 10) is the third planet from the Sun in our solar system (Figure 9). It is the fifth-largest planet, orbiting on an almost circular path around the Sun in approximately 365.256 days (this is called the sidereal year) and rotates around its axis in 23 hours 56 minutes 4 seconds (this is called the sidereal day). Its axis of rotation is inclined, which in turn determines the existence of four seasons throughout the sidereal year.

Its shape is that of a spheroid, meaning an almost perfect sphere which, due to its rotation around its axis, has a diameter at the equator only 21 kilometers larger than the one measured between the poles of the planet. Therefore, it is said to have a geoid.1) shape (Figure 10).

The shape of the Earth is approximately an oblate ellipsoid; that is, the shape formed by rotating an ellipse around its minor axis. The terms ellipsoid and spheroid can be used interchangeably and more commonly heard in the form of a flattened spheroid ([source](https://ro.wikipedia.org/wiki/Geoid)). Since the difference between the polar diameter and the equatorial diameter is only 0.3% (thus only 42 km), the appearance of the planet cannot be visually distinguished from a perfect sphere (as seen in Figure 9).

Earth is a terrestrial planet that emits heat from within. This heat originates from a combination of residual energy from planetary accretion (representing 20%) and heat emitted by radioactive elements that are currently decaying (representing 80%). The main heat-producing isotopes are potassium-40, uranium-238, uranium-235, and thorium-232. At the Earth's core, the temperature rises to 6,726.85°C. Since most of the heat comes from the decay of radioactive elements, it is estimated that heat production was much more significant in the beginning.

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1) "Geoid" literally means "Earth-shaped". The geoid is the surface that describes the theoretical sea level at all points on the globe. It is determined by calculating the elevation at which the gravitational acceleration is equal to that at mean sea level.

Terra has a natural satellite, the Moon, which influences the planet around which it orbits through its gravity.

It is crucial to mention that Earth is the only planet where a combination of factors has led to its current situation, such as the optimal distance from the Sun (approximately 150 million kilometers), the existence of a relatively thick atmosphere, and an optimal magnetic field. Its geological evolution and existing physicochemical conditions allowed the emergence of life 3.5 billion years ago ([source](Danger, 2011)).

Figure 9. Terra, the blue planet, as seen from a spacecraft.
(https://en.wikipedia.org/wiki/Earth)

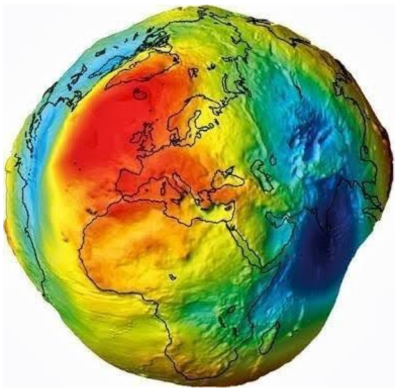

Figure 10. Simulation of the shape of planet Earth Seen as a geoid (with its elevationse exaggerated).
(https://www.google.com/search =Pamantul+ca+un+geoid)

Table 2 presents data on the main characteristics of planet Earth compared to the data of other planets in our planetary/solar system.

Table 2. The main characteristics of planet Earth

Orbital Characteristics	
Parameters	**Values**
Semi-major axis	149 597 887,5 km (1,000 000 112 4 au)
Aphelion	152 097 701 km (1,016 710 333 5 au)
Perihelion	147 098 074 km (0,983 289 891 2 au)
Orbital circumference	939 885 629,3 km (6,282 747 374 au)
Eccentricity	0,016 710 22
Orbital period	365,256 363 z
Average orbital speed	29,783 km/s
Maximum orbital speed	30,287 km/s
Minimim orbital speed	29,291 km/s
Inclination to the ecliptic	0^0
Ascending node	$174,873^0$
Argument of periapsis	$288,064^0$
Number of natural satellites	1
Physical Characteristics	
Planet radius at equator	6 378,137 km
Planet radius at pole	6 356,752km
Average volumetric radius	6 371,008 km
Flattening of the globe	0,003 353 ≈ $^1/_{300}$ ($^1/_{(298,25\pm1)}$)
Equatorial circumference	40 075,017 km
Meridional circumference	40 007,864 km
Surface area	510 067 420 km^2
Volume	1,083 21 × 10^{12} km^3
Mass	5,973 6 × 10^{24} kg
Global volumetric mass	5,515 × 10^3 kg/m^3
Surface gravity of Earth	9,806 65 m/s^2 (1 g)
Escape velocity from Earth's gravity	11,186 km/s

Rotation period (sidereal day)	0,997 269 49 d (23 h 56 min 4,084 s)
Rotation speed (at equator)	1 674,364 km/h
Axis inclination of Earth	23,436 690 775 2°
Axis tilt at the North Pole	90°
Visual geometric albedo	0,367
Solar radiation	1 367,6 W/m^2
Black-body equilibrium temperature	254,3 K (−18,7°C)
Maximum surface temperature	56,7°C
Average surface temperature	15°C
Minimum surface temperature	−93,2°C

The formation and evolution of the planet

The history of planet Earth unfolded over the course of four eons (long periods of time with durations that are difficult to precisely determine): Hadean, Archean, Proterozoic, and Phanerozoic (Fig. 11) (Meunier, 2014; Stanley, 2005).

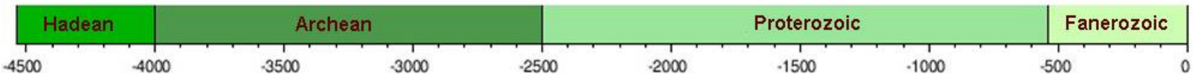

Figure 11. The periods through which the planet has passed since its formation until today (https://en.wikipedia.org/wiki/Formation_and_evolution_of_the_Solar_System)

The Hadean era (Figure 11) - is the period of the planet's formation starting from the dust of material particles and gas that constituted the solar nebula and which was organized in the form of a disc detached from the primordial sun. This planetary nebula was initially made up of materials in fusion, on the surface of which a gradually thin solid crust was formed, above which an atmosphere mainly composed of water vapor and methane gas accumulated.

The water vapor, falling on the crust of the Earth, led to the emergence of abundant rains, which over time, above the crust, formed the first basins of liquid water. They subsequently constituted the planet's oceans.

After approximately 20 million years, our planet collided with a large planetoid called Theia - which was roughly the size of Mars - leading on one hand to the formation of the Moon, while the rest was included in the forming Earth's mass. As a result of the intense volcanic activity that followed, the surface temperature of the planet rose to approximately 10,000°C, causing a greenhouse effect above the Earth's crust. This resulted in the maintenance of a gaseous mixture at the planet's surface (a primitive atmosphere where solar luminosity was lower), whose temperature favored the retention of water at temperatures compatible with those of liquid water (i.e., below 100°C). Under these conditions, on the primitive Earth's crust, alongside the oceans, there remained a dry surface, the future supercontinent Pangaea. To understand how the solid part of the planet was, the Earth's crust looked like what can now be seen as a lava field formed on Earth following a volcanic eruption (Figure 12).

Figure 12. A lava field formed after a volcanic eruption on the seashore (Kertz, 1992)

The Archean era (Figure 11) begins around 4 billion years ago. At its inception, life appeared in the waters of the planetary ocean under the influence of intense chemical activity and a large amount of energy derived from both the planet and from space (the solar energy within our planetary system). Their synergistic action caused organic substance molecules to organize and initiate the process of self-complexity and self-reproduction. Whether life appeared spontaneously or came from space through meteorites or other means, we still do not know precisely. However, life on Earth emerged approximately 3.5-3.8 billion years ago. These assertions are based on the discovery of biomolecules in a 3.7 billion-year-old granite in Greenland and on the basis of fossilized carbon samples dated to 3.5 billion years ago found in Australia. At the same time, the formation of the terrestrial magnetic field begins, stabilizing an atmosphere capable of enduring even under the continuous action of solar wind

The Proterozoic era (Figure 11) begins around 2.5 billion years ago when photosynthesis processes carried out by cyanobacteria appear, releasing oxygen molecules gas first into the waters, and then into the atmosphere, through their physiological activity. Now the first rocks specific to the Proterozoic era appear, the stromatolites.

The appearance of oxygen molecules first changes the composition of the atmosphere, from one primarily composed of methane, to one composed of nitrogen and oxygen molecules, and subsequently, the formation of the ozone layer. The activity of living organisms to perform photosynthesis led to the production of very diverse organic substances, which were essential for the future development and diversification of life on Earth.

The increase in oxygen content in the atmosphere and ozone in the stratosphere, after oxygen saturation first occurred in the seas and oceanic waters, led to the emergence of a protection process for the first colonies of complex single- and multicellular organisms equipped with a nucleus (eukaryotic organisms), and later to embark on the conquest of a new living environment, the terrestrial environment (thus leaving the water to populate the dry environments on the planet).

About 750-580 million years ago, a temperature drop occurred (a glaciation), which led to the coverage of a large part of the planet's surface with a layer of ice. In the new environmental conditions, living beings created new survival capabilities, which, after the thawing process, triggered a true explosion of new life forms in the subsequent geological era (the Cambrian era), during which multicellular living organisms became dominant on the planet.

In this early period of the Cambrian, the supercontinent Pangaea began to break apart into several pieces, so that about 650-450 million years ago, the plates forming Pangaea became the future zones for the formation of continents, which later formed the current terrestrial structure of the continents we know today.

The next eon, **the Phanerozoic era** (Figure 11), begins approximately 541 million years ago and encompasses the period from the beginning of the Cambrian era until the present, including us. It starts with the Cambrian explosion, during which the diversification of multicellular plants and animals occurs. About 176 million years ago, the outlines of the current continents were finalized (thus shaping the terrestrial planetary environment).

During the Phanerozoic, five major extinctions occurred in the world of life, with the last one occurring about 66 million years ago due to the impact of a large meteorite on Earth in present-day Mexico (known as the Chicxulub impact), resulting in the extinction of dinosaur reptiles and the occupation of ecological niches thus left vacant by mammals and birds.

Subsequently, the planet is dominated by the most recent organisms, mammals, and flowering plants, Gymnosperms. About 5-6 million years ago, the first hominids appeared - from which modern humans descend. They gradually populated the entire planet, modified plants and animals (creating domestic organisms), caused major changes in the natural biosphere, and thus created the anthroposphere.

2.6 million years ago, during the Pleistocene epoch, the last glaciations that affected the planet occurred. The duration of each glaciation was about 80,000 years. Currently, we are in an interglacial period, the exact duration of which cannot be accurately determined, as human activity now influences the planet with mechanisms that we cannot yet predict or control.

From the above, we can observe that from the Archean era until now, life has increasingly come to control the history of our planet, determining both the duration and type of eons, as well as the living and non-living processes on the planet. The role of living organisms on planet Earth will be discussed in the following chapters.

Currently, the interior structure of the Earth is as presented in figure 13. It contains a solid core at the center, above which lies a liquid core. Following this is a very hot lower mantle, an upper mantle, also hot but liquid, above which lies the solid lithosphere on the exterior. Surrounding the planet is a gaseous envelope called the atmosphere.

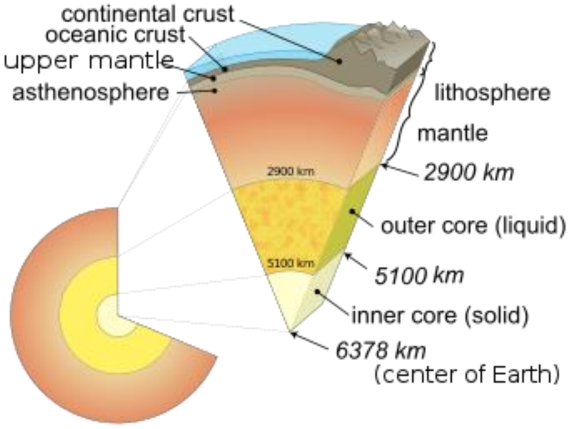

Figure 13. Section in the planet Earth from the surface to the center of the planet (details are not to an exact scale). (https://en.wikipedia.org/wiki/Outline_of_Earth_sciences)

The Moon - Earth's natural satellite

Planet Earth has a single natural satellite, the Moon (Canup, 2001). In size, it is the fifth-largest natural satellite in our solar system. The Moon formed approximately 4.51 billion years ago, shortly after the formation of Earth. Regarding its origin, the most accepted explanation is that the Moon formed from the debris left behind after a massive impact between Earth and a Mars-sized body called Theia. The impact ejected a lot of material from Earth, which then coalesced, compacted under gravity, to form the present-day Moon (Figure 14).

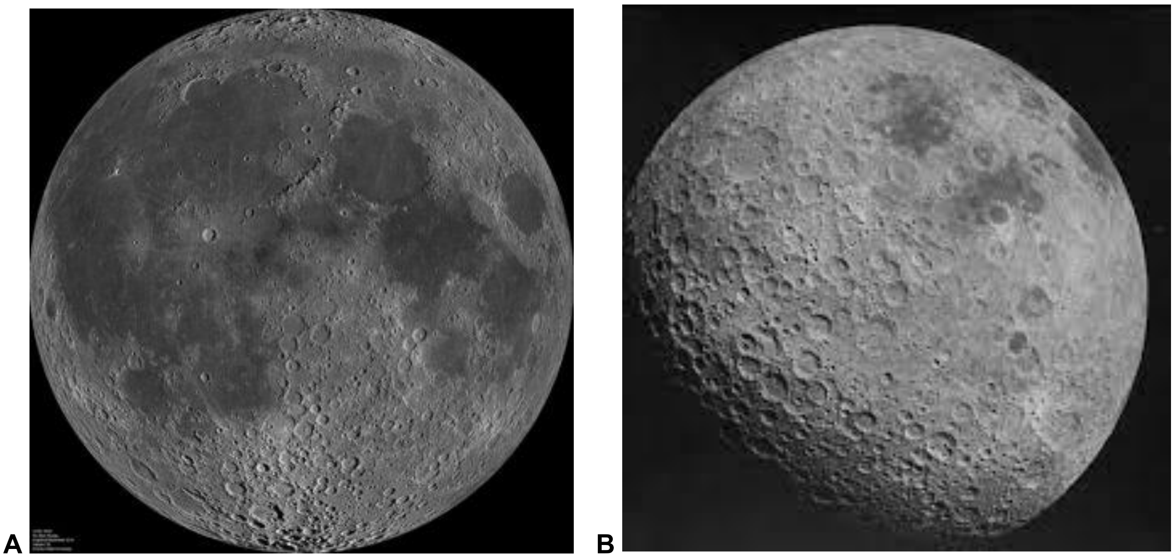

Figure 14. The Moon and the craters existing on it as a result of meteorite impacts. **A.** The side that is permanently oriented towards the Earth. **B**. The side that is never visible from the Earth. (https://www.google.com/search?client=firefox-b-d&sca_esv=583317652&q=luna+-+fata+sa+nevazuta&tbm)

The Moon of Earth is exceptionally large relative to the size of the Earth: it has a quarter of the diameter of this planet and has 1/81 of its mass. The Moon completes a full orbit around the Earth in relation to the fixed stars once every 27.3 days (its sidereal period). Since the Earth also moves along its orbit around the Sun, this movement takes slightly longer until the Moon reaches the same phase in relation to the Earth, about 29.5 days (its synodic period). The Moon is tidally locked with Earth (meaning it always shows the same face to it, as it rotates around its axis in approximately the same amount of time it takes to complete one revolution around the Earth). Therefore, it always has almost the same face turned towards Earth. Its gravitational influence produces ocean tides, land tides, and a slight lengthening of the Earth's day. The Moon's orbit is subtly perturbed by the Sun and Earth with small, complex, and mutually interacting influences.

The Moon has a crust, a mantle, and a core consisting of an iron-rich inner core, followed by a liquid, primarily iron core. The lunar plains on its crust are darker and relatively featureless to the naked eye. They are called seas and are vast basins of solidified basaltic lava. Most of these lavas erupted during the formation of meteorite impact craters that later hit the moon. The volcanic domes existing on the moon are found near depressions in the crust (called seas by astronomers), especially on the visible side from Earth. It is estimated that there are approximately 300,000 craters with a diameter larger than 1 km on the Moon (only on the visible side of the moon). On the upper layer of the lunar crust is a layer of extremely finely crushed rock (broken into smaller particles, which often became powders) and processed by impacts, called regolith.

Liquid water cannot persist on the surface of the moon. The moon has such a rarefied atmosphere that it is almost a vacuum. The moon has a gravitational field, but it undergoes positive gravitational anomalies associated with some of the impact craters. It possesses a magnetic field over a hundred times weaker than that of the Earth.

The Moon has a low albedo. Despite this fact, it is the brightest object in the sky after the Sun because the sunlight reflection on its surface is strong enough during Earth's night to make it the brightest celestial object from the Earth's perspective.

The Moon has a significant influence on Earth by creating tidal forces that affect the planet's oceanic waters. Tidal forces affect both the Earth's crust and its oceans. The most obvious effect of tidal forces is the formation of two bulges on the Earth's oceans, one on the side facing the Moon, and the other on the opposite side of the Moon. This leads to an increase in the Earth's sea level, known as oceanic tides. As the Earth rotates about its own axis, one of these oceanic bulges (the tide) lifts the water "beneath" the Moon, while on the other side of the planet, the opposite occurs. Consequently, there are two high tides and two low tides on Earth within 24 hours. Since the Moon orbits the Earth in the same direction as the Earth's rotation, the tides occur at intervals of 12 hours and 25 minutes. The Sun has the same tidal effect on Earth, but its gravitational forces are only about 40% compared to those of the Moon.

1.6 How does Earth differ from the other planet

When we take a closer look at our planet, Earth, we find both similarities and significant differences compared to the other planets in our solar system (source: https://ro.topinfoweb.com/the-difference-between-earth-and-other-planets-of-solar-system and https://planet-terre.ens-lyon.fr/ressource/comparer-planetes-satellites-systeme-solaire.xml):

1. Earth belongs to the terrestrial planets, and among these, our planet is the largest.

2. Earth has only one natural satellite, the Moon. It has the largest size among the natural satellites of the planets in our solar system. There are also opinions suggesting that it is not a natural cosmic object but an artificial one, populated by intelligent populations from outside our solar system, which observe our evolution, and the interior of the Moon might be hollow.

Its dimensions make the influences it has on Earth significant: its gravitational attraction leads to fluctuations in the planet's diameter (they exist, even though they are of small amplitude), it causes the tides in Earth's oceans, it appears illuminated at night because it reflects the sunlight on Earth, and it undergoes fluctuations determined by the shadow produced by Earth on the Moon, leading to 13 cycles of lunar visibility annually (full moon → invisible moon), known as lunar cycles. It also influences the developmental cycles of many creatures on Earth. However, the Moon is much younger than the planet Earth.

3. Earth is located at a distance from the sun that is most suitable for receiving the energy emitted by the sun in our solar system: it neither results in very high temperatures—like those experienced by Mercury and Venus—nor excessively low temperatures—like those experienced by Mars. As a result, the average temperature on Earth undergoes fluctuations determined by the planet's orbital and rotational movements. The orbital movement determines seasonal fluctuations, while the rotational movement influences circadian ones. Planets closer to the sun have much higher average and extreme temperatures, while Mars has lower ones.

4. Being a terrestrial planet, Earth has a core made of iron, nickel, and silicates. In its chemical composition, there is a wide variety of chemical elements (118 elements), present in varying amounts; new quantities are continually added as a result of nuclear fusion processes occurring within its interior. Compared to other planets, Earth is still chemically active. Nuclear fusion no longer occurs on Mercury and Venus, and on Mars, as far as is known, these processes occur very slowly.

5. Earth receives thermal energy from two sources, from the sun of our stellar system, energy resulting from the nuclear fusion of hydrogen that occurs inside the planet.

The sun emits immense amounts of energy that spill into the space of our solar system; planets closer to the sun receive too much energy, practically scorching them, while those farther away receive less (Mars, the next terrestrial planet, receives less energy). This energy is insufficient to allow the persistence of life on its surface for an undetermined period, considering that life depends on liquid water. On Earth, solar energy provides an amount of energy with an average value of around +15°C (the extreme values measured so far are -89.2°C and +56.7°C), with relatively small fluctuations during the planet's orbital movements on its circumsolar orbit, which is quite close to circular, and which, in turn, causes seasonal fluctuations during the planet's rotation over the course of a year (terrestrial).

The energy produced by the nuclear fusions occurring inside the planet allows magma beneath the Earth's mantle to be liquid and ensures—at the upper levels of the lithosphere—temperatures slightly higher than 15°C.

In this way, the two sources of thermal energy allow for the emergence, diversification, and evolution of the Earth's biosphere.

6. If on other planets the existence of a uniform mantle - solid or liquid (formed of hydrogen or helium - it is only on the outer gas planets of the asteroid belt) - only on planet Earth is the mantle made up of solid plates of different shapes, sizes, and thicknesses. These plates have different shapes, float on the liquid magma beneath them, constantly approach or move away from each other, collide or uplift, creating mountains and oceanic trenches. Because, as a result of the radioactive nuclear fusions occurring in the center of the Earth, the planet's volume slowly but continuously decreases, the mantle plates are in constant motion. Consequently, they either collide (and then islands or mountains form, triggering volcanic eruptions when they release molten lava) or they separate (causing new volcanic processes). In all cases, earthquakes of different amplitudes constantly occur at the edges of these plates (hence the talk of movements of the Earth's crust).

The mantle plates are not equally large and thick. Those forming the older solid surfaces (constituting the so-called terrestrial environment) are thicker, while those that are more submerged and where water accumulates in its liquid form are thinner. In the area where, in the early stages of the planet's formation, a collision with a large terrestrial body occurred (perhaps when the moon was formed from the piece torn off at the time of impact), the plate beneath the Pacific Ocean is the thinnest (being the last one formed). Around it is currently the so-called Pacific Ring of Fire (an area with numerous active volcanoes) where the most frequent and intense earthquakes occur.

7. Planet Earth is the only one that - at the moment - has a lot of water on its surface. Water (H2O) is found on Earth in all three states: solid, liquid, and gas. Solid water is predominantly found in the colder regions of the planet in the form of glaciers, snow, or floating in oceans as icebergs.

The proportion of liquid water is high: the surface of oceans and seas currently occupies almost 70% of the planet's surface. From space, the color of our planet is blue (which is why it is also called the blue planet). On Mercury and Venus, water is absent; on Mars, it is scarce and mainly appears at the planet's poles in the form of ice. On the outer planets, it is present in small quantities (for example, on Jupiter and some of its moons).

8. Planet Earth contains the largest amount of oxygen in its atmosphere (typically accounting for 18%). This element is highly reactive (it is an oxidizer), which means it attacks a large number of elements, creating with them a wide range of oxides that enter the structure of the lithosphere, pedosphere, and biosphere (the latter being itself a producer of free oxygen, which it disperses into the air and water). The production and role of oxygen in biological processes will be discussed later.

9. Comparing the compositions of the atmospheres of Venus and Mars with that of Earth, we see that, unlike Earth's atmosphere composed of nitrogen and oxygen, Venus and Mars have atmospheres mainly composed of carbon dioxide. The pressure near Venus's surface is over 90 times greater, while Mars's pressure is nearly 150 times smaller than that at Earth's surface.

We are accustomed to Earth's clouds, formed from small water droplets or ice crystals. Venus's clouds contain sulfuric acid droplets and, possibly, hydrochloric acid. The cloud layer greatly attenuates sunlight, but as measurements taken by the Venera-11 and Venera-12 spacecraft show, the illumination near Venus's surface is approximately the same as that near Earth's surface on a cloudy day. Research conducted in 1982 by the aforementioned spacecraft showed that Venus's sky and landscape are orange. This is explained by the particular scattering of light in the atmosphere of this planet. There are no clouds on the planet Mars.

10. Earth is the only planet in our solar system where life exists. Earth has unique physical and chemical properties that allow for the development of carbon compounds that have enabled the emergence and evolution of life. This constitutes a well-organized envelope called the biosphere, with a significant role on the planet and also on the current functioning of planet Earth. We will delve more into this in the following chapters. Since life appeared until now, microbes, plants, and animals have transformed the surface, waters, and atmosphere of the planet in various ways.

11. Above the Earth's lithosphere, under the action of the biosphere, a separate envelope, the pedosphere, has been created. This is a complex of inorganic material, derived from the lithosphere, mixed with water and dead organic matter (necromass), which, under the action of a wide range of aerobic and anaerobic organisms, consumers of decomposing organic matter, and predators, have created an organo-mineral protective layer of the lithosphere, specific to planet Earth, a layer that is also the support of life for primary producers of organic matter, photosynthetic plants2).

1.7 The Solar System - Perspectives and Future Dangers

So far, we have reviewed the solar system. However, there is another aspect that is often underestimated, although its existence has long been known: our solar system, although it appears calm and stable, if looked at more closely and from an objective temporal perspective, it is found that a wide range of internal and external impacts persistently affect it, which have existed since its formation and will continue to manifest in the future. It depends on the frequency and intensity of these changes whether notable modifications will occur or not.

Among the internal impacts, we mention the dangers caused by the disorganized movement of meteorites, which can fall onto the current planets at any time, where they can cause impact craters (Figure 15), fissures, or even severe fractures of the planets. The solid planets are only those within the asteroid belt; those outside the belt are very "soft", often liquid, formed of hydrogen, methane, or other elements in gaseous, liquid, or solid state.

All the inner planets are made up of solid rocks, "baked" more or less by the heat radiation coming from the sun. They all bear traces of strong impacts caused by meteorite strikes (Figure 15). These unequivocally demonstrate the great danger of hard formations (rocks, meteorites of various sizes, or other types of solid materials) circulating chaotically in the solar system as a result of gravitational attractions exerted by various planets (or their moons), among which they circulate irregularly, thus being almost impossible to predict when they will occur.

Mercury is a single rock, hard from core to surface, but it does not have an atmosphere, as it was long ago drawn by the sun. Its surface temperature is over +487°C, and on the side opposite the sun, it is -183°C. Such temperature variations make the planet perpetually at risk of breaking apart due to continuous and permanent processes of expansion and contraction, and the pieces might end up in the sun. It is like a ripe, hot fruit, which, in the event of a possible impact from a larger asteroid, could shatter into pieces and suddenly disappear.

Venus has a gaseous atmosphere that hides the true state of its surface due to the greenhouse effect currently in effect, as mentioned earlier, which maintains surface temperatures of over +460°C. There are significant fluctuations between the side exposed to solar radiation and the opposite side.

Additionally, this planet is "baked" by solar radiation and heavily impacted by the impacts of many meteorites that have fallen on it. We will discuss planet Earth in more detail in the next chapter.

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2) In the above data, we did not refer to other characteristic aspects of environmental factors, such as electromagnetic radiation, planetary protective energy belts (Van Allen belts), cosmic radiation, or the action of other cosmic bodies, planets, meteorites, and comets. etc.

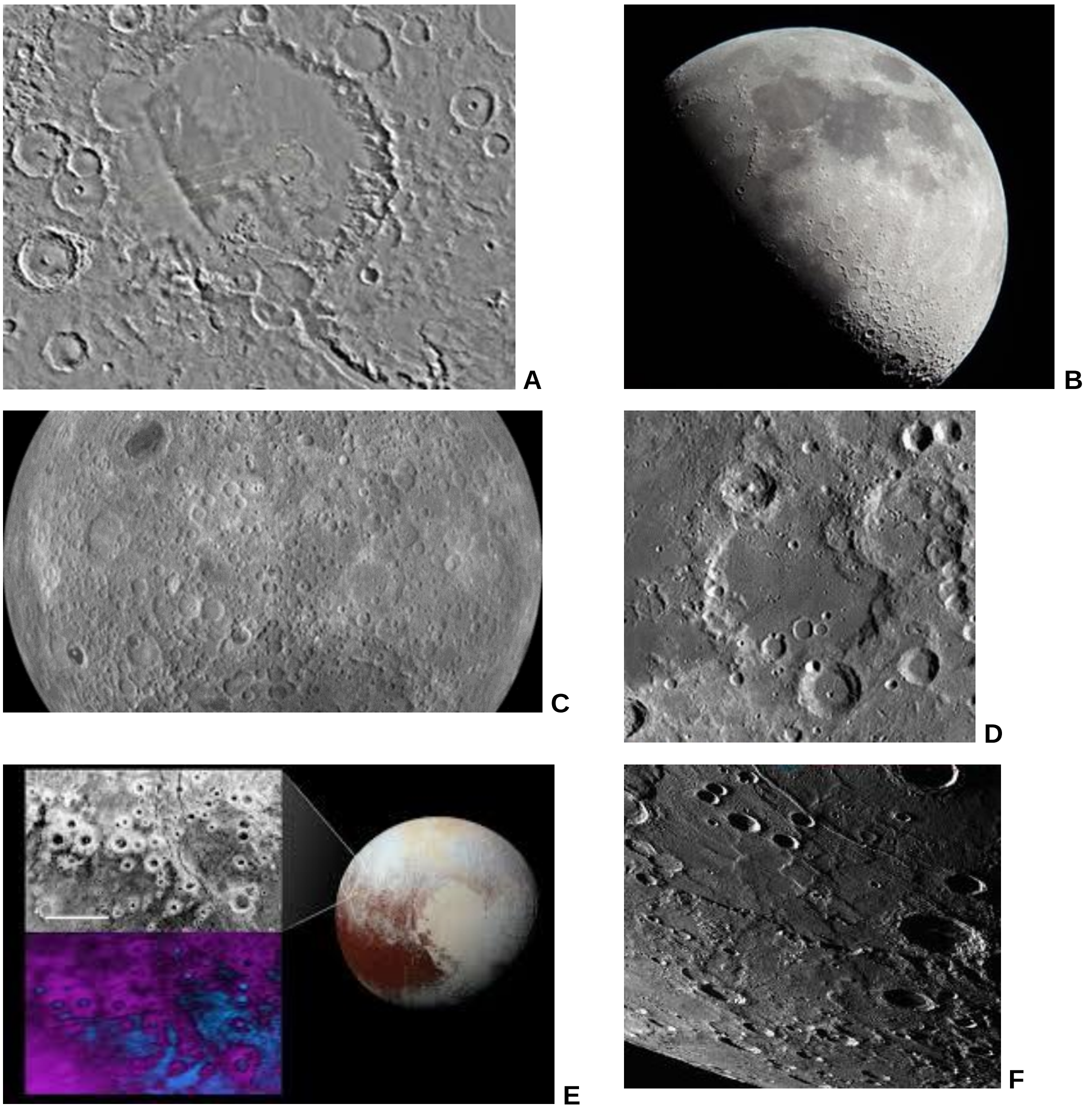

Figure 15. Craters caused by meteorite impacts. A- on Mars, B, C, D- on the Moon (planet Earth), E- on Venus, F- on Mercury (https://www.britannica.com/science/solar-system)

Mars is the most thoroughly studied solid inner planet. Upon close examination, we can see a glimpse of the fate that awaits our planet, Earth, sooner or later. Mars once had water, which now remains on its surface only as traces at the poles. There is still water, but in its solid phase, beneath the layer of cosmic dust or derived from the erosion of the lithosphere. Mars has an atmosphere, albeit greatly reduced, which no longer shields it from the impacts of various meteorites coming from its immediate vicinity (from the asteroid belt). Therefore, it is now a quasi-dead planet that may indicate a future course for our planet.

The asteroid belt. There are still debates, and it is not certain whether it has remained unchanged since the appearance of our solar system's planets, or whether there was once a planet here that, for unknown reasons, broke apart into thousands of pieces, which then continued to shatter through repeated collisions with each other. However, this belt is the main source of meteorites that reach the inner planets (Figure. 7 and 16). Traversing this belt with satellites created on Earth will pose significant challenges to humanity in the future. Moreover, circumventing this belt is still a dream of humanity, as we do not have reliable bypass systems at sufficient distances to pass through to the icy outer planets without colliding with solid bodies from the asteroid belt.

Figure 16. Images of asteroids photographed in our solar system.
(https://www.britannica.com/science/solar-system)

Another perspective can be provided by the movement of planets in the outer planetary system, which, having numerous satellites, can attract them, causing them to fall onto the planet's surface and crash, being permanently drawn, and thus disappearing. The speed of the gases in the atmospheres of these planets is very high ; they experience the largest and most powerful storms, with speeds exceeding 300 km/second, so any impact from outside on the surface of these planets will have catastrophic effects. Their gravity is significant: they are large, with immense gravitational force, so they will continuously attract smaller solid bodies, which, practically, they will engulf.

The greatest dangers for them come from comets or asteroids coming from outside the solar system (which are drawn by the sun from the interstellar abyss), so from the possible future impacts that our solar system could receive if it crosses paths (or intersects) with other solar systems. These planets are the ones that have suffered and will suffer the most from the lack of solar radiation energy, hence the perpetual cold. Although they are large planets, it is possible that they will still maintain their internal radioactive activity for a long time.

Unfortunately, the distance to them prevents us from having more information about these planets at the moment. However, all the known physical phenomena occurring on them are of much greater magnitude compared to what happens on the inner planets.

Regarding external impacts, there is very little information. They refer to comets that periodically reach our solar system, about the large impacts observed by the striking of some of the outer planets by large solid bodies (which can be the size of medium or small planets) gravitationally attracted from the intergalactic space by our solar system upon the bodies that circulate chaotically through the cosmos.

The most serious impacts will come with the process of revolution of our solar system within its movement at the galactic level when we intersect with other solar systems or with another galaxy, as some astronomers predict. But since such situations are difficult to conceive but will surely occur over millions of years, we have too little knowledge, and there is no public concern about them.

2 THE NON-LIVING COVERINGS OF PLANET EARTH

2.1 Geosphere versus Toposphere

I had difficulties in deciding whether we can use the term Geosphere or Toposphere for the non-living spheres of the planet Earth. Even in the specialized geographic literature, opinions are divided: some use either one term or the other. For this reason, we will present different definitions and characterizations of the two terms, and at the end, we will decide.

In Romania, Geosphere represents a collective name for the lithosphere, hydrosphere and atmosphere, because they constantly exchange matter and energy. In modern texts and in the earth sciences, the term geosphere refers to the solid parts of the planet; it is used along with the atmosphere, hydrosphere, and biosphere to describe Earth systems, although the interaction of these systems and the magnetosphere is sometimes used. In this context, sometimes the term lithosphere is used instead of geosphere. The lithosphere, however, refers only to the solid upper layers of the Earth (oceanic and continental crustal rocks and the upper mantle).

In England the geosphere is a structural part which, together with the biosphere, forms what we now call the Earth. The name refers to the four constituent layers of the Earth's globe, namely the lithosphere, hydrosphere, cryosphere, atmosphere and biosphere. All the components of the geosphere can exchange various exchanges of matter and/or energy with each other. Exchanges between these spheres affect the overall balance of the planet. One example is how the soil acts as part of the biosphere. In this context, the term lithosphere is sometimes used instead of geosphere or solid earth. However, the lithosphere refers only to the upper layers of the solid earth (oceanic and continental rocks, crusts and the upper part of the Earth's mantle).

In France, the term geosphere is synonymous with "planet Earth" or "terrestrial globe", although it has several definitions that are partly contradictory. For example, "geosphere can mean in earth sciences lithosphere, hydrosphere, cryosphere and atmosphere". But another meaning is "the geosphere is only the solid part of the planet, which differs from the atmosphere, hydrosphere or biosphere". The term geosphere is given to all parts of the planet from the surface to the interior. In this case the atmosphere, which is outside the planet, is not part of the geosphere. The geosphere is subdivided into the following layers: crust, mantle and core.

For the Toposphere we found the following definition in Romania, which seems to us to be the clearest: *"The Toposphere comprises the entire hydrosphere, the upper layer of the lithosphere and the lower layer of the atmosphere"* (Florea *et al.,* 2014).

Taking into account that we are clearly presenting the living and non-living layers on the surface of the planet Earth, that we intend to highlight the characteristics of the ecosphere of this planet, we believe that we can better distinguish its components using the term Toposphere.

2.2 Lithosphere

The lithosphere is the solid part on the outside of a planet. Most geologists understand the lithosphere to be not only the Earth's crust, but also the upper part of the mantle (the upper mantle, or lower lithosphere) (Ţicleanu *et al.,* 2008; Planet Earth, 2003). Its position and role is as an interface between the inner parts of the planet (core and mantle) and the outer parts (atmosphere and hydrosphere). Because of this its appearance and characteristics are constantly changing (Smith, 1981).

2.2.1 The lithosphere in geological and geographical terms

The planet's surface is made up of large *tectonic plates,* which are constantly eroded by water from precipitation, surface water dissolving a wide range of solid chemicals, and wind erosion of rocks, from the action of glaciers on the surface layer of the lithosphere, from the permanent erosion processes of marine waters along their coastline with the continents and from the permanent destruction of the calcium carbonate corals continuously make (hence the erosion of coral reefs). In the past, the above factors were also contributed to by the impact of various meteorites that came from the cosmos and fell to earth under the influence of the planet's gravitational pull (today this meteorite 'rain' has been significantly reduced). All these factors are permanently changing the planetary landscape (Turcotte, 2002; Chernicoff *et al.,* 1990). Figure 17 shows the current (unfolded) topography of our planet.

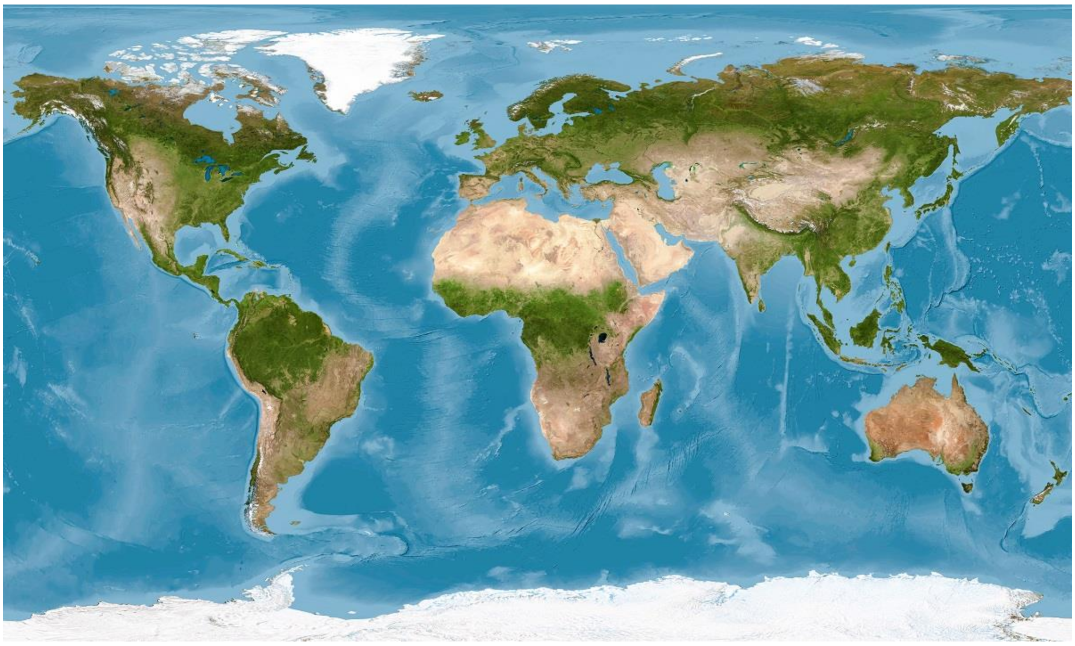

Figure 17. Altimetric and bathymetric aspect of the lithosphere (https://www.google.com/search?client=firefox-b d&sca_esv=583396942&q=harta+lithosphere&tbm=isch&source=univ&fir)

The lithosphere floats on the lower layer of the Earth called the asthenosphere. It lies beneath the lithosphere and is viscous. Because of convection movements within the asthenosphere, the lithosphere is fragmented into several solid parts that move independently of each other (these are called tectonic movements). Tectonic plates are rigid and move relative to each other. When they meet, a convergence process occurs, when they separate a divergence process occurs, and when they rub against each other a transcurrence process occurs. Earthquakes, volcanic activity, mountain building and the creation of ridges or ocean trenches occur most frequently at the edge of these plates or in their fissures, and depend mainly on convective movements in the Earth's mantle (Figure 18) (Țicleanu *et al.,* 2008; Chernicoff *et al.,* 1990; Renard *et al.,* 2015).

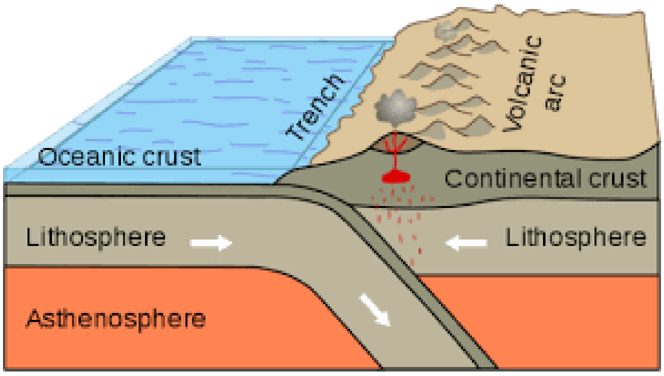

Figure 18. Lithospheric structure at the confluence of two tectonic plates (one oceanic, one continental) (https://www.meteorologiaenred.com/ro/litosfera.htm)

There are currently seven major plates on Earth (Figure 19): Pacific, North American, Eurasian, African, Antarctic, Australian and South American. There are also smaller ones (Figure 20). Oceanic plates move at different speeds. For example, the Pacific plate moves at 52-69 mm/year, and the Eurasian plate at 21 mm/year. As they move, some may burrow underneath their neighbours, while in areas where they touch and press against each other, they rise to form today's young mountains, or create ridges in the middle of the oceans.

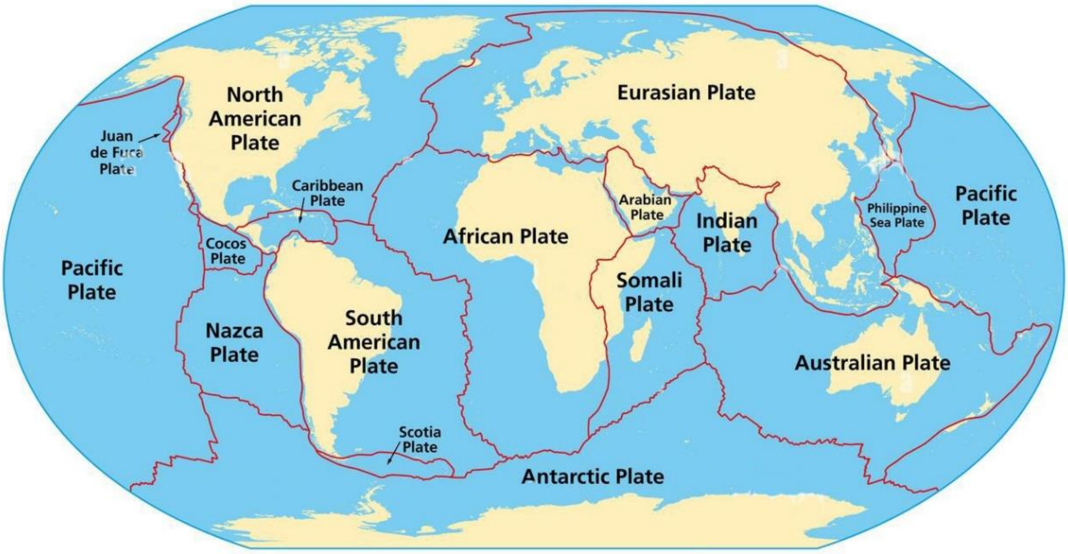

Figure 19. Main plates of the Earth's lithosphere (https://www.alamy.it/principali-placche-tettoniche-della-terra-mappa-grigia-i-sedici-pezzi-principali-di-crosta-e-mantello-piu-alto-della-terra-chiamati-litosfera, modified)

Between the crust and the upper mantle is a discontinuity called the Mohorovich (or Moho) discontinuity. It lies at the lower crustal boundary, with the distance from it to the Earth's surface varying between 5 and 75 km. At this level there is a sudden increase in the speed of seismic waves, because the density of the rocks in this area increases sharply and there is a change in their composition. In the mantle of the lithosphere there are ultramorphic rocks, in the oceanic crust there are basaltic rocks, in the lower continental crust there are granulolitic rocks and in the continental crust there are granitoid rocks. Below this boundary are the dense, silica-depleted, magnesium-enriched ultra-morphic rocks of the upper mantle (peridotite, dunite, etc.). Moho discontinuity determines the thickness of the Earth's crust itself.

The upper part of the mantle is made of solid, consistent materials. The mantle differs substantially from the crust in chemical composition, mechanical properties, rock types and seismic characteristics. The crust is mainly a product of melting rocks in the mantle. Because of melting, some incompatible chemical elements separate, with less dense material rising to the surface. The Earth's crust is composed of a multitude of minerals. Metals and metalloids make up most of the Earth's crust: 24% of the crust is made up of just 6 metals: iron, aluminium, sodium, calcium, potassium and magnesium. Most of the crust is made up of silicates and oxides (about 74%); the remaining 2% is made up of 84 other chemical elements. All factors contributing to landform formation can be divided into two groups : internal (endogenous) and external (exogenous) (Terra, 2006).

Endogenous factors draw their energy from deep within the earth, namely from rotational decay, radioactive decay and the energy of geochemical accumulators. Planetary rotational energy occurs when the Earth's rotation about its axis slows down due to the influence of friction (fractions of seconds per millennium). The energy of geochemical accumulators is given by the sun's energy stored over many millennia in rocks. It is released when the rocks sink beneath the inner layers.

Exogenous factors lie outside the earth. Their energy comes directly from the sun. For the action of exogenous forces to be manifested, irregularities on the earth's surface must be involved, by creating a potential difference and the possibility of gravity intervening. The second important exogenous force is that of the Earth's moon.

The energy of the sun's rays and gravity (hence exogenous forces), on the one hand, destroy the shapes created by endogenous forces, and on the other, create new shapes. In the process, it takes place:

- destruction of rocks (weathering does not create landforms, it just prepares the material);
- removal of the destroyed material. This process consists of turning it down the slope (denudation)
- redeposition (accumulation) of the demolished material.

The temperature of the crust varies. The lithosphere is in permanent contact with the atmosphere, it takes up part of the atmosphere's temperature and gradually rises towards the centre of the Earth to about +900^{0}C (at the contact with the upper mantle).

Internal forces create the structure (base) of the relief, while external forces act as a sculptor, creating bumps. Endogenous forces are therefore sometimes called primary and external forces secondary. This does not mean that external forces are weaker than internal ones. Throughout geological history, the results of the manifestation of these forces are comparable.

The relief of the planet is very different. 70.8% of the world's surface is covered by water. The planet's oceans, at their contact with the continents, possess a continental shelf, after which the submerged part of the lithosphere suddenly deepens, forming on the ocean floor a quite varied relief: there are several ocean ridges that circle the planet, submarine volcanoes, ocean trenches, submarine canyons, plateaus and abyssal plains. The remaining 29.2% of the upper part of the lithosphere lies above the oceanic waters; it is represented by mountains, hills, plateaus, plains, deserts and various other geomorphological forms. (Terra, 2006; Cesare, 1992).

The altitude of the Earth's surface (above the current level of the oceans) ranges from -418 m (at the level of the Dead Sea) to 8849 m (at the summit of Mount Everest). In the terrestrial environment, mountains, plains and highlands differ in height in terms of the nature of rock formation, time and methods of formation.

In the oceans the following structural elements can be distinguished:

- mid-ocean ridges
- mobile belts with axial breaks called grabens;
- ocean shelves - calm areas of abyssal basins, here and there with some protrusions (future islands).

On the continents, the main structural elements are:

- mountainous (orogenic) structures; these, similar to oceanic ridges, may show tectonic activity. Mountain structures are separated and bordered by low areas - troughs and intermountain depressions, which are filled with products of ridge destruction. Not all mountain structures have been involved in repeated mountain building. Most, after levelling, slowly sank, were inundated by the sea, and marine sediments spread over mountain range sites.
- platforms; these are vast tectonically quiet territories covered with thick layers of sedimentary rocks. Older orogenic platforms are denuded, unaffected by later (younger) movements of orogeny. In contrast to the quiet shelf regions, there are also tectonically active geosynclinal regions.

Depending on the constituent rocks, the lithosphere is made up of minerals and rocks that can be grouped into the basaltic layer (which rests on the mantle), the granitic layer (which is in the middle) and the sedimentary layer (which lies above, at the interface with the hydrosphere and atmosphere). It is thin (5-10 km below the oceans - hence the name oceanic crust) and thicker (20-80 km below the continents - hence the name continental crust). Unlike continental crust, oceanic crust lacks the granitic layer. Most of the Earth's crust is covered by the hydrosphere, and the least is under the influence of the atmosphere (Skinner *et al.,*1987, Planeta Terra, 2006, Pomerol *et al.,* 2000).

The Earth's crust is composed in the continental zone of three layers (Chernicoff *et al.,* 1990):

- *the sedimentary layer*, up to 15 km thick in the region of young mountains, but thinner beneath the oceans,
- *the granitic layer,* consisting of granites, granodiorites, gneisses, is up to 15 km thick under continents and up to 60 km thick in the young mountain region, and is discontinuous or even absent under the oceans, and
- *the basaltic layert*, which is around 17 km thick under land and up to 5 km thick under the oceans.

The Earth's crust beneath the oceans is also composed of three layers, but:

- *the upper layer* is thinner and does not have a layer of metamorphic granite. At the surface it is made up of a thin layer of unconsolidated sediments;

- *second layer*, a layer of basalt, but at its top the basalt pillows alternate with thin layers of sedimentary rocks. Above it is a thin layer of unconsolidated sediments. Below the second layer is a layer of basalt, overlain by alternating thin layers of basalt lava pillows and thin layers of sedimentary rocks. At the bottom is a complex of parallel basaltic dikes;
- The *third layer* consists of magmatic crystalline rocks of predominantly basaltic composition. The oceanic crust is 6-10 km thick.

Most of the Earth's crust is composed of magmatic and metamorphic rocks, with few outcrops at the crustal surface. Of the magmatic rocks, the most common are intrusive rocks - granites and effusive rocks - basalt, and metamorphic rocks - gneisses, schists and quartzites. Various sediments accumulate on the earth's surface due to various external factors and then, over several million years, as a result of diagenesis (compaction and physico-chemical changes), they are transformed into sedimentary rocks (clayey, clastic or chemical).

Rock is a natural aggregate in the structure of the earth's crust (Țicleanu *et al.,* 2008; Skinner *et al.,* 1987). By origin, rocks are divided into four groups: *eruptive, sedimentary, metamorphic* (rocks formed in the thickness of the earth's crust as a result of changes in sedimentary and magmatic rocks that have undergone changes in their physico-chemical conditions) and *residual.*

Depending on their genesis, they differ:

1. Eruptive rocks (magmatic or volcanic). They are formed by the movement, solidification and solidification of magmas or mineral-rich volcanic products, and are further divided into:
    - *intrusive rocks* (plutonites), formed by the consolidation of molten masses of silicates within the crust (granite, granodiorite, diorite, syenite, gabbro);
    - *effusive rocks* (volcanics), formed by consolidation of silicate melts on the crustal surface (rhyolite, dacite, andesite, trachyte, basalt).
2. Sedimentary rocks. They are rocks that have been formed by erosion or weathering of minerals and their deposition in lakes or seas by wind, water, vegetation or evaporation. They are known:
    - *clastic (detrital) rocks,* formed by the deposition of materials resulting from the process of weathering and weathering of rocks on the crustal surface and transported by wind, water and glaciers. In turn, clastic rocks can be subdivided into
        - ✓ unconsolidated rocks (sand, gravel, grout, dust, mud, volcanic ash, etc.)
        - ✓ consolidated rocks (sandstone, conglomerate, breccia, loess, clay, volcanic tuff);
    - *precipitation rocks,* formed by chemical precipitation in marine, lake or spring waters, (limestone, dolomite, salt, gypsum, etc.). They can be :
        - ✓ biogenic (organogenic) rocks, formed by the transformation of plant and animal remains in the absence of oxygen. They can be classified into: acaustobiolites (which do not burn) and caustobiolites (which burn): oil, natural gas, ozokerite, asphalt, oil shale, coal, amber;
        - ✓ carbonate rocks. Limestone accounts for 10% of all sedimentary rocks. Most limestone forms in marine environments from the fossilised remains of marine organisms that fall to the ocean floor and over time compact into sedimentary layers. There are two types of limestone in which its biological origins are very evident: coquina (a coarse-grained rock composed of poorly cemented shell fragments) and chalk (a soft, porous rock composed only of the calcareous shells and skeletons of various sea creatures).
3. Metamorphic rocks. These are rocks formed by changing the chemical and physical properties of sedimentary and eruptive rocks over time. Metamorphic rocks can be:
    - contact rocks (epimetamorphic), formed by the transformation of existing rocks under high temperature conditions (sericite shales, chlorite shales, etc.) and
    - cataclastic (mesometamorphic) rocks, formed by the transformation of existing rocks under intense dislocations of the earth's crust (gneisses, amphibolites, quartzites, etc.).
4. Residual rocks formed by the disintegration and dissolution of other rock types. Insoluble fragments form other rocks. Examples: tera-rock, bauxite.

Magmatic and metamorphic rocks make up about 90% of the volume of the Earth's crust (however, on the actual surface of the continents, their areas of distribution are relatively small). The remaining 10% are sedimentary rocks (occupying 75% of the Earth's surface).

Landform factors are divided into two groups: internal (endogenous) and external (exogenous). Of the endogenous factors the most important are rotational decay, radioactive decay and the energy of geochemical accumulators. The energy of external (exogenous) factors is generated by energy coming directly from the Sun, which is in turn influenced by the fluctuation of the Earth's surface (Cesare, 1992).

2.2.2 Chemical composition of the lithosphere

The Earth's chemical composition consists mainly of iron salts (32.1%), oxygen (30.1%), silicon (15.1%), magnesium (13.9%), sulphur (2.9%), nickel (1.8%), calcium (1.5%) and aluminium (1.4%). The other elements account for only 1.2% (Table 3). The most common minerals that make up rock in the Earth's crust consist almost entirely of oxides; the total chlorine, sulphur and fluorine content of rocks is usually less than 1%. The main oxides are silica (SiO2), alumina (Al2O3), iron oxide (FeO), calcium oxide (CaO), magnesium oxide (MgO), potassium oxide (K2O) and sodium oxide (Na2O). Silica serves mainly as an acidic medium and forms silicates; the nature of all major volcanic rocks is associated with it.

Table 3. Chemical composition of the lithosphere (Chernicoff *et al.,* 1990)

Components	**Formula**	**Percentage**	
		Continental	**Oceanic**
Silicon	SiO_2	60,2 %	48,6 %
Aluminum oxide	Al_2O_3	15,2 %	16,5 %
Calcium oxide	CaO	5,5 %	12,3 %
Magnesium oxide	MgO	3,1 %	6,8 %
Iron oxide (bivalent)	FeO	3,8 %	6,2 %
Sodium oxide	Na_2O	3,0 %	2,6 %
Potassium oxide	K_2O	2,8 %	0,4 %
Iron oxide (trivalent)	Fe_2O_3	2,5 %	2,3 %
Water	H_2O	1,4 %	1,1 %
Carbon dioxide	CO_2	1,2 %	1,4 %
Titanium dioxide	TiO_2	0,7 %	1,4 %
Phosphorus pentaoxide	P_2O_5	0,2 %	0,3 %
Total		99,6 %	99,9 %

2.2.3 Lithosphere relief

The petrographic relief complex is made up of all the landforms whose genesis, evolution and external appearance are predominantly conditioned by the nature of the rocks on which they develop. The influence of rocks on relief is evidenced by their physical and chemical properties (hardness, permeability, solubility) in relation to erosion (Turcotte *et al.,* 2014).

The following landforms are distinguished (Terra, 2006; Smith, 1981):

Granitic relief.
It occurs on granites but also on other rocks that behave similarly to the modelling agents, such as granulites, diorites, syenites and some crystalline schists. Granite is a specific rock. As a deep-seated, holocrystalline eruptive rock, granite is hard (unless cracked) and compact. Because of its stiffness, the mass of granite cracks during tectonic movements when it is subjected to high pressures. Although it is impermeable as a rock, because of the network of cracks, it acquires a certain degree of permeability. Because of its mineralogical heterogeneity (quartz, feldspar and mica), granite is more easily subject to disintegration and alteration. When it is subjected to large thermal amplitudes (sudden and repeated cooling and heating), it disintegrates. Granite is highly resistant to erosion by flowing water. In addition to the climate, the altitude of the relief is of particular importance in the evolution of granite morphology. Typical granitic relief develops mainly in low-lying regions, where we find predominantly mamelon shapes, from which (especially in tropical climates) landforms emerge in the form of blocks, chaotic piles of boulders and sugar lumps. At higher altitudes some distinct features stand out, constituting the granitic relief of high mountains. It is marked by pyramidal shapes, jagged ridges, huge columns, sharp blocks.

Relief developed on sandstones and conglomerates.

Both rocks have a mass composed of cemented granitic elements or particles. Sandstones are made up of sand grains, which have a relatively homogeneous grain size composition; they are distributed in strata of varying thickness and hardness. Conglomerates form a cemented assemblage made up of particles of different sizes, mainly pebbles or cobbles, and sometimes blocks. Depending on the nature of the cement there are calcareous, siliceous, clayey, glauconitic sandstones. The type of cement can make the sandstone more or less waterproof. For example, the highest degree of impermeability is found in siliceous sandstone, the constituent material determining its bulkiness. When the tiles are hard and cracked, they have a rough appearance and a high degree of fragmentation and slopes. On clayey sandstones, the relief forms appear more obliterated, with the slopes having lesser gradients. Due to the permeability of the sandstones, the network of valleys is generally rare (except in areas with hard sandstones). The valleys have slope breaks and shoulders. Where harder banks alternate, local poles or steps may form. Siliceous sandstones cause valleys with the appearance of keys. If the sandstone is hard but permeable, a massive relief develops on it that approaches the granitic in appearance, evolving along the path of physical disaggregation. At the base of the slopes there is an accumulation of sandy-clay deposits, forming a train or a plateau. In other conditions, grooves are deposited. Conglomerates, made up of crystalline elements, are strongly cemented and resistant to erosion; they create an imposing relief with steep slopes and sharp profiles. Conglomerates with calcareous cement or calcareous elements can form a pseudocarst represented by lapies, sinkholes, gorges. If the conglomerates are slightly clayey, due to weathering, badlands occur.

Clay relief.

Clays are produced by cementing or consolidating a very fine-grained material (less than 2µ). There are several kinds of clays, depending on their mineralogical constitution. Those with the lowest silica content form kaolinite and those with the highest silica content are called montmorillonite. Dry clays are very water-hungry. When saturated, it becomes impermeable, and by swelling it increases in volume, becomes plastic and slides downhill. So, the storage of a quantity of water or its loss by evaporation causes important variations in volume. At a very high degree of waterlogging, the clay becomes semi-fluid. When the clay is very dry, it can break down the cohesion of its component particles and is easily pulverised by the wind. Climatic conditions have different effects. In temperate climates gullies, gullies, gullies and many types of landslides are present. In subpolar climates, clay shaping is predominantly through the process of solifluction. The river network formed on a clay relief has wide valleys, frequently marked by marshes that sometimes interrupt the water flow. The slopes have shallower and very shallow slopes, the interfluves are rounded and flat. Water run-off from atmospheric precipitation is rapid, due to the behaviour of clays as impermeable rocks when they reach saturation. On these landforms, linear erosion develops intensively, especially where there is no vegetation cover. Ravines and gullies can appear in clays, which quickly develop into torrential valleys. In subdesert and Mediterranean climates, gullies develop very intensively; they branch off sharply, forming labyrinthine excavations that are very dense and quite deep (from a few metres, sometimes up to several tens of metres, and separated from each other by narrow ridges).

Sandy relief.

Sand is a detrital, unconsolidated rock with a specific property of high mobility and permeability. Predominantly quartziferous sands are highly mobile, while those containing various minerals may form a kind of binder (these form micaceous or feldspathic sands). In the latter case, they may be shaped by scree or shallow slides. If the sand does not contain a binder, it can be blown away by the wind.Water from atmospheric precipitation quickly infiltrates the sand mass, penetrating down to the impermeable rock layers. Landform shaping occurs to a small extent in sandy terrain and only under the action of flowing water. The most varied and typical features of sandy relief are found in arid and semi-arid climates, especially in desert regions, which offer the most favourable conditions for the development of this morphology. Another category of regions with sandy relief is the areas of marine and lake shores, along which a beach develops. They also exist in the accretionary plains, on the broad valleys of large rivers and in some areas where the sands have been brought up to date by the erosion of flowing waters.

The relief formed on loess.

Loess is a detrital rock, made up of very fine particles (in the order of tenths and hundredths of a millimetre in size), which in the dry state take on the appearance of dusty, slightly cemented rocks with a loose structure. Because of its reddish-brown-yellowish colour, loess is also called yellow earth. It can be of different origins:

- aeolian (by the action of the wind, which carries fine dust over long distances),
- diluvial (under the action of flowing water, which plays an important role in its transport and accumulation)
- pedological or eluvial (due to the pre-fall that an eluvial alteration crust undergoes, on water ridges and gently sloping slopes)
- fluvio-glacial (from fluvio-glacial accumulations at the periphery of ice caps, where glacial meltwater has acted intensively).

The relief developed on loess is quite varied in shape, but small in size and not very resistant over time. The flowing waters deepen rapidly, carving narrow, deep gorge-like valleys whose sides collapse and collapse vertically.

Karstic relief.

All the processes related to the movement of water in soluble rocks (limestone, dolomite, gypsum, salt) and the landforms to which they give rise (surface and deep) are called karst. The term karst indicates limestone rock or cliff and the phenomena grafted onto it. The occurrence and development of karst is conditioned by three main processes:

- corrosion (dissolving or dissolution) occurs as the main process, due to water and carbon dioxide;
- erosion, through laminar or turbulent flow (evorsion, turbidity, marbling)
- biochemical alteration (releasing acids - nitric, sulphuric or fulvic).

On the surface of calcareous soils, particularly when they are devoid of soil cover and vegetation, numerous forms can be found, starting with the smallest, with the appearance of gullies or grooves and ending with depressions of the order of square kilometres. They fall into the category of extenuating karst or exocarst.

Endokarst is a deep karst form. Arriving by various routes inside limestone masses, the waters exert a triple action on karstified rocks: erosion-corrosion, transport and deposition-concretion. They form caves. These are natural cavities of very different sizes.

2.2.4 Final appreciations on the lithosphere

The lithosphere undergoes tectonic movements that have been and are constantly occurring, with varying intensities almost everywhere on Earth. They are accompanied by earthquakes (shocks and rapid vibrations of the earth's surface) and volcanism (the ascent of magma from under the lithosphere into the earth's crust and its overflow to the earth's surface). Most earthquakes and active volcanoes are located on the edges of the lithosphere plates, on the so-called seismic belts. The most important currently are the one that surrounds the Pacific Ocean. It is followed by the belt that stretches through Central Asia from the Atlantic Ocean to the Pacific.

No reliable predictions have yet been made about future earthquakes or volcanic eruptions. Both, at the planetary level, are permanent and have extremely different amplitudes of manifestation. The generally after the first shocks, which are larger, they are followed by sequences of movements, but increasingly weaker

The surface of the planet is made up of larger and smaller tectonic plates, which are constantly undergoing erosion processes carried out by precipitation waters, from the dissolution by surface waters of a wide range of chemical compounds in a solid state, from the erosion by winds of rocks, from the action of glaciers on the superficial layer of the lithosphere, from the permanent erosion processes of marine waters along their coasts with the continents, from the permanent destruction of the calcium carbonate cords made by corals (hence the erosion of coral reefs) and under the action of living organisms that either create the limestone deposits or dissolve the compounds of other types of rocks, which thus disintegrate much faster. In the past, the impacts of different meteorites that came from the cosmos and fell to earth under the influence of the planet's gravitational attraction also contributed to the above factors (currently this "rain" of meteorites has significantly reduced). All of these factors are permanently altering the planetary landscape.

Tectonic plates can climb one on top of the other; in these cases earthquakes occur. There are also slow movements that can only be highlighted with the help of a highly sensitive device. What is certain is that tectonic plates are permanently changing their shape, floating on magma beneath the lithosphere. In this way they are the main physical factor that modifies both the planetary relief and the physical dimensions of the planet. In these movements, the daily tides caused by the moon, the geomagnetic fluctuation of the spheroid that is Earth, as well as the possible attractions of the sun (when the planet is closest to the sun during its annual revolution) play a not inconsiderable role.

2.3 Hydrosphere

Water is one of the most widespread substances on Earth, forming one of its layers, the hydrosphere. Water covers 71% of Earth's surface. It is a colorless, odorless, and tasteless liquid, sometimes appearing slightly bluish or even greenish in thick layers. Water is an indispensable substance for life, regardless of its form, and is one of the most universal solvents (Encyclopædia Britannica, 'Hydrosphere”; Warren *et al.,* 2003; Wood *et al.,* 2008).

Three sciences are concerned with water:
- meteorology (for atmospheric water),
- hydrology (for water in solid, terrestrial environments),
- hydrobiology (for organisms in oceans, seas, continental waters, and underground waters).

Water is an excellent solvent; it dissolves many types of substances, facilitates chemical reactions of numerous mineral or organic substances, and plays a fundamental role in the proper functioning of the metabolism of living organisms. One simple, unique and extremely important property for the environment is that in its solid form, ice, it floats on liquid water. The solid form of water has a lower density than liquid water. For nearly all substances and for all other 11 unusual states of water, except for ice, the solid state is denser than the liquid state. Freshwater has the highest density at 4°C and will sink due to convection as it cools to that temperature; if it continues to cool, it will rise. Due to this property, deep water will be warmer than the surface ice, so ice forms from the surface downward, and most of the water below remains at temperatures close to 4°C. Thus, the bottom of a large lake or an ocean is practically insulated from the cold, allowing the coexistence of various plant and animal species. Almost all other chemical substances are denser in the solid state and freeze from the bottom up.

Life on Earth has evolved and adapted to these properties of water. The existence of water in its solid, liquid, and gaseous states on Earth has been an important factor for the colonization of various environments by life forms adapted to diverse and often extreme conditions. Biologically, water has numerous properties indispensable for life's processes. Water fulfills this role by allowing organic compounds to react in ways that eventually permit replication. It is an excellent solvent and has a high surface tension, enabling the movement of organic compounds and living organisms. Freshwater has maximum density at 4°C; this density decreases as water cools, warms, or freezes. Being a stable bipolar molecule dominant in the atmosphere, it plays a crucial role in absorbing infrared radiation and is essential in the greenhouse effect, without which the Earth's surface temperature would be -18°C. Water also has an unusually high specific heat (4181.3 J/(kg·°C) at 1 bar pressure and 25°C). It plays multiple roles in regulating global and regional climate. Since it absorbs a lot of infrared radiation, it has a very slight blue tint due to the elimination of a small amount of red light passing through it. The blue color can only be observed when water is in large quantities. Additionally, water has a high latent heat of vaporization, 2262 kJ/kg at 1 bar pressure and 98°C temperature. Therefore, water has a significant influence on climate and heat transfer between the ocean and the atmosphere (Morariu *et al.,* 1962).

The hydrosphere is the Earth's water cover. It exists in the form of free water, whether in a liquid, solid, or gaseous state. Water is found on the planet's surface, in the upper layers of the lithosphere, or in the atmosphere. Although it may not appear to be a continuous layer at first glance, it is widespread in various forms across our planet (as rivers, lakes, seas, oceans, stagnant and flowing waters, both on the surface and underground, as well as in the form of vapor or ice crystals in the atmosphere. It is found as oceans and seas on the Earth's surface in the form of rivers, and lakes, but it is also present in the lithosphere as groundwater (Antonescu, 1967; Coste, 1982) (Figure 20).

The hydrosphere has lower mobility compared to the atmosphere but is much greater than the lithosphere. The transformations that occur in the hydrosphere can be physical, chemical, or mechanical in nature. At the planetary level, the hydrosphere appears as a permanent functional system, constantly penetrated by a certain amount of energy (solar or terrestrial), capable of setting water in motion, leading to the so-called permanent water cycle (see details below).

The volume of Earth's hydrosphere is estimated at 1,500,000,000 cubic kilometers, of which 93.3% is in the oceans [which are salty due to sodium ions (Na+) and chloride ions (Cl−)]. Its total mass is 1,385,990,800,123 million tons, approximately representing 0.023% of Earth's total mass. Out of this volume, 97.1% belongs to the planetary ocean; glaciers and permanent snow represent 1.7%; groundwater accounts for 1.2%, and the rest is water present in other components of the hydrosphere (Encyclopædia Britannica, 'Hydrosphere').

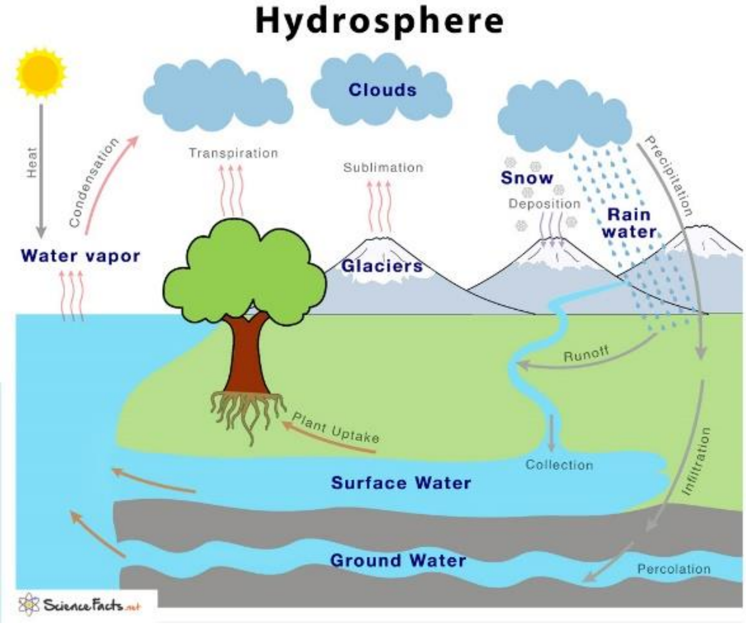

Figure 20. Components of the Hydrosphere (https://www.sciencefacts.net/hydrosphere.html)

The water cover is one of the fundamental factors that make the existence of planet Earth and organic life possible on it. It influences all the other layers of the planet: determining the amount of water in the atmosphere, causing the condensation and sublimation of water vapor, the formation of clouds and atmospheric precipitation, optical and electrical phenomena, and so on. Waters are a fundamental agent in shaping and leveling landforms on the Earth's surface—fluvial, coastal, karstic, sufosional, glacial, erosional, etc.

Water runoff on the Earth's surface is the mechanism through which erosion sculpts the natural environment, leading to the creation of valleys and deltas with fertile surfaces favorable for the development of human settlements. Additionally, water infiltrates into the soil, reaching the groundwater table. Groundwater can form basins of stagnant water or an exceptionally complex network of flowing waters; this groundwater resurfaces as freshwater springs or thermal springs and geysers.

Water from the oceans influences the planet's climate at a global level since it serves as a massive heat reservoir that both protects and maintains a relatively constant average temperature. Regional temperature changes can, in turn, lead to highly important meteorological and bioclimatic conditions (see the cold climate of North America or the periodic climatic phenomena determined in South America by the El Niño phenomenon).

The coexistence of water in its solid, liquid, and gaseous states on Earth is vital for the origin, evolution, and existence of life on Terra. The distance between Earth and the Sun and the combination of received solar radiation and the greenhouse effect of the atmosphere ensure that its surface is neither too cold nor too hot for liquid water. If Earth were farther away, water would freeze, and if it were closer to the Sun, the higher surface temperature would prevent the formation of ice caps, or water would exist only in vapor form. In the first case, Earth would absorb more solar energy due to the low albedo of the oceans, and in the second, an out-of-control greenhouse effect would result in inhospitable conditions similar to those on the planet Venus.

2.3.1 Origin of Water and the Formation of the Hydrosphere

There are several hypotheses about the origin and evolution of the hydrosphere, which can be classified as either terrestrial or cosmic in origin. The most convincing hypothesis is that water is of terrestrial origin. Accordingly, water was formed along with other substances. It is believed that water was released from the Earth's mantle and crust. Four billion years ago, the volume of the hydrosphere was only 20 million km³, but later, the volume of water increased through the release of water from the mantle. Water vapor condensed, transformed into liquid water, and thus, the primordial ocean emerged. Other components of volcanic gases dissolved in it, especially carbon dioxide, some acids, sulfur compounds, and a part of ammonia. The acids, in contact with water, reacted with silicates and other elements. As a result, water ceased to be acidic; moreover, over time, various other salts dissolved in it. The primordial ocean was very warm; therefore, the processes of evaporation were highly intense, causing water to evaporate, rise into the atmosphere, cool down, and fall back into the ocean as extremely intense rains.

The lithosphere, atmosphere, and hydrosphere formed in a single process, resulting from the melting and release of gases from the mantle: water in a gaseous state, nitrogen from nitrites and nitrates, oxygen from metallic oxides, carbon from carbides and carbonates. Earth heated up due to the gravitational compression of its interior and the decay of radioactive isotopes in the mantle. These phenomena led to the melting and differentiation of matter into volatile, fusible, and refractory forms (Wood *et al.,* 2008; Warren *et al.,* 2003).

Initially, there was a single ocean (Panthalassa) and a single continent (Pangaea). Then, Pangaea fragmented; initially into two parts (Laurasia in the north and Gondwana in the south), and later, further fragmentation occurred, leading to the formation of the current continents.

2.3.2 Water Cycle in Nature

A continuous circulation process of water within Earth's hydrosphere occurs in nature (also known as the hydrological cycle or water cycle). This process is set in motion by solar radiation and gravity. During the course of this cycle, water changes its state of matter, successively existing as solid, liquid, or gas. Water moves from one component of the cycle to another; for instance, it falls from the air as rain, flows over solid ground forming rivers, and eventually reaches an ocean through various physical processes, the most significant of which are evaporation, transpiration, infiltration, and runoff (Lambert, 1996; Encyclopædia Britannica, 'Hydrosphere') (Figure 21).

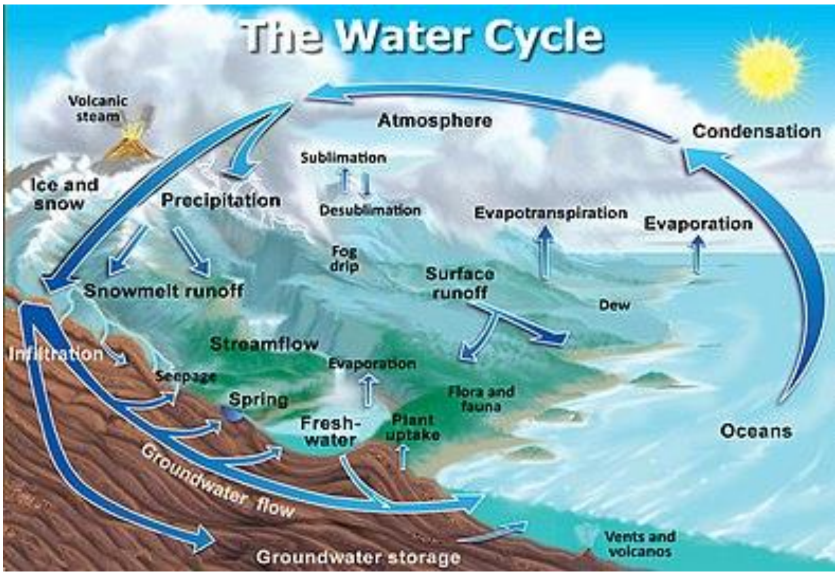

Figure 21. Water Cycle on Earth (https://en.wikipedia.org/wiki/Hydrosphere)

The water cycle consists of the following processes (l'Hôte, 1990):

Evaporation. It is the process through which water is transferred from the surface of oceans and other bodies of water to the atmosphere. This transfer involves a change in the water's state of matter, from liquid to gas. Water is also released into the atmosphere through plant transpiration and, to a much smaller extent, through the respiration of other living organisms (through evapotranspiration). Approximately 90% of the water in the atmosphere comes from evaporation, and only 10% from evapotranspiration.

Advection. It is the process of transferring an atmospheric property (heat, cold, humidity, vorticity) through the horizontal movement of air masses. Concerning the water cycle, it refers to the movement of water in its three states: solid, liquid, or gas. Without advection, the water evaporated from the ocean surface could not move to reach the land, where it produces precipitation.

Condensation. It is the process through which water vapors in the air transform into liquid water droplets, forming clouds or fog.

Precipitation. Water that has condensed in the atmosphere falls to the Earth's surface. The most common form of precipitation is rain. Other forms include snow, sleet, hail, drizzle, and the dripping of water due to the condensation of tiny droplets in fog.

Sublimation.The process through which solid water (ice or snow) transforms directly into vapors without passing through the liquid state.

Foliage Interception. The part of precipitation intercepted by plant foliage, which evaporates without reaching the soil surface. The amount of intercepted water depends on the duration of rainfall, wind speed, temperature, foliage density, and other minor factors.

Infiltration.The process of water penetrating from the surface into the interior of the soil, filling the gaps between soil particles and moistening the soil.

Melting. The process of transforming water from the solid state (ice or snow) into the liquid state.

Runoff. The process through which water moves on or below the soil surface. This movement can be distinguished between: Surface runoff: It occurs on the soil surface, happening in thin layers or streams, covering most of the soil; Channel runoff: This process occurs in channels, where water from surface runoff concentrates, forming streams, rivers, and creeks; Subsurface runoff: The runoff that occurs below the soil surface, either through the water table or deep aquifers. Water from subsurface layers returns to the surface through springs, infiltration into rivers, oceans, or other surface reservoirs.

Capillarity. The mechanism that enables the vertical movement of groundwater and water in very thin vessels, allowing water to move up in plant structures.

The overall water balance on a planetary level is presented in Table 4.

Table 4. General Water Balance of Water on a Planetary Level (volumes of water accumulated in natural water cycle reservoirs) (https://ro.wikipedia.org/wiki/Circuitul_apei_%C3%AEn_natur%C4%83)

Type of waters	Volume of water (millions of Km3)	Percent out of the total
Oceans	1370	97,25
Ice caps and glaciers	29	2,05
Groundwater	9,5	0,68
Lakes	0,125	0,01
Soil moisture	0,065	0,005
Atmosphere	0,013	0,01
Rivers	0,0017	0,001
Biosphere	0,0006	0,00004

2.3.3 Forms of the Hydrosphere on Earth

Although the hydrosphere is a quasi-continuous envelope, at the planetary level, the hydrosphere is represented by solid water (in the form of ice and snow), liquid water, and water vapor and droplets in the troposphere (the lower layer of the atmosphere) (Maidment, 1993).

2.3.3.1 Water in Solid State (Cryosphere)

The cryosphere is, according to some geographers, a distinct geosphere from Earth's hydrosphere, consisting of all the water in a solid state, including glaciers, ice caps, and frozen ground (permafrost) (World Water Resources, 1998) (Figure 22).

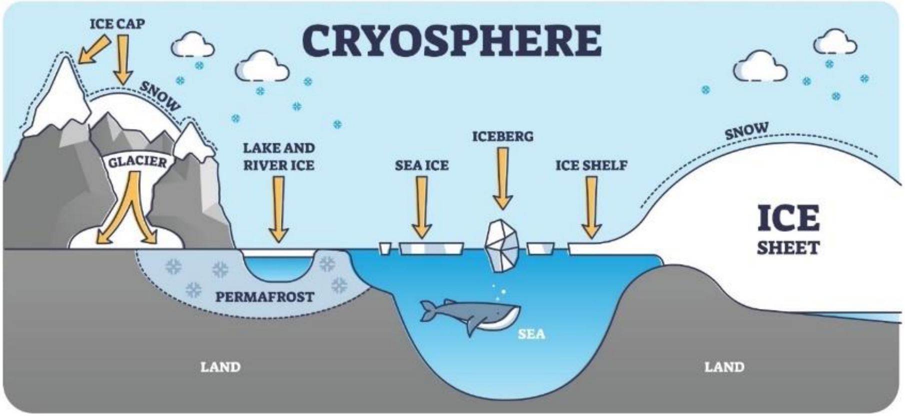

Figure 22. Types of Frozen Water on the Planet (https://www.news-medical.net/life-sciences/Microbiology-of-the-Cryosphere.aspx)

A glacier represents a massive and persistent body of frozen water, formed in polar and alpine regions, which can, under its own weight and gravity, slowly move along valleys or slopes. The current area covered by glaciers (approximately 16.3 million km²) represents 11% of the Earth's land surface. Continuously, extensive portions break off from continental glaciers adjacent to seas and oceans, becoming floating glaciers known as icebergs.

Glaciers form in regions where it snows heavily for most of the year, and the substantial snow accumulation does not have enough time to melt. By accumulating a sufficiently large quantity of snow, a transformation process occurs (or metamorphosis), and over the years, the snow mass, continuously layered, undergoes a slow transformation, becoming progressively denser, with larger ice crystals. The further compression of the lower layers results in a more significant increase in density, creating the characteristic structure of the glacier. Once it reaches a critical mass, the glacier starts to move slowly but significantly over time, under the influence of gravity and its own weight, causing deep fissures or crevasses in its structure. The topographic relief determines the speed of movement and the shape of the glacier. If the slope is steep enough, a so-called glacier tongue appears, which is the part that determines its "flow" or sliding. During its flow, the glacier exerts strong erosional action on the terrain it traverses. Everything the glacier carries during its slide becomes a part of it (such materials include rock fragments carried by the glacier, known as moraines). Surface glaciers at lower altitudes undergo periodic melting and refreezing processes. Unlike glaciers in high mountains or polar regions (where the melting process is minimal), these processes lead to the formation of large glaciers.

Glaciers can be classified based on the environment they are in: continental glaciers and marine glaciers, based on the climatic zone: polar glaciers, subpolar glaciers, and glaciers in temperate or warm regions, and based on their form and dynamics: mountain glaciers and ice cap glaciers. At the lower end of a melting glacier, a water reservoir is created (Figure 23), and solid rocky material (moraines) brought by the glacier remains in the valley.

Figure 23. Landscape produced by a receding glacier (https://www.google.com/search?client=firefox-b-d&sca_esv=583396942&q=retragerea+ghetarilor&tbm)

Rate of erosion caused by a glacier depends on: the speed of glacial movement, the thickness of the ice, the shape, abundance, and hardness of rock fragments contained in the glacier's bottom ice, the relative ease of erosion of the surface beneath the glacier, the thermal conditions at the glacier's base, and the permeability and pressure of water at the glacier's base. More than 2/3 of the world's freshwater reserves are locked in the form of ice at the Earth's poles, in the Arctic and Antarctic regions.

2.3.3.2 Water in Liquid Form

Globally, the distribution of liquid water exhibits varying degrees of non-uniformity. Referring to the two hemispheres, northern and southern, it can be observed that in the northern hemisphere, oceanic areas (154.5 million km²) are relatively close compared to land areas (100.5 million km²) (but in a smaller proportion - a ratio of 1.5 - compared to the southern hemisphere, where the oceanic surface (206.5 million km²) is 4.2 times larger than the land area (48 million km²) (Figures 24 and 25).

Out of the total surface area of the Earth (510 million km²), land represents 29.2% (149 million km²), while seas and oceans occupy 70.8% (361 million km²). The Pacific Ocean alone has a larger surface area than the entire landmass (it is 178.7 million km²).

Figure 24. The Earth as Seen from the South Pole (Oceans in Blue, Continents in White) (https://www.google.com/url?sa=i&url=https%3A%2F%2Fro.wikipedia.org%2Fwiki%2FOcean&psig=AOvVaw3knEqU1hQ5)

Freshwater accounts for about 0.62% of the total volume of the hydrosphere, amounting to 315.2 x 10^3 km³. It consists of lakes and ponds (230,000 km³), groundwater (82,000 km³), rivers (1,200 km³), and living organisms (2,000 km³).

Waters from seas and oceans

The volume of water in the planet's oceans is 1.37 × 10^18 tons. Oceans cover an area of 3.618 × 10^8 km², with an average depth of 3,682 meters and an estimated water volume of 1.332 × 10^9 km³. Approximately 97.5% of this water is salty, while the remaining 2.5% is relatively less salty, originating from rivers flowing from the Earth's surface or melting glaciers (https://www.meteorologiaenred.com/ro/mares-y-oceanos.html).

About three-quarters (71%) of Earth's surface is covered by oceans. Oceans are vast bodies of water that are currently bordered by continents. There are five oceans on Earth: the Atlantic Ocean, the Pacific Ocean, the Indian Ocean, the Arctic Ocean, and the Antarctic Ocean (Kennish, 2001) (Figure 25).

Figure 25. Seas and oceans of the Earth
(https://www.google.com/search?q=Marile+si+oceanele+lumii&client)

Through the dissolution of salts from rocks, the waters of oceans and seas have a certain chemical composition. Their salinity averages 35‰ and is derived from the dissolution of salts resulting from volcanic activities and the erosion of weathered rocks. This concentration varies: it is higher in warm tropical regions and lower in cold regions, where there is a significant influx of freshwater from rivers (for example, the Baltic Sea has an average salinity of 14–18‰, the Black Sea has 24–25‰, in contrast to the Gulf of Oman where salinity exceeds 37‰). Because the evaporated water from seas and oceans does not contain dissolved solid materials, the salt content of inland seas and the planet's ocean continuously increases (Antonescu, 1967; Pora *et al.,* 1974).

Every ocean has three main zones: the coastal, pelagic, and abyssal zones (Figure 26). Sunlight penetrates only into the so-called photic zone, where photosynthetic plant organisms can live. Both plant and animal life, as well as prokaryotic and eukaryotic microorganisms, exist in both the photic and aphotic zones.

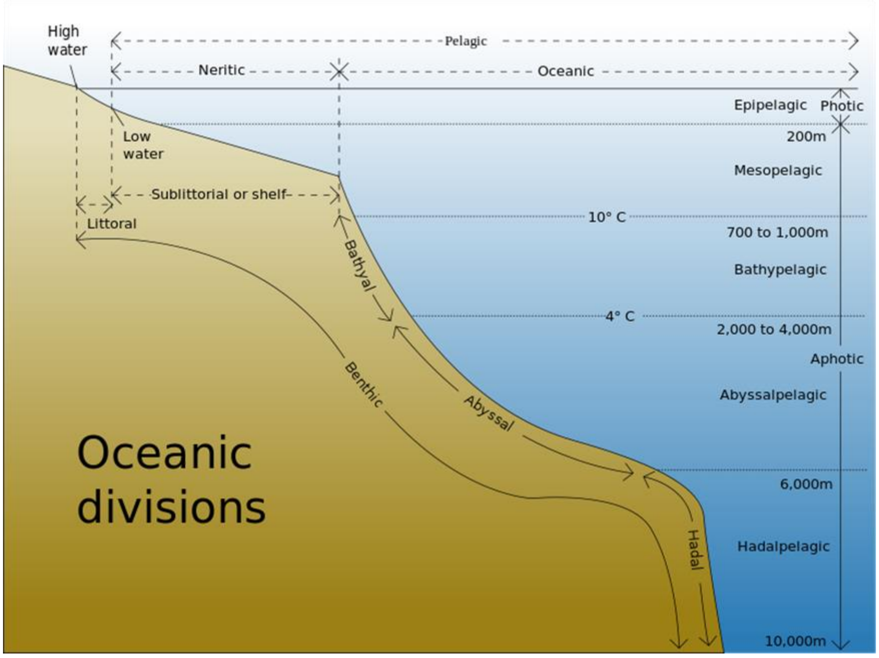

Figure 26. Geographical subdivisions of seas and oceans
(https://greenly.ro/biodiversitate/mediul-oceanic-si-fauna-din-adancuri)

In oceans, the planet's rotational movement, winds, and varying salt concentrations lead to the formation of ocean currents, causing the mass of water to move over long distances.

The Moon also influences marine waters, periodically raising their levels, giving rise to tides characterized by ebb and flow. The difference between low and high tide levels varies. Narrow gulfs on the east coast of Canada act as funnels due to their shape; there, the largest tidal amplitudes can be observed (for example, in the Bay of Fundy, the daily amplitude is 15 meters). In comparison, tidal amplitudes on the North Sea coast are 3.5 meters, and in the Black Sea, they are only 5-10 centimeters.

Similar to giant conveyor belts, numerous surface and deep-sea currents circulate through all the world's oceans. They achieve complete mixing of Earth's ocean waters, but this process takes several hundred to 2000 years (Figure 27).

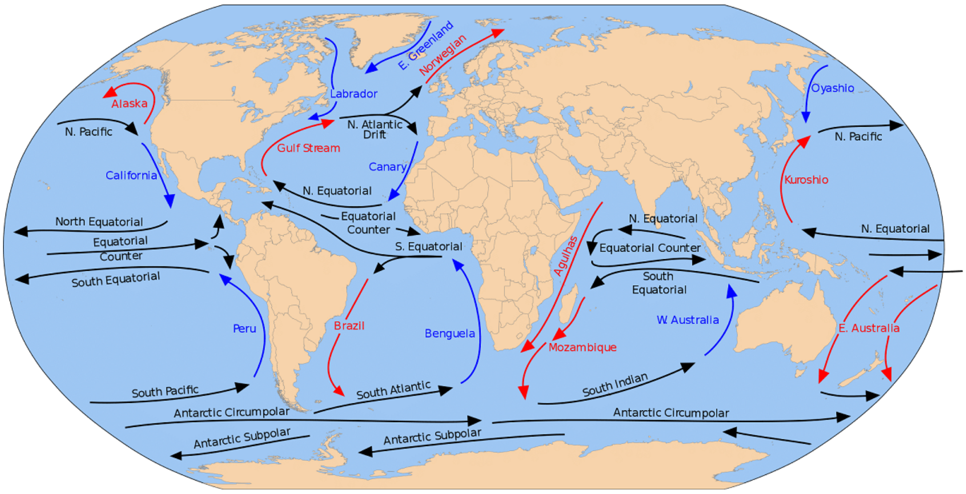

Figure 27. The planet's oceans and the warm and cold currents in the oceans (https://www.meteorologiaenred.com/ro/curenti-oceanici.html)

Many islands have emerged in the seas and oceans as a result of volcanic eruptions. Most volcanic islands are located in areas where mid-ocean ridges rise. Islands can also form above hotspots in the Earth's crustal plate fracture zones. For example, Iceland and the Azores Archipelago are islands in the Mid-Atlantic Ridge. Other islands have been formed by coral reefs or atolls and are found in oceans only between 30° north and south latitude (because coral polyps predominantly thrive in warm and very clean water). Coral reefs are present in shallow oceanic areas and grow and shrink (or disappear) under the influence of erosional processes occurring continuously on the limestone substrate produced by corals. Coral polyps extract calcium ions and carbon dioxide from seawater and use them to create an external skeleton made of calcium carbonate. As new living tissue grows over older (and therefore dead) skeletal material, they grow significantly. This is how the **Great Barrier Reef** off the northeastern coast of Australia was formed, where reefs stretch over a length of 2,600 km.

The largest island in the world is **Greenland**, with an area of over 2,000,000 km². In comparison, the smallest islands are some "crumbs" scattered in all seas and oceans. Islands are often associated with a continent. In these cases, they are elevated areas of the continental shelf, which seem detached from the land, being surrounded by water.

The chemistry of ocean waters is very complex, with water containing numerous anions and cations of various chemical elements (Table 5).

Table 5. Main salts found in ocean waters with a salinity of 35g/l (https://fr.wikipedia.org/wiki/Eau_de_mer)

Anions	**g/kg**	**mol/kg**
Chlorides (Cl^-)	19,3524	0,54586
Sulfates (SO_4^{2-})	2,7123	0,02824
Hydrogen carbonates (HCO_3^-)	0,1080	0,001770
Bromine (Br^-)	0,0673	0,000842
Carbonates (CO_3^{2-})	0,0156	0,000260
Fluoride (F^-)	0,0013	$6,84 \times 10^{-5}$
Hydroxides (OH^-)	0,0002	$1,2 \times 10^{-5}$
Cations	**g/kg**	**mol/kg**
Sodium (Na^+)	10,7837	0,46907
Magnesium (Mg^{2+})	1,2837	0,05282
Calcium (Ca^{2+})	0,4121	0,01028
Potassium (K^+)	0,3991	0,01021
Strontium (Sr^{2+})	0,0079	$9,02 \times 10^{-5}$
Lithium (Li^+)	$1,73 \times 10^{-4}$	$2,49 \times 10^{-5}$
Rubidium (Rb^+)	$1,20 \times 10^{-4}$	$1,404 \times 10^{-6}$
Barium (Ba^{2+})	$2,0 \times 10^{-5}$	$1,46 \times 10^{-7}$
Polyatomic ions of molybdenum	$1,0 \times 10^{-5}$	$1,04 \times 10^{-7}$
Polyatomic ions of uranium	$3,3 \times 10^{-6}$	$1,39 \times 10^{-8}$
Polyatomic ions of vanadium	$1,9 \times 10^{-6}$	$3,73 \times 10^{-8}$
Bivalent and trivalent iron (Fe^{2+}; Fe^{3+})	$1,3 \times 10^{-6}$	$2,33 \times 10^{-8}$
Polyatomic ions of titanium	$1,0 \times 10^{-6}$	$2,09 \times 10^{-8}$
Aluminum (Al^{3+})	$1,0 \times 10^{-6}$	$3,71 \times 10^{-8}$
Other substances	**g/kg**	**mol/kg**
Water (H_2O)	965	53,57
Boric acid ($B(OH)_3$)	0,0198	0,000320
Tetrahydroxyborate ($B(OH)_4^-$)	0,0079	0,000100
Carbon dioxide (CO_2)	$4,0 \times 10^{-4}$	$9,09 \times 10^{-6}$

Seas are larger, shallow and saltwater bodies often located within the Earth's continental shelves or in the transition zone between land and ocean. The main difference between seas and oceans is their size (seas are smaller). Seas and oceans also differ in the size of the waves they produce; oceans tend to generate large waves (waves can exceed 12 meters in the middle of oceans), while seas produce much smaller waves (as seen in the Adriatic Sea or the Black Sea).

Typically, the waters of seas are calmer because the influence of ocean currents and tides is much reduced. Often, smaller seas are separated from ocean basins by island chains, straits, or peninsulas. Oceans and seas differ in terms of salt content, surface temperature, and depth. They also vary significantly in terms of the flora and fauna that exist within them.

Because oceans reach greater depths, they have lower temperatures. Seas closer to the Earth's surface receive more solar radiation and are warmer than oceans. Some seas have relatively small extensions, which is why they are sometimes considered large lakes. Examples include the Caspian Sea, Lake Baikal, or the Dead Sea.

In some regions of the land, the drainage system ends in an inland sea or depression, rather than being connected to the global ocean. Such regions are referred to as endorheic zones or basins. In these cases, the water level of the inland sea will maintain hydrological equilibrium, ensuring that the influx of water from land runoff and surface precipitation into the inland sea equals the losses through evaporation.

Continental Waters

Continental waters encompass both surface waters and groundwater (Antonescu, 1967; Pora *et al.,* 1974; Tufescu *et al.,* 1981; Li *et al.,* 2020; de Villiers, 2003; Anderson *et al.,* 2005; Wetzel, 2001).

Surface Waters

Surface waters come in two forms: flowing waters and stagnant waters. Despite their apparent abundance, surface waters account for less than 1% of the Earth's freshwater resources globally (Table 5) (Wetzel, 2001). They are primarily fed by rainfall, snowmelt/glacial meltwater, and groundwater sources.

Running waters are represented by streams, rivers, creeks, temporary waters, and runoff waters. They carve valleys into the lithosphere through which they flow under the influence of gravitational forces, from higher to lower areas. They can be permanent or temporary and can have several types of hydrological regimes, depending on the climatic characteristics of each region. There are waters with an equatorial regime (with a constant, stable, and high flow rate throughout the year), waters with a tropical regime with two seasons (monsoonal and subequatorial), which have a maximum during the rainy season and a minimum during the dry season, waters with a desert regime (water is intermittent and has episodic flows), waters with a Mediterranean regime (characterized by high flows in winter and low flows in summer), waters with a temperate regime (determined by the rhythm of precipitation and the snowmelt period), and waters with a polar regime (frozen areas that thaw in summer and form temporary watercourses).

The mode of supply and the flow regime of rivers depend on their feeding sources. Their water comes from the emergence of underground waters, from rainfall, snowmelt, and ice melt, or from lakes and marshes. Several sources contribute to the feeding of rivers, distinguishing two types of rivers: those with a pluvial pluvial-nival supply or those with a pluvial-glacial supply. The river's flow rate depends on the amount of precipitation falling in the river's feeding basin, air temperature, the degree and type of vegetation in the watershed, relief, slope, rock type, and soils. The length of a river is given by the distance between its source and mouth and can vary from a few hundred meters to thousands of kilometers (Amazon, Nile, Mississippi, etc.).

Temporary running waters are found only in very drought-prone continental areas. They appear after short but intense rains, are active for a few days, and then their flow gradually decreases as the water infiltrates the underground environment; only a small part remains in the minor riverbed, forming stagnant water pools, but even these disappear after a few days.

Standing waters are represented by lakes, ponds, and marshes.

Lakes are stagnant water bodies accumulated in excavations on the earth's surface. The main elements of a lake are its basin or lake bed and the water contained within it. Lakes vary widely in size, from a few square meters to tens of thousands of square kilometers, in depth, ranging from less than 1 meter to 1,620 meters, and in water volume, depending on their surface area and depth. Lakes can be classified into two types based on their origin: natural and man-made.

The following types of natural lakes are known: glacial lakes (formed by the melting of glaciers), tectonic lakes (formed in rift/crack zones of the Earth's crust or in the craters of extinct volcanoes), volcanic lakes (formed in the craters of inactive volcanoes), natural dam lakes (resulting from a landslide that blocked the valley of a river), lakes formed by the dissolution of rocks – salt, limestone, gypsum), river limans (the main river blocks the mouth of a tributary), marine limans (the mouth of some rivers is blocked by sediments brought by the sea), or lagoons (former closed marine gulfs with sandbars).

Man-made lakes (formed behind dams built by humans) are created for generating electrical energy (hydroelectric power plants), supplying drinking water to settlements, irrigation, fish farming, or tourism.

Puddles are stagnant water bodies with smaller extents and depths compared to lakes. Their bottoms are completely covered with aquatic vegetation because sunlight penetrates to their depths. They are mainly found in river valleys and deltas but also occur in areas of land subsidence where, due to previous accumulations of sediments impermeable to water, water collects from prolonged precipitation or at the terminal part of former glaciers.

Marshes are lands saturated with a lot of water, much of it coming from lakes filled with alluvium and vegetation, or on slightly depressed lands where water cannot infiltrate. Marshes always develop abundant semi-aquatic hydrophilic vegetation. In most cases, their water has an acidic pH.

Groundwater

Groundwater encompasses all the water present beneath the Earth's surface within the planet's lithosphere. It accumulates in the cavities of the Earth's crust under the gravitational pull of the planet. Gravity forces a considerable portion of rainwater and river water to seep into the Earth's crust through the pores and cracks of permeable rocks. The movement of water among the pores of these rocks continues until it encounters an impermeable rock layer, usually clay. From this point, the water begins to accumulate, filling the rock pores like a sponge, and then slowly drains under the influence of Earth's gravity. Groundwater comes in several forms: shallow (phreatic), deep (confined), and springs.

Subterranean water is the water present beneath the Earth's surface within the pores of rocks and soil. Approximately 30% of all available freshwater on Earth is groundwater.

This vital resource emerges on the surface through springs, which can take various forms. One of the most striking types is geysers, caused by the heating of waters in the warmer layers of the lithosphere, leading to intermittent high-pressure eruptions. Other springs emerge in karst regions, flowing either continuously or intermittently (these are known as artesian waters).

In closed desert regions, especially the Sahara and Australian deserts, deep waters exist, sometimes found at depths exceeding 1000 meters. These depths result from accumulations formed due to abundant precipitation during the last glacial period or immediately after its ending.

Groundwater is fresh water located beneath the Earth's surface in the pores of soil and rock. It is sometimes important to distinguish between groundwater closely associated with surface water and deep groundwater in an aquifer (referred to as "fossil water" if it infiltrated the ground thousands of years ago).

Typically, groundwater is considered to be the water that flows through shallow aquifers. It can provide soil moisture, create permafrost (frozen ground), or remain stationary in the bedrock with very low permeability. Additionally, it can be geothermal water coming from deeper layers of the Earth's lithosphere.

Surface water contributes to groundwater through infiltration. The outflows from groundwater are springs and subaqueous infiltrations into marine or oceanic basins. Due to its slow circulation rate, groundwater storage is generally much larger in volume compared to inflows than it is for surface waters. This difference allows people to use unsustainable groundwater resources more easily for extended periods without severe consequences. However, in the long term, the average infiltration rate above a groundwater source serves as the upper limit for the average water consumption from that source. Utilized groundwater is continuously replenished naturally by surface water originating from precipitation, streams, or rivers that seep into the groundwater environment.

Groundwater comes in three main types: constitution water (water that enters the crystalline structure of minerals, such as gypsum), retention water (water adsorbed, adhered, or capillary water), and free water (which can be accessed through wells or boreholes).

Within groundwater, there are also **fossil waters**, which are aquatic basins that originated millions of years ago. Examples of these are the basins beneath the Sahara Desert or the Ogallala Aquifer in North America (Braxton, 2009) (Figure 28). An aquifer is an underground layer of permeable rock formed by the fracturing of rocks or found in unconsolidated materials such as gravel, sand, or clay. Aquifers vary widely in their characteristics.

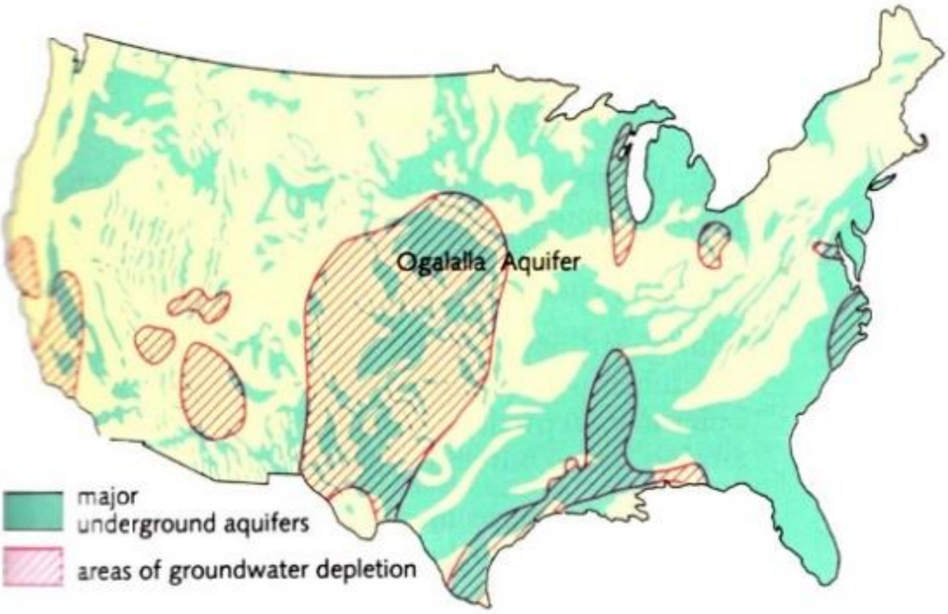

Figure 28. Large underground aquifers exist beneath the territory of the United States (Braxton, 2009).

The characteristics of aquifers vary depending on the geology, substrate structure, and topography of the area in which they occur. Generally, more productive aquifers are found in sedimentary geological formations. In comparison, weathered crystalline rocks retain smaller amounts of groundwater. Unconsolidated alluvial materials, including poorly cemented sediments filling valleys in major river valleys and structural basins with geological subsidence, are among the most productive sources of groundwater.

Groundwater, like surface water, flows under the influence of gravity, but its flow rate is much slower, influenced by the nature of the rock (size of granules or pores through which it flows), which also acts as a filter.

2.3.3.3 Water in Gaseous State (Water in the Atmosphere)

The presence of water in the atmosphere is one of the reasons life exists on this planet. Although the quantity of water in the atmosphere represents only 0.001% of the Earth's total water volume, its role in all biological, physical, and chemical processes is enormous. The majority of the total water content in the atmosphere (95%) exists in the form of water vapor; the rest is in the form of liquid or solid particles that form clouds. Annually, 519,000 km³ of water evaporates from the Earth's surface, with 448,000 km³ coming from the seas and oceans, and 71,000 km³ originating from the evaporation of water from land surfaces and inland waters.There is a continuous exchange of humidity between the Earth's surface and the atmosphere due to complex processes of evaporation, condensation, and precipitation.

In the atmosphere, water exists in three states of matter: solid (ice crystals), liquid (water droplets), and gaseous (water vapor). These transformations of water are accompanied by exchanges of heat energy (depending on air temperature and pressure until the molecular exchange between phases reaches equilibrium). The transition from one state of matter to another occurs through evaporation and/or evapotranspiration.

The content of water vapor existing in the atmosphere at a given moment represents the humidity or moisture of the air. Condensation and sublimation of water vapor are two physical processes transforming water vapor into water droplets or ice crystals, contributing to various forms of atmospheric precipitation: clouds, fog, dew, frost, hoarfrost, rime, hail, or glaze. These processes are specific to certain seasons.

Atmospheric precipitation is the final product of the condensation and sublimation of water vapor, comprising all liquid and solid water particles that fall from clouds and reach the Earth's surface (Figure 29).

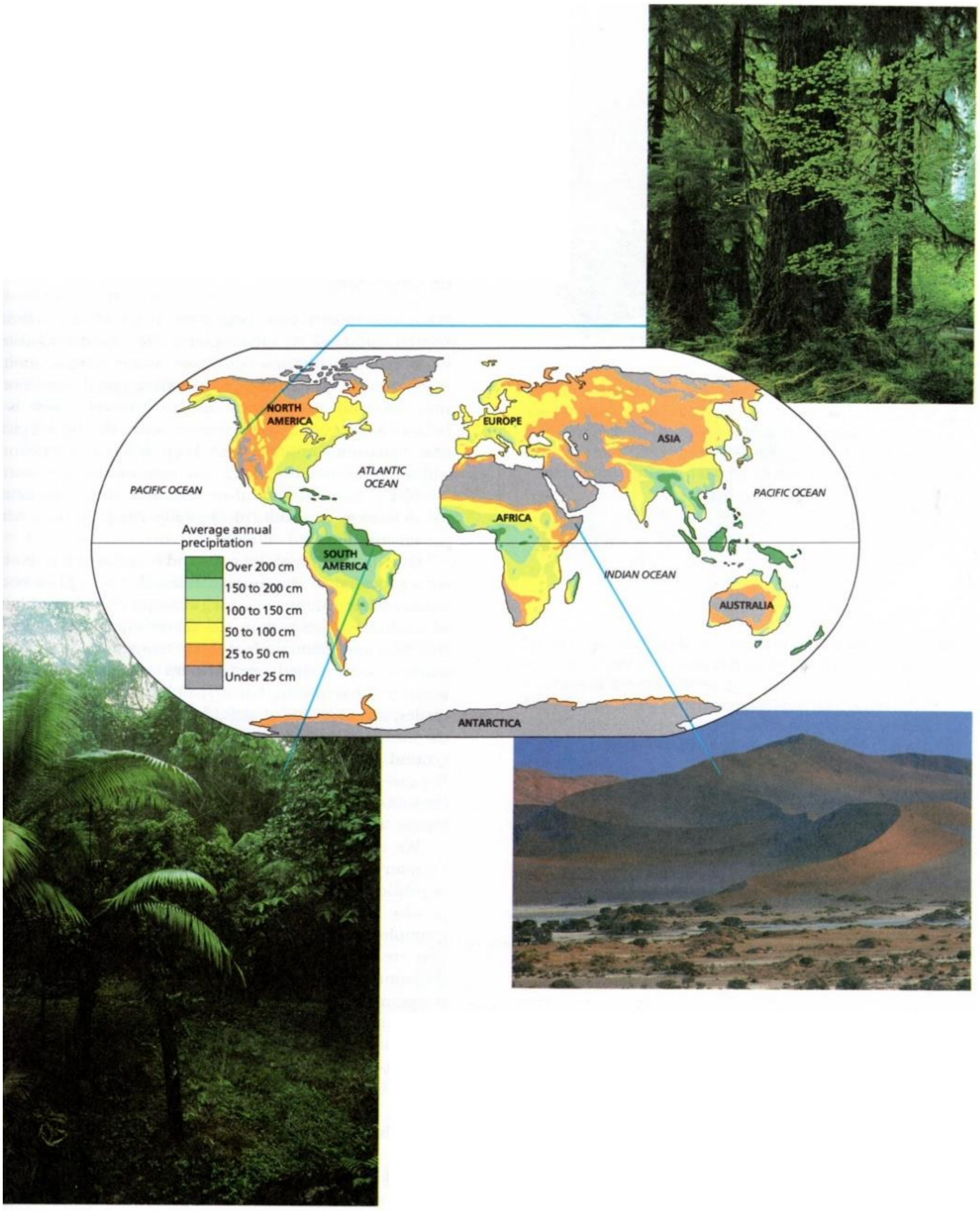

Figure 29. The effect of precipitation intensity on plant growth in different places on Earth. Terra (Levine and Miller, 1994)

2.3.4 Conclusions on the Hydrosphere

The hydrosphere is a planetary envelope composed mainly of water (H_2O) in its three states: solid, liquid, and gas.

Solid water, regardless of its form, is a valuable water reservoir and influences local and regional climates. Glaciers can be dangerous as they can cause avalanches or bury cities and tourist settlements under snowdrifts, bury people in snow, or disrupt various human activities (especially transportation).

Liquid water is the most abundant and everything depends on it: it covers most of the planet, interacts with the lithosphere, and becomes a part of it (from where it then emerges cold, warm, or very hot).

In the warm waters of the primordial planetary ocean, living organisms emerged and developed. As a consequence, all vital processes occur only in the water inside cells and living organisms in the aquatic environment. Even later, when life conquered the terrestrial environment, the vital processes of organisms still took place in the conditions of the primordial aquatic environment (the sap in all types of cells, including the physiological serum used in human infusions, is a saline solution with well-controlled concentrations of mineral salts, with a chemical composition similar to that of the primordial ocean). Regardless of the origin and state of aggregation of water, it remains an indispensable element for life. There are still aquatic organisms (from marine, oceanic, freshwater environments), but all terrestrial organisms cannot live without access to water; it is a fundamental element for their metabolic processes. Plants and animals in deserts have special adaptations to protect themselves or preserve a sufficient amount of water in their bodies for life to proceed under optimal conditions. If they do not have access to water, they enter a state of anabiosis - summer (or winter) dormancy - until living conditions become optimal for them. Another aspect is the existence of adaptations in all species of organisms to live in water or obtain it - and if necessary, to store the water required for their metabolism (if they live in terrestrial environments).

Seas and oceans are immense bodies of water that sustain all forms of life and serve humanity to obtain their food (the plants they cultivate, domestic animals whose meat they consume, fish that constitute the basic nutritional element for some populations, etc.).

Most of the products that support the global economy are circulated and transported on seas and oceans, and the largest human settlements are located along their shores, even in the present, in the era of air transportation.

Freshwater is used for drinking, as well as for a wide range of industrial, recreational, or medical activities. Freshwater is also used to dispose of waste resulting from the multitude of human societal activities. Water provides crops with the humidity stored in soils, ensuring the subsequent development of agricultural cultures. And the examples can continue.

Liquid water also has an unpleasant component: in seas and oceans, the action of waves can cause the sinking of ships created by humans. Waves erode coastlines, affect coastal tourism, erode port structures, and destroy human-made crops (if they are planted too close to the shores). Flowing waters are one of the main factors eroding the lithosphere and especially the pedosphere. They can cause floods that may lead to changes in the course of water bodies, have destructive consequences on agricultural lands, and in some cases, thousands of people can drown. Water is capable of destroying human settlements or hydraulic engineering structures designed for proper management of inland waters, etc.

Since groundwater is one of the most important sources feeding surface waters, in areas where it is insufficient, it can lead to desertification, transforming surface lands into arid, unproductive areas, unsuitable for any human use. If used carefully, it ensures the irrigation of agricultural lands, provides us with quality drinking water, or serves as a medical water source for people suffering from various medical conditions (it is involved in a wide range of balneotherapeutic actions).

Water in the form of vapors provides us with breathable air, but also rains or snowfall on which much of humanity's activities depend. However, it is a fundamental component of air currents, creating storms, typhoons, and hurricanes, being one of the factors that make these aerial phenomena so destructive.

Water, in its three forms, is thus the most important environmental factor on our planet; it has beneficial and sometimes catastrophic effects, but without it we cannot live, nor can the whole living world. Whether we can use it rationally or prevent its undesirable effects is another matter.

2.4 Atmosphere

The Earth is surrounded by a layer of air, called the atmosphere. Earth's atmosphere is a layer of gases that separates the planet from the cosmic environment (Figure 30). The atmosphere is practically 100% gaseous. It is composed of air but also contains finely divided solid and liquid substances (or traces). In the air, mineral dust, pollen, spores, aerosols of human-made compounds (pollutants, pesticides, chlorine, fluorine, mercury, sulfur, methane, etc.) can be found. Airplanes pollute the atmosphere with gases produced from the burning of the fuels they use (Table 6) ("Atmosphere | National Geographic Society", "Atmospheric Composition", 2019; Auld, 2008; Lutgens 1995*)* .

Figure 30. Earth's atmosphere seen above the upper layer of clouds (https://en.wikipedia.org/wiki/Atmosphere)

The atmosphere protects life on our planet from harmful solar radiation, creating a greenhouse effect at the Earth's surface (if there were no atmosphere, the average temperature on the planet would be -18°C, but due to the greenhouse effect, it maintains optimal values, averaging around +15°C), and it reduces temperature differences that can occur between day and night, as is the case on planets with no atmosphere (Lutgens *et al.,* 1995).

Table 6. Characteristics and Components of Earth's Atmosphere (tornado.sfsu.edu)

Atmospheric pressure	101 325 Pa
The volume of the soil mass	1,217 kg/m^3
Total weight	5,148 × 10^{18} kg
Scale height	8,5 km
Average molar mass	28,97 g/mol
Azote N_2	78,084 % volume sec
Oxygen O_2	20,946 % volume sec
Argon Ar	0,9340 % volume sec
Carbon dioxide CO_2	413 ppm volume sec
Neon Ne	18,18 ppm volume sec
Helium He	5,24 ppm volume sec
Methane CH_4	1,79 ppm volume sec
Krypton Kr	1,14 ppm volume sec
Hydrogen H_2	550 ppb volume sec
Nitrous oxide N_2O	300 ppb volume sec
Carbon Monoxide	100 ppb volume sec
Xenon Xe	90 ppb volume sec
Ozone O_3	0 à 70 ppb volume sec
Nitrogen dioxide NO2	20 ppb volume sec
Iodine I	10 ppb volume sec
Water vapor H_2O	~ 0,4 % volume global ~ de 1 à 4 % en surface (valeurs typiques)

Its most important property is that it contains oxygen in its gaseous form, without which life on Earth would be impossible. At the same time, the atmosphere acts as a protective shield against meteorites, heat, and solar radiation. The atmosphere contains a significant amount of water, either in the form of invisible vapors or as clouds (which are formed from tiny water droplets, snowflakes, or fine ice crystals). Water vapors are the source of the rains that fall from the clouds formed in the atmosphere.

Despite fluctuations in solar radiation, the Earth's surface temperature has remained relatively constant over geological eras. This indicates the existence of a dynamic process governing the Earth's temperature through a combination of the greenhouse effect and atmospheric and surface albedo.

The Earth's mass allows gravitational attraction to maintain an atmosphere around the planet. Water vapors and carbon dioxide in the atmosphere create a greenhouse effect that ensures a relatively constant surface temperature. If Earth were smaller and had a thinner atmosphere, extreme temperatures would exist, allowing water accumulation only in polar ice caps (as is the case on the planet Mars).

Over billions of years, the concentration of carbon dioxide has experienced significant fluctuations due to internal, external, biological, and anthropogenic factors.

The "Kármán line," located approximately 100 km above the Earth's surface, is considered the boundary between the atmosphere and outer space (Figure 31). The altitude of 120 km marks the limit beyond which atmospheric effects become noticeable for any solid object entering Earth's atmosphere.

The atmosphere is influenced by the rotation of the Earth-Moon system, as well as interactions between our Moon and the Sun.

2.4.1 Formation of Earth's Atmosphere

Approximately 4.56 billion years ago, when the Earth was formed, hydrogen and helium were the dominant gases in the planet's outer layers. As the Earth cooled down, these two gases, due to their chemical properties, density, and specific weight, dissipated into the cosmic space around the planet (Lutgens *et al.,* 1995).

The current Earth's atmosphere originated from gases extracted from the lithosphere after the planet's formation. Under the influence of the slow cooling process of the planetary mass and extremely intense volcanic activities resulting from the thermonuclear reactions occurring beneath the Earth's crust, elements or simple chemical compounds, lightest in nature, were brought to the surface through volcanic eruptions. These elements were present in the following proportions: water (80%), carbon dioxide (10%), hydrogen sulfide (7%). This combination of gases can still be found in volcanic emissions and eruptions today.

Throughout Earth's geological history, its atmosphere has evolved under the influence of several factors: the dissipation (volatilization) of a portion of atmospheric gases into cosmic space, the release of gases from the lithosphere through volcanic activity, and the molecular dissociation (splitting) of compounds from the lithosphere and hydrosphere.

With the cooling of the Earth's crust, water vapor condensed and fell onto the surface of the crust in liquid form (as rain), but it almost immediately re-evaporated and returned to the atmosphere. For a long period of time, there were intense and continuous warm rains, resulting in an atmosphere dominated by water vapor. As the temperature on the Earth's surface decreased, water vapor condensed more slowly and began to accumulate in its depressions. This marked the beginning of the formation of the planetary ocean. The temperature of the liquid water steadily decreased; it dropped from 100°C to temperatures ranging gradually from +4 to +50°C (the highest density of water), and then further decreased below 0°C (the freezing point of water). The temperature of Earth's waters was not uniform.

It varied depending on the thickness of the crust, the planet's exposure to solar radiation (day-night cycle), the thickness of the water layer, the distance from the sun, etc. Intense ultraviolet radiation led to a photochemical decomposition of water molecules, methane, and ammonia, releasing nitrogen and carbon dioxide into the atmosphere. This process changed the primary composition of Earth's atmosphere, with nitrogen becoming dominant and carbon dioxide taking the second place. Since nitrogen is chemically inert, its proportion in the atmosphere remained unchanged later on.

After the emergence of life and with the development and diversification of forms, some bacteria developed the process of photosynthesis out of the necessity to enhance the efficiency of energy acquisition that sustains life. This process utilizes solar energy to split carbon dioxide and utilize water molecules, releasing oxygen (the resulting carbon was used to create specific organic substances for living organisms). The released monoatomic oxygen immediately formed oxygen molecules (O_2), which dissolved in the planetary ocean's water. Once this gas became saturated in the ocean waters, the excess began to escape into the atmosphere, rising from the water in the form of gas bubbles. This process occurred continuously. Over time, oxygen molecules also became a permanent component of the atmosphere. Initially, oxygen had an extremely low concentration, but gradually its quantity increased, reaching over 21% at present. As its production intensified, photosynthetic and aerobic oxidizing organisms predominated, becoming dominant on the Earth's surface (see the evolution of life on Earth). Currently, the intensity of oxygen production for the atmosphere is in balance with the amount of carbon dioxide released by living organisms in respiration processes and the production of organic compounds synthesized by them.

With the emergence and increase in the concentration of oxygen in water and the atmosphere, oxides of various chemical elements appeared, which currently play a significant role in the processes occurring in the lithosphere and hydrosphere.

About 350 million years ago, a portion of the oxygen, through the ionization of the upper layers of the atmosphere and under the influence of solar radiation and cosmic rays, formed an ozone layer (O3). Ozone, an allotropic form of oxygen, currently protects Earth from the harmful effects of ultraviolet rays originating from solar radiation on living organisms. Since then, the composition of the atmospheric air has remained relatively stable.

2.4.2 Atmospheric stratification

The Earth's atmosphere has a mass of approximately 4.9×10^{18} kg and is composed of several layers, with the upper part of each layer ending in a region called the 'pause' zone (Lutgens *et al.,* 1995). These layers are depicted in Figure 31.

•Troposphere. It extends from sea level to the level of seas and oceans, up to 8 km above high mountains and in polar regions, up to 17 km at the tropics, and may vary depending on meteorological or seasonal factors. It has an average thickness of about 11 km (1/600 of Earth's radius of 6,371 km). The troposphere constitutes approximately 90% of the total mass of the atmosphere (including the tropopause). All known meteorological phenomena occur in the troposphere (air currents, cloud formation, solar light filtering, the suspension of dust and pollutants from the Earth's lithosphere and pedosphere, etc.). Therefore, the troposphere is the most turbulent, changing, and tumultuous layer of the Earth's atmosphere. In the troposphere, air opacity is the highest. Here, solar radiation is most strongly retained by water particles in the form of vapor, liquid, or ice (all of these forms create clouds that shade the Earth's surface, fall on it and moisten it, or cover it with a layer of snow or ice). Opacity also depends significantly on the finest dust particles brought into the troposphere by ascending currents of warm air, especially emissions of dust from volcanoes erupting from the lithosphere.

•Stratosphere – this atmospheric layer is situated between 7 and 50 km (including the stratopause). The ozone layer is formed in this layer. The ozone layer is located in the stratosphere, but it consists of oxygen molecules formed with three atoms of oxygen (O3), as a result of the action of ultraviolet radiation from the sun on oxygen molecules (O2). Chemically, ozone is an unstable molecule, but under the conditions where it forms in the stratosphere, it has a long lifespan. The ozone layer forms a thick layer of about 20-40 km and has a concentration of up to 20 ppm.

• Mesosphere is situated between 50 and 80 km (including the mesopause).

• Thermosphere (also called the "ionosphere") is located between altitudes of 80 and 640 km. The term "thermo-" is related to the relatively abrupt increase in temperature with altitude, and "iono-" is related to the ionization phenomenon of existing oxygen and nitrogen atoms, which become good conductors of electricity and can influence radio transmissions.

•Exosphere extends from 500 - 1,000 km to approximately 100,000 km. It marks the transition from the Earth's atmosphere to interplanetary space.

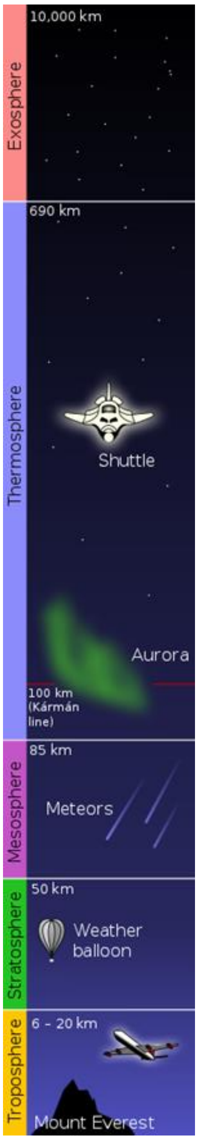

Figure 31. The Stratification of Earth's Atmosphere

Main characteristics should be presented in Table 7.

Table 7. Principal characteristics of the atmosphere on earth since 1976 (Auld, 2008)

Layers (in ISA) Layer	Name	Altitude geopotential at the base h (in km)	Altitude geometric at the base z (in km)	Gradient of temperature α (in °C/km)	Temperature at the base layer T (in °C))	Pressure at the base layer p (in Pa)
0	**Troposphere**	0,0	0,0	−6,5	+15,0	101325
1	**Troposphere**	11,000	11,019	+0,0	−56,5	22632
2	**Stratosphere**	20,000	20,063	+1,0	−56,5	5474,9
3	**Stratosphere**	32,000	32,162	+2,8	−44,5	868,02
4	**Stratopause**	47,000	47,350	+0,0	−2,5	110,91
5	**Mesosphere**	51,000	51,413	−2,8	−2,5	66,939
6	**Mesosphere**	71,000	71,802	−2,0	−58,5	3,9564
7	**Mesopause**	84,852	86,000	—	−86,2	0,3734

Temperature on Earth's atmosphere varies significantly across its different layers. In the troposphere, it decreases from the Earth's surface (where it is approximately +15°C) to -56°C. Then, in the stratosphere, it increases to about -2.5°C, likely influenced by the presence of the ozone layer, which imparts a greenhouse effect to the atmosphere. In the mesosphere, the temperature drops again to around -86°C, and in the thermosphere, it increases once more to about -40°C. In the exosphere, the temperature is akin to that of outer space, just slightly above -250°C (Figure. 32).

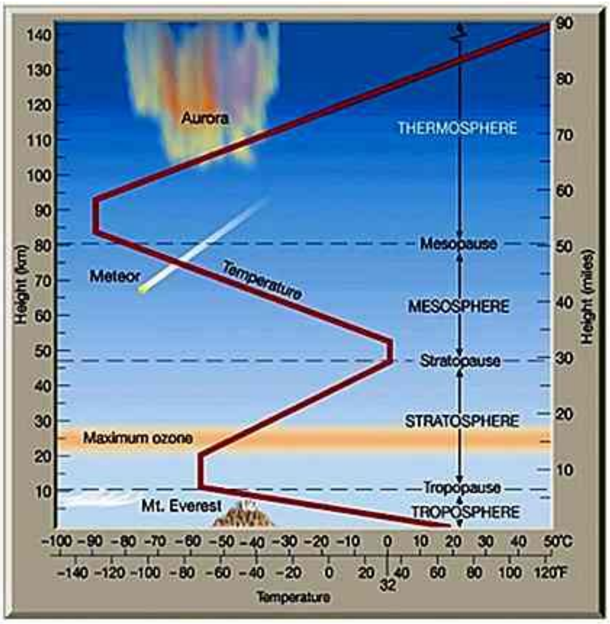

Figure 32. Vertical temperature profile in different layers of the atmosphere (https://en.wikipedia.org/wiki/Atmosphere).

The atmospheric pressure at the planetary ocean level is 1 atmosphere (a value conventionally given by humans to measure the weight of a column of air from the stratosphere to the ocean water level). It is the direct result of the total weight of the air above a specific location on the surface of our planet. It varies depending on location, altitude, time, and the speed of air currents. Pressure is highest at sea and ocean levels and decreases exponentially with altitude (on the highest mountains, for example, on Mount Everest, it decreases to about 50% of the pressure at sea level).

The colors of the atmosphere are due to the scattering of air, water particles, and various mineral or organic particles that reach the atmosphere. The rainbow is caused by the separation of solar radiation into its seven basic components.

The northern lights (auroras borealis) result from the interaction between solar wind particles and the upper atmosphere, influenced by the Earth's magnetosphere.

2.4.3 Other aspects of our planet's atmosphere

The atmosphere is the Earth's most uniformly distributed covering. Like everything that happens on Earth, there is a periodicity to many processes occurring in the atmosphere. Observing the atmosphere over even relatively short periods, air circulation is constant; it is a characteristic that we normally refer to as "weather" (Commoner, 1980).

Atmospheric circulation is the movement of the air layer surrounding the planet, redistributing the heat coming from the sun in correlation with the planet's rotation and the vertical and horizontal circulation (ocean currents) of the planet's waters. The continuous fluctuation of the weather is determined by solar energy. When the sun's rays fall on the planet's surface, they carry energy that heats the components of the lithosphere, pedosphere, or hydrosphere. As a result, if all substances heat up, and the temperature of the lower layer of the atmosphere, the troposphere, rises, upward air currents occur. The cooler air above descends, giving rise to cool breezes or cold air currents. Heat absorbed by water, especially marine and oceanic, causes the liquid water to transition into its gaseous form (forming vapors) that rise into the atmosphere. Each gram of vapor in the atmosphere contains about 536 calories. This energy heats the air, thus generating winds. Depending on the speed of movement of warm and cold air, the wind speed can be lower or higher, and these, in turn, move the clouds. If the circulation of warm and cold air is very rapid, hurricanes and cyclones are born. Air currents are one of the most important factors influencing the climate in different regions of the planet, conditioning the way vital processes of organisms constituting the biosphere unfold.

Troposphere is the most crucial zone of the atmosphere because, although it is the thinnest layer, it has the highest density and the most fluctuating thickness: at the poles, it is only 7-8 km, while at the equator, it increases to 13-16 km (due to the centrifugal movement caused by the planet's daily rotation). The troposphere is the most turbulent layer of air, both naturally and under the influence of various human activities. Here, the variations in climatic conditions on the planet's surface are most pronounced, as well as the variations determined by the climatic conditions on its surface. The mixture of gases in the troposphere not only involves some of the components of these envelopes but also solid, liquid, and gaseous pollutants resulting from various human activities that enter the atmosphere. Therefore, the cold air currents that replace the warm, polluted air that rises are the ones that bring clean air to areas where humans, through their activities, degrade the chemical composition of the air, causing pollution. When the temperature drops, water vapor can condense (forming rain clouds) or even solidify (forming snowflakes or ice needles); now, latent heat is released, which in turn leads to a new rise of the air mass. This process determines a decrease in temperature with altitude (the so-called adiabatic temperature gradient). Airplanes still fly only in the troposphere, polluting it with gases.

Troposphere contains approximately 80% of the total mass of the planetary atmosphere, and half of it is located below 5.5 km altitude. This helps us understand why, when climbing mountains, air pressure drops rapidly, and people find it more difficult to breathe, with the inhaled air not providing enough oxygen for their physiological needs. Up to an altitude of 3 km, the air is the most polluted because air currents carry dust, fine particles, and microorganisms from the Earth. Here, clouds formed from water vapor or ice crystals move horizontally and vertically, human-made aircraft navigate, and the effects of volcanic activities on the Earth's surface are most strongly felt. Birds also fly in this layer.

Living organisms and their resistant forms (spores and cysts) can only be found in the troposphere. The upper layers of the atmosphere do not contain representatives of the biosphere. Moreover, it should be noted that among all the layers of the planet, the representatives of the biosphere are least represented in the atmosphere.

Comparatively, the atmosphere of planet Earth, especially the troposphere, is heavily influenced by water compared to the atmospheres of other celestial bodies. Water exists in all three forms here and creates clouds. These clouds shade the Earth's surface, reduce temperature and its fluctuations, and play a role in the negative impact of water currents resulting from precipitation and the intensity of airborne circulation of dust and fine sand from the lithosphere.

Carbon dioxide, although currently present in small quantities, has a special influence because it allows the passage of most solar radiation but retains infrared radiation. As mentioned above, solar radiation heats the Earth's crust, and warm air rises. However, carbon dioxide triggers the greenhouse effect, retaining heat that would otherwise dissipate into the upper layers of the atmosphere. In this way, carbon dioxide in the atmosphere acts as a giant energy valve.

At the beginning, when the planet was much warmer, carbon dioxide was abundant, and the greenhouse effect was much more significant. The greenhouse effect is the factor that led to massive, intense, and almost constant rains, resulting in the formation of the primordial planetary ocean.

2.5 Magnetosphere

The magnetosphere is the region around our planet where the dominant magnetic field is that of Earth (also called the geomagnetic field). This field originates from movements within the Earth's outer liquid core and can be likened to a magnet located inside the Earth. A planet's magnetosphere forms when there is a flow of electrically charged particles, such as the solar wind, interacting with the planet's magnetic field or that of a similar celestial body. Earth is surrounded by a magnetosphere, as are other planets with magnetic fields in our solar system (only Venus and Mars lack magnetospheres) (Gunell *et al.,* 2018; Blanc *et al.,* 2005; van Allen, 2004).

The Earth's magnetic field is generated by the convective movement of the outer core, which is primarily composed of liquid iron. It can be approximated as a dipolar field whose axis is inclined at an angle of approximately 11° to the Earth's rotational axis (Figure. 33). Over time, the Earth's magnetic field has been used by humans for terrestrial and maritime orientation (the compass needle itself is a dipolar magnet indicating the direction toward the geomagnetic north and south poles) (Van Allen, 2004; Tsyganenko, 1995).

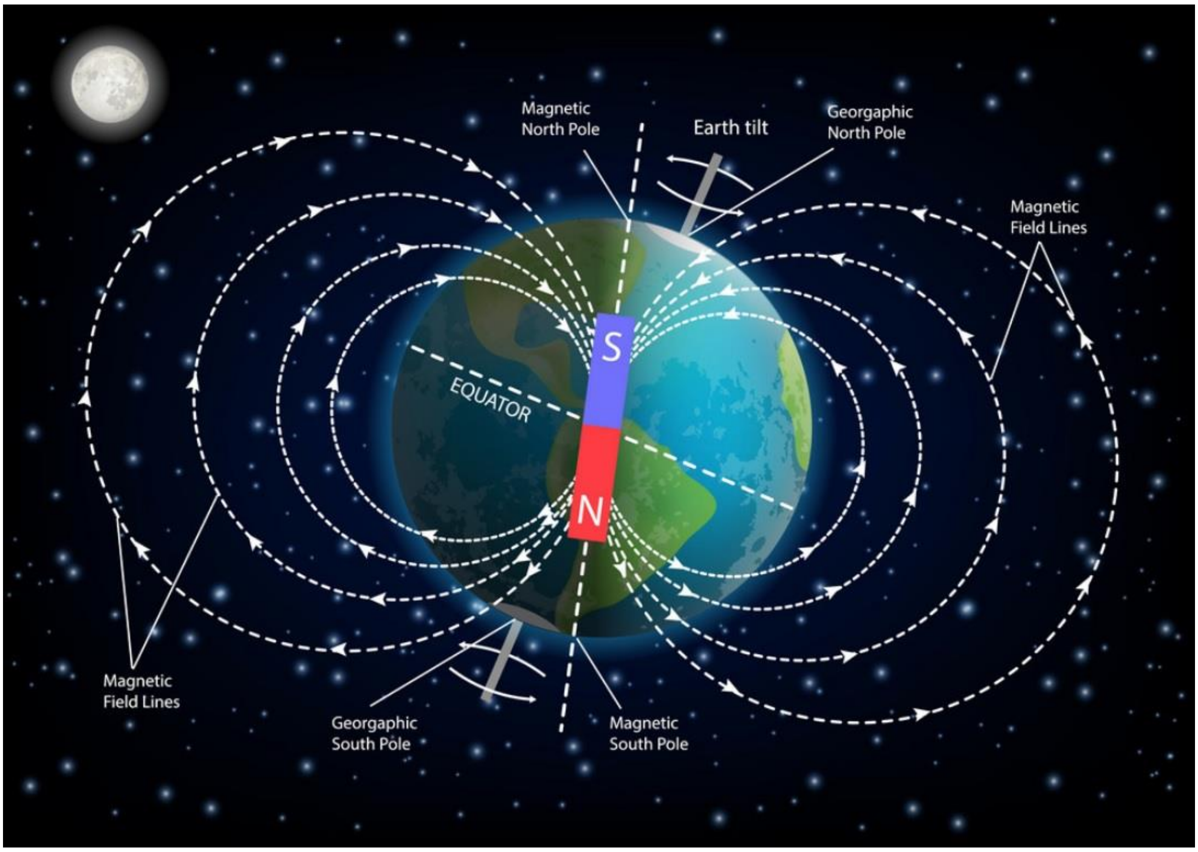

Figure 33. Earth's magnetic field *(*https://polarpedia.eu/ro/magnetosfera-pamantului)

The solar wind is a continuous stream of plasma emitted by the Sun into the entire interplanetary space (Blanc *et al.,* 2005). Its propagation speed near Earth is on the order of hundreds of km/s. Its action on the geomagnetic field has a compressing effect on it in the frontal region and an elongating effect in the anti-solar direction (Figure 33 and 35). This process gives rise to the magnetosphere, defined as the region around the Earth dominated by the action of the Earth's magnetic field ("Ionosphere and magnetosphere"*.* Encyclopædia Britannica*,* 2012; van Allen, 2004; Buis, 2021*).*The magnetosphere acts as an invisible shield for humans, protecting us from high-energy particles brought by the solar wind (Buis, 2021). Its upper limit is called the magnetopause, and its lower limit is the ionosphere – the ionized layer of the Earth's atmosphere. Although the magnetosphere plays the role of a protective shield, under certain conditions, high-energy particles from the solar wind can penetrate it through the regions above the magnetic poles, heading towards the upper atmosphere along the field lines. There, electrons from the solar wind collide with the oxygen and nitrogen atoms and molecules that make up the Earth's atmosphere. This interaction leads to a modification of their internal structure. After an extremely short time, a de-excitation process follows, emitting light of various colors and forms. This is how polar auroras are produced at the two ends of the planet: the aurora borealis (in the northern hemisphere) and the aurora australis (in the southern hemisphere) (Encyclopædia Britannica, 2021) (Figure 34).

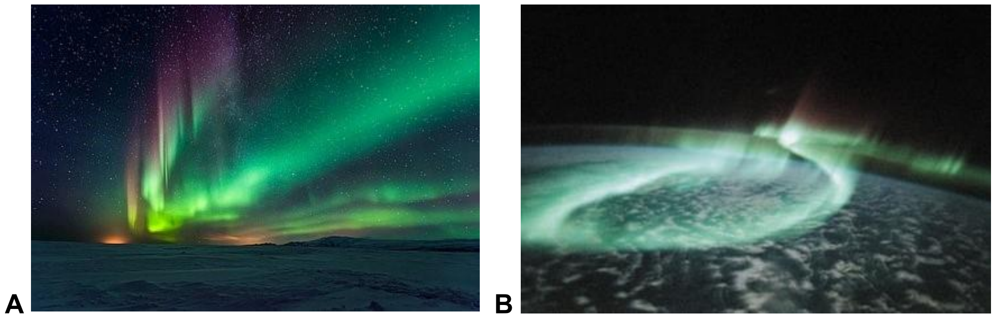

Figure 34. A- The appearance of an aurora borealis in Greenland (https://facerealumii.ro/magnetosfera-forta-invizibila/), **B**. The southern aurora of the earth seen from a spaceship (Ionosphere and magnetosphere – Magnetosphere, Britannica)

The Earth's magnetic field is generated by an electric current that circulates in the planet's outer core. As it flows through the metal core, this current inherently loses energy. The energy of its movement is dissipated as heat. This decline has been measured in real time over many years. It is estimated that in about 10,000 years at the most, even the strongest field would have to decay to zero, allowing cosmic rays to destroy all life on Earth. If cosmic radiation were allowed to bombard the surface of our planet, it would have extremely harmful effects on all life. However, the existence of the magnetosphere ensures that most of it will never reach us. This is due to the way a magnetic field exerts a force on a charged particle moving through it. The constant bombardment of the solar wind “compresses” the sunward side of the Earth's magnetosphere (Seki *et al.,* 2001; Gunell *et al.,* 2018).

The sun-facing side of the Earth's magnetosphere extends about 6-10 times the radius of the Earth. The part of the magnetosphere facing away from the sun extends in the form of a massive magnetic tail, fluctuating in length and can measure hundreds of Earth radii (Figure 35).

The Earth's magnetic field is generated by the geosphere and pedosphere and opposes the magnetic fields acting on the planet (both from the sun and other celestial bodies). It protects living organisms from the effects of cosmic radiation, thus enabling life to thrive on Earth. The Earth's magnetic field is sensed by many species of living organisms, especially plants and animals.

The Earth's magnetic field can influence the health of living beings, allowing the spatial orientation of many terrestrial and aquatic organisms. It forms the basis for the migrations of some species of mammals, birds, fish, worms, and marine cnidarians. Its perception by living beings guides them in some of these migrations for reproduction (such as salmon, eels, trout) or to avoid the negative effects of climate change (for example, it serves birds for orientation during their migrations over long distances, especially at night).

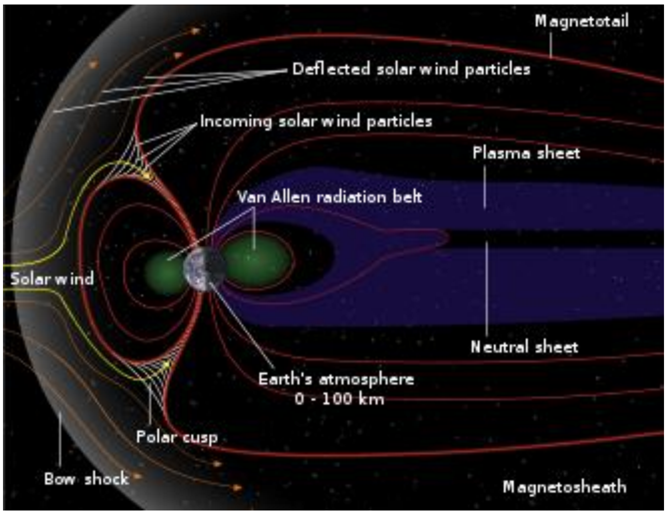

Figure 35. Diagram of Earth's magnetosphere (https://www.nasa.gov/magnetosphere)

2.6 Interactions between the components of the geosphere

The three main components of the geosphere - hydrosphere, atmosphere, and lithosphere - are closely interconnected, forming together with the living component of the planet (biosphere) a single functional system, the ecosphere. The uniqueness of our planet lies in the fact that it is the only one in the solar system where life exists. The emergence of life is a consequence of the existence of two essential elements: water and oxygen in the air.

The history of the Earth is also the history of its enveloping layers.

2.6.1 The role of energy from the cosmos on the toposphere

From the appearance of the planet and thereafter uninterrupted, Earth has received cosmic and geomagnetic radiations, and undergoes various influences from the solid masses of our solar system, as well as different energy emissions (across its entire spectrum, not just the visible spectrum - which everyone is familiar with (Dixon *et al.,* 2001; Dalrymple, 1991).

The planet protects itself from cosmic radiation through the presence of a fairly complex atmosphere, precisely as a result of the biosphere's tendency to act especially on the troposphere (with the help of water vapors) and the stratosphere (due to the ozone layer). These two have allowed the planetary biota to diversify and be capable of protecting the planet from the action of these radiations.

We can therefore speak of a wide range of radiations acting on the planet, but with which life on Earth has become accustomed, and therefore does not even notice them anymore. If any of them were missing, then we would certainly feel their absence immediately.

After the radiations in the visible light range, the most important ones are solar magnetic radiations, but they have long been attenuated by our planet's magnetosphere, so we no longer realize that we are "missing" them or that they are greatly attenuated.

A second category of radiations, those originating from our sun (thermonuclear in origin), are also greatly attenuated by the structure of our planet's atmosphere.

2.6.2 Simple Interactions

Interactions Between the Planet's Core and Lithosphere

Planet Earth is distinguished by the presence of a lithosphere in the form of rigid plates arranged adjacent to each other. Due to the pressure exerted by these plates on the mantle, constant horizontal and vertical movements occur, along with collisions and friction between plates. These phenomena lead to a permanent fracturing of the Earth's crust plates and continuously generate earthquakes of varying degrees of intensity.

Inside the planet, nuclear reactions take place in which atoms are constantly formed and dissociated. These reactions are exothermic, resulting in extremely high temperatures within the planet. The mantle is in a liquid state, while the lithosphere is solid, with varying thicknesses. At its surface, the lithosphere reaches an average temperature of about +15°C. However, as we delve deeper into the lithospheric layer, the temperature increases, reaching approximately 1,100°C at the interface between the lithosphere and mantle.

At the contacts between the plates of the lithosphere there are cracks through which molten lava rises from the mantle, which, due to the friction of the plates, often comes out with great pressure (in these places there are active volcanoes and geysers with boiling water).

All energy phenomena that occur on planet Earth are due to the interactions between the effects of solar energy and those of the Earth's internal energy.

Interactions between the Lithosphere and Hydrosphere

There are several hypotheses regarding the origin of Earth's water. It is considered that water was released from the mantle and Earth's crust approximately 4 billion years ago. Initially, the volume of the oceanic hydrosphere was only about 20 billion km3. Through the release of water from the mantle, it gradually increased, and currently, the estimated volume of free water is 1380 billion km3. Of this volume, 97% is stored in the planet's oceans, approximately 1.7% belongs to glaciers and permanent snow, 1.2% is groundwater, and the remaining 0.1% of the water on the planet is distributed among other components of the hydrosphere (freshwater on the terrestrial environment and stored in living organisms).

Volcanoes release a large amount of particles into the atmosphere. These particles serve as nuclei for the formation of water droplets (and thus precipitation). This is evidenced by the fact that precipitation intensity usually increases following volcanic eruptions. Eruptions entrain dust, powders, and other small materials thrown into the atmosphere by volcanoes, which dissolve some of the gases released by the volcanoes.

The lithosphere is not a strict boundary for the hydrosphere, as water penetrates into the Earth's crust through its fissures and cracks in the ground (fissures and voids in the lithosphere), forming underground water deposits. Through the direct or indirect actions of water, the Earth's crust takes on different aspects and can undergo noticeable changes. Regardless of its state of matter (liquid, solid, or gaseous), water is one of the most active external shaping factors of its surface. By entering the fissures or porosities of rocks, water mediates some of the preliminary processes of erosion, namely mechanical disintegration and chemical decomposition. This gives rise to phenomena such as scree, karst formations, weathered crust, etc. In colder regions, another form of disintegration is caused by the freezing of water, resulting in the formation of preglacial relief.

The connections between the hydrosphere and the lithosphere are multiple:

The lithosphere provides the support on which water can exist in all three states of matter:

- *liquid* (in seas and oceans, watercourses, lakes, ponds, marshes, in the pores and fissures of rocks, etc.),
- *solid* (in glaciers, permanent snow),
- *gaseous* (in water vapor in the atmosphere and in rocks).

The lithosphere, through its dynamics, contributes to altering the contours of stagnant waters (their shapes and dimensions). For flowing waters, the lithosphere's action in changing the altitudes of the terrestrial substrate determines the slope, course, and speed of flow (which, in turn, influences the intensity of erosion and sedimentation processes).

The lithosphere, through its geothermal characteristics or magmatic phenomena, contributes to changes in the temperature of water and even to its transition from a liquid state to a vapor state.

Erosion is the geological process by which the lithosphere and/or soil material are fragmented and transported by water. Erosion leads to changes in the landscape, coastal or oceanic shores. The material resulting from erosion occurring within an aquatic basin is carried by flowing water, and when the water current decreases, depending on the size and weight of the particles, they gradually settle on the bottom of the respective aquatic basin under the influence of gravity.

Sedimentation is the process of depositing particles carried by water. This process occurs as a result of certain forces (gravity, centrifugal force, or electromagnetism) acting on solid particles in rainwater or flowing waters that are brought to the surface of the lithosphere from its depths.

Clogging is the process of depositing material carried by flowing waters, resulting in the gradual elevation of the bottom of a basin or a portion of a channel due to a decrease in water flow velocity, etc. The clogging process is accelerated during floods. The transiting waters carry a high discharge of suspended solids; moreover, they transport downstream quantities of sediments entrained from previously deposited areas in confluence zones—sediments that, under normal water discharge, were not mobile. Clogging involves the deposition of eroded material by water from the lithospheric substrate through which it flows. The result of the clogging process is the elevation of the bottom of the respective basin or a portion of the channel. Ultimately, this leads to the disappearance of the watercourse, its diversion onto a different path, or the creation of new, dry land. This dry land gradually goes through the following phases: initially becoming a marshy area, then a wetland, and finally evolving into dry land where typical terrestrial plants grow.

Solifluction is the sliding of the superficial layer of soil and the superficial layer of bedrock's fractured strata. It occurs under the influence of infiltrating groundwater.

The hydrosphere represents a primary shaping agent on the Earth's crust with a triple action: erosion, transportation, and accumulation, especially in liquid (but also solid) state. Water plays a very important role in the unfolding of all geophysical and geochemical processes on the planet. Regardless of its state of aggregation, water is one of the most active external shaping factors of its surface. By penetrating into the fissures or porosities of rocks, water mediates some of the preliminary processes of erosion, namely, mechanical disintegration and chemical decomposition. In this way, scree, karst phenomena, weathered crust, etc., are formed. In cold regions, another form of disintegration is caused by the freezing of water, giving rise to pre-glacial relief.

The hydrophysical action of water (its mechanical action) is just as important as its hydrochemical action. It consists of the disaggregation of rocks through freezing and thawing, through denudation, runoff, erosion, transportation, and the deposition of alluvium.

The hydrochemical action manifests in dissolution processes, highly dependent on the solubility of various rocks. It is more active in salt, gypsum, limestone, marl, and calcareous clays. Among the chemical actions of water, the most common ones are hydration and oxidation. The hydration processes give rise to gypsum and a series of silicates with importance in agriculture. Oxygen in water promotes oxidation processes, which are crucial in mineralization. Carbon dioxide in water causes the decomposition of silicates into different elements (clays or sands). Through this process, volcanic rocks transform into sedimentary rocks. The hydrochemical action of water is even more evident during water circulation, where, through evaporation, the concentration of certain salts increases significantly (it is estimated that approximately 2.3 billion tons of salt and calcium carbonate are annually deposited in oceanic and marine basins). Springs with mineral water result from the water's dissolution action on various salts present in the rocks it traverses.

- Water contributes to the disaggregation and alteration of the Earth's crust because:
- It destroys, but also creates many of the relief forms of the lithosphere.
- It is the largest absorber and emitter of heat.
- It is the main link in the water cycle in nature.
- It is the primary means of reducing temperature extremes that can occur between the thermal energy from the depths of the Earth, solar thermal energy, and the extreme cold present in the cosmic space through which our planet circulates.
- In coastal areas, the interaction between the lithosphere and hydrosphere leads to an increase in the crust of the lithosphere.

The Earth's own energy, generated in the lower layers of the ocean during underwater volcanic eruptions and associated earthquakes, causes changes in the submarine relief and is the trigger for tsunamis. During volcanic eruptions there is an underwater flow of volcanic solids and gases into the ocean. The changes are associated with the accumulation of sedimentary layers.Soil can be washed off the lithosphere under the action of precipitation. The soil, reaching flowing waters, is entrained and carried downstream to places where water flows slowly; here, its deposition begins in the form of mineral and organic sediments. There are cases where the adsorption properties of the soil can form a kind of "barrier" that protects waters against pollution.

Waters are a fundamental agent in the formation and leveling of relief forms on the Earth's surface. Turbulent water moistens the soil and modifies the Earth's surface.

Interactions between the lithosphere and the atmosphere

The connections of the hydrosphere with the atmosphere are also multiple:

Water exists in the atmosphere in various forms: solid, in vapor form, and liquid (through droplets forming clouds and generating rainfall).

Water contributes to the water cycle in nature.

The main gaseous elements of the air (oxygen and nitrogen) dissolve in water and together contribute to sustaining life.

It is estimated that if snow covered the entire Earth, its average surface temperature, currently around +15°C, would drop even to -88°C, although the average temperature of the lithosphere's surface would be +40°C in the absence of water. This doesn't happen because water vapor, in the form of steam, globally produces a so-called "greenhouse effect."

The result of the interaction between the lithosphere and hydrosphere in coastal areas leads to an increase in the thickness of the lithosphere over time. Gravity plays a significant role in the formation of sediments in the lithosphere and the relief in flat areas.

Water vapor in the atmosphere easily penetrates the pores and fissures of rocks, acting upon them through physical or chemical means.

Interactions between the hydrosphere and the atmosphere

The primary source of geographically significant processes is the sun's energy.

Its uneven distribution on the Earth's surface causes significant spatial differentiation and various geographical natural conditions.

Surface currents in oceans are set in motion by prevailing winds. The upper layer of the ocean is a strong absorber of thermal energy from the atmosphere. In contrast, in the lower layers of the water, a process of dissipation of thermal energy occurs. Because the heat capacity of air is much lower than that of water, when air comes into contact with the water surface, heat is lost to the atmosphere, leading to a reduction in the surface layer temperature of the ocean.

Trade winds create current systems that transport warm water away from the Equator and cold water towards it. Cold ocean currents near the coast contribute to the formation of coastal deserts because the air masses near the water are cooler than the air above. Moist air does not rise, and therefore, clouds do not form, resulting in little to no rainfall. Without warm ocean currents, several regions of the globe would have a colder climate, as the air currents above them warm and dry out. A well-known component of this massive water transport system is the Gulf Stream.

The atmosphere is heated by sunlight falling on the Earth's surface. The atmosphere protects all living things on Earth from the harmful effects of ultraviolet radiation from the sun and cosmic rays.

Evaporation, more intense above seas than over land, influences and conditions the vapor masses in the atmosphere, cloudiness, and precipitation, which are more abundant in maritime climates than in continental ones. The role of a "heater" played by maritime basins in the cold season for the atmosphere and the adjacent coastal areas is well-known. Marine breezes during the day and night are also a consequence of the differential heating and cooling of the sea and land. Therefore, on the coast, compared to the interior of continents, autumns are longer and warmer, and springs are later and cooler.

The thermal regime of the atmospheric envelope is directly influenced by the distribution of oceans and land (continents). Water and land behave entirely differently in response to solar radiation. In seas and oceans, there are vertical and horizontal currents that sometimes circulate over distances of thousands of kilometers, allowing the mixing of large quantities of water with different temperatures and their subsequent homogenization.

The thermal regime of the atmosphere and pedosphere can determine certain characteristics related to the qualities of water. In turn, water plays a very important role in local, regional, and global climate. Under the influence of solar rays, water heats up more slowly than land but also releases accumulated heat more slowly. Compared to solar rays that stop at the surface of the soil, those penetrating into water (in rivers, lakes, seas, and oceans) can reach very deep depths, distributing their heat to a considerable mass of water.

From these few examples, it can be observed that there is a close interdependence and interaction between the two envelopes, the hydrosphere and the atmosphere, mutually conditioning each other.

The atmosphere is a major supplier of carbon dioxide, nitrogen, and oxygen to the ocean. In the cold water of the oceans, it is one of the best solvents for carbon dioxide. At higher latitudes, this gas is absorbed more intensively.

The atmosphere contains a large amount of water, either in the form of vapor or as clouds. Clouds are formed from small water droplets or fine ice crystals. The latent energy received by an atmosphere with water vapor ensures the movement of air masses.

Liquid hydrosphere is one of the fundamental factors that make the existence of the planet and organic life possible. It strongly influences all other components of the Earth's surface, determining the amount of water needed in the atmosphere, causing the condensation and sublimation of water vapors, the formation of clouds and atmospheric precipitation, optical and electrical phenomena, etc.

An important contribution to the increase in the percentage of greenhouse gases in the atmosphere is the heating of the Earth's surface - a process estimated to increase the evaporation of surface water and accelerate the hydrological cycle. In turn, a warmer atmosphere can retain more water vapor.

2.6.3 Interactions among multiple components of the geosphere

The three components of the geosphere, the hydrosphere, atmosphere, and lithosphere, are closely interconnected, forming together a single functional system. All their interaction processes can be divided into two groups:

- Circulating substances - substances involved in processes occurring between the atmosphere, hydrosphere, and lithosphere. The water cycle connects them all, forming a closed system: ocean - atmosphere - lithosphere;
- Substances that circulate very slowly or not at all - substances existing mainly in the lithosphere, which humans extract for use in technological processes invented by them. Examples include gold, titanium, zirconium, and many other heavy elements.

More details will be provided in the Ecosphere chapter.

3 BIOSPHERE

The biosphere is the covering of the planet made up of living organisms that occupy and interact physically and functionally with the four major components of the toposphere: the lithosphere, the pedosphere, the hydrosphere and the atmosphere (Figure 36).

It is the result of a long process of evolution, started about 3.8 billion years ago, which continues even now and which was permanently influenced by three major factors: the cosmic ones, the biotic factors and the abiotic factors on earth. In the course of this evolution, they appeared, they diversified, and now there are more than 14 million species of living things (although over time paleontologists have discovered that among the living things of the planet, over the eons, almost 99% of the species have disappeared who at some point spent their lives on our planet).

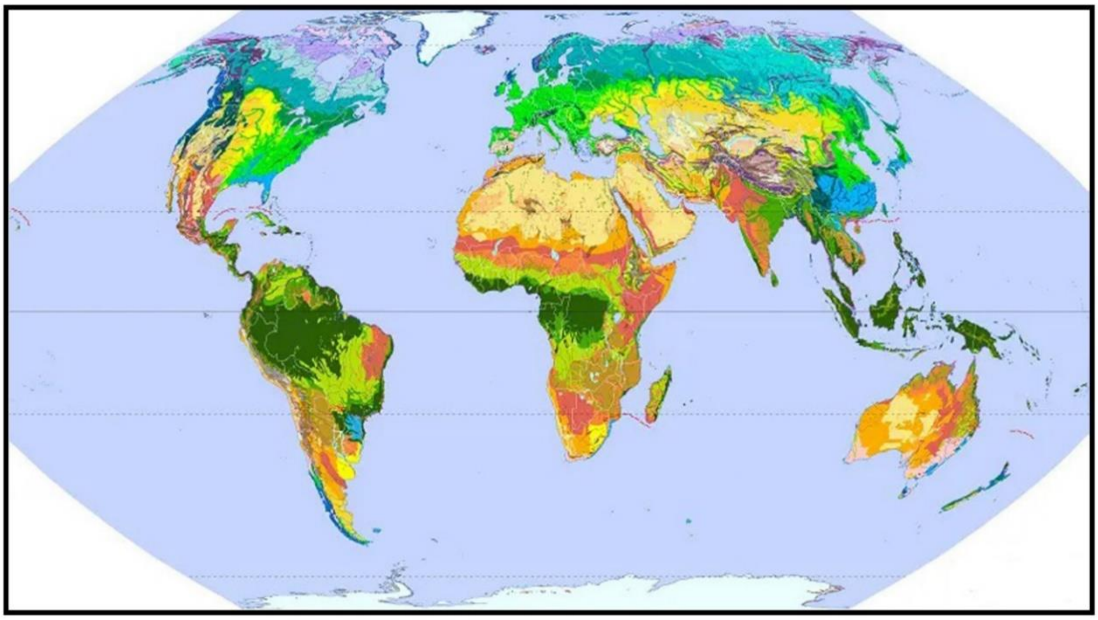

Figure 36. Terrestrial biomes of the planet (https://www.meteorologiaenred.com/ro/biomas.html)

The living world is, in all its forms, extremely diverse. It now consists of billions of species of organisms, each represented at a given time by an immensity of individuals. These species live associated in a wide range of associations (called biocenoses), which integrated with their biotic environment (biotope) constitute different ecological systems that exist on our planet. The totality of biocenoses forms several other supertypes of associations that cover most of our planet: biolandscapes, biomes and biogeographic areas (Botnariuc, 1967; Godeanu *et al.,* 2010; Godeanu, 2012).

The term "biosphere" was proposed by the Austrian geologist Eduard Suess as early as 1875. Later V.I. Vernadsky had an important contribution to the development of the theory of the biosphere (Botnariuc, 2003), but he, by the biosphere, understood the living shell of the planet which is intrinsically linked to the non-living environment, so exactly what we now call the ecosphere. This confusion unfortunately continues even now, causing great theoretical and practical disputes between biologists, geographers, ecologists and conservationists.

The criteria for analyzing the state of a living system are very heterogeneous. Biology has long ceased to be a descriptive science, and nowadays any organism represents a complex embryological, anatomical, physiological, temporal and distinct informational unit (Şerban, 1986). The particularities of the nervous influx, the coordination of the body's components and ensuring the stability of the internal environment (on a hormonal and cerebral basis) also raise special problems.

All living organisms exist on the border of two diametrically opposed tendencies: *seclusion* (separation from the environment of material structures specific to life, plus the creation of an internal environment favorable to the perpetuation of those structures) and *integration* (the ability to adapt to the environment and to evolve in accordance with the incessant transformations of it). The aforementioned regulatory mechanisms all work towards maintaining optimal parameters of all body functions.

Homeostasis preceded evolution. It is apparently at odds with evolution because it is constantly searching for a more appropriate homeostatic state, able to respond optimally to constantly changing environmental factors. Viewed in this way, evolution is nothing more than an uninterrupted transition from one homeostatic state to another, states that in turn depend on the integrity and self-regulating capacity of these systems, as well as on their existence in specific material forms. So it can also be said that life is the homeostatic form of existence of matter. Here a demarcation can be made between living systems (which maintain their integrity and functionality unaltered, regardless of how external factors act - within certain limits-) and non-living systems (whose state changes depending on the change of environmental factors).

All processes resulting from the ability of living matter to maintain itself in precise forms have a double determination: material and temporary.

Throughout the eons, the particular nature of the biosphere is the main mode of manifestation of living matter. This feature clearly distinguishes it from the other earth's shells. Living matter, according to Vernadsky*, "spreads over the surface of the earth and exerts a certain pressure on the environment, bypasses the obstacles that prevent its progress or take possession of it."* The energy produced by life manifests itself in the transfer of chemical elements and the creation of new living beings. According to V.I. Vernadsky, the geochemical energy of life is expressed in the movement of living organisms through reproduction and specific metabolism, which is constantly unfolding in the biosphere. The multiplication of organisms produces the "pressure of life" on the other non-living envelopes of the planet. In this sense, a complex interaction is born between organisms for space, food, obtaining energy and especially "for gas (the free oxygen necessary for breathing)" (Botnariuc, 2003).

Time is the most beautiful fiction born of the human mind. Time is not independent, nor is it contained in the structure of physical or chemical phenomena that occur in the Universe. It is only the result of human experience, a conclusion stemming from the observation of the sequentiality and repetitiveness of natural phenomena. If we want to establish the correct sequence of events of how life unfolded on Earth, we must resort to relative units.

"To be alive - noted Vernadsky *- means to be organized"* (Vernadsky, 1986).

3.1 The emergence and evolution of the biosphere

The issue of the emergence and evolution of the biosphere has concerned researchers in the field of biology for a very long time.

If at first the creationist idea prevailed, of the creation of life in several stages by a deity, gradually voices appeared that doubted this and believed that life appeared on earth from the moment when the conditions favorable to the realization of this process arose on natural bases.

There was also the view that the primordial germs came to earth from the cosmos, either naturally (brought accidentally by meteorites or other solid bodies from the cosmos), or that our planet was intentionally seeded by entities more evolved than us who came from other planets, where life had appeared earlier, and the humanoids on these planets were already capable of creating life forms with well-established characteristics. These ideas were determined by the fact that life on our planet possesses, from the beginning, certain very well-determined characters, which did not have many variants (as would happen if life had spontaneously appeared here on earth). Among these we mention the fact that all organic compounds in the living world rotate in polarized light only to the left (they are levorotatory), while chemists found that many organic compounds synthesized in the laboratory can also rotate to the right (they are dextrorotatory). Why does life only have levogyric compounds? Why are there no dextrorotatory forms in nature? If they existed, how did they all disappear?

The energy taken by living things from the environment is controlled by a single (unique) substance – adenosine triphosphate (ATP), etc. The same questions can be asked as in the situation presented before. Another question is why is life based only on an extraordinary variety of carbon compounds and not on compounds of other elements, such as silicon? Of course, there have been many debates on these issues, and the pro and con answers will never end.

We join the ideas according to which our planet was formed about 4.5 billion years ago. In the beginning the Earth's atmosphere was of a reducing type and the Earth's gravity was very weak. Moreover, the surface of the planet received very strong UV radiation from the sun, and the atmosphere contained a lot of carbon dioxide that created the greenhouse effect. Either these two ensured a high temperature on Earth for a long time. As a result of the high temperature, the water was mostly in the form of vapors, which formed thick and dense clouds. Over time, as the planet cooled, the vapors condensed and water fell from the atmosphere onto the surface of the planet in the form of endless rain, which led to the formation of the planetary ocean.

Because the earth's crust was thin, under the action of thermonuclear reactions in the earth, the primary ocean at the beginning would have had a high temperature. In addition, the very chemical composition of its waters was very different from today. Many bicarbonates of iron, calcium, and manganese were dissolved in the water, and very small amounts of sulfates and phosphates. The chemistry of the waters was also strongly influenced by the impact with meteorites and metallic asteroids that bombarded the young planet and that caused an increase in the concentration of certain elements in the waters, some of them becoming catalysts in prebiological chemical processes. In the planetary ocean or in very wet sources of emissions of substances and gases from the primitive lithosphere life arose.

It is now well established that living organisms make permanent exchanges of substance and energy with their surroundings. Moreover, they all transmit their own characteristics to their offspring with high fidelity - and always through the same biochemical mechanisms -, and all have the capacity for self-organization, self-improvement and adaptation to the environment (all this proving the existence of a permanent biological information, transmissible through DNA their from one descendant to another).

Commoner (1980) found as early as 1972 based on the research of chemists and biochemists that all living organisms are almost always made up of four elements: carbon, hydrogen, oxygen and nitrogen. These were predominantly found in the planet's primordial atmosphere and lithosphere. The characteristic feature of any organic compound is that the bonds between the carbon atoms are tetravalent and are arranged in a chain (which can be straight, branched or take a ring form, being made up of 6 carbon atoms). Within these networks, carbon also includes other atoms, such as those of sulfur, phosphorus, or those of some metals. These combinations possess spatial arrangements characteristic of each organic compound.

The chemistry of organic compounds is characterized by an amazing variety and complexity that is not found in the combinations of other chemical elements and that is the basis of an important branch of chemistry, organic chemistry.

Let's think about the many ways to look at the environment. First we have to deal with the complexity of the space world; then there is the multitude of living things in the environment, each with its own specific behavior. There is also a multitude of biochemical processes that act within each living organism, but which mediate both its interaction with other organisms and that with the non-living environment. In the real world all elements of the environment are interconnected.

According to Commoner (1980) all living things arose from the non-living mantle of the Earth. We must recognize that life is a very powerful form of chemical activity, which, once it appeared on earth, rapidly changed its face.

Every living thing is closely related to its physical and chemical environment, so that, as it changed, new forms of life suited to the new conditions could arise. Life begets life, and thus new forms arising in a favorable environment could multiply and spread until they came to occupy every corner of the environment within their reach. Every living thing depends on many factors, either indirectly through the physical and chemical limiting elements of the environment, or directly as a result of their needs to obtain food and shelter. In the organism of every life on earth there is another network - on its own scale - as complex as the environmental system - which is made up of many complicated molecules, between which are woven a multitude of chemical reactions on which the vital properties of the whole are based organism (Commoner, 1972).

Because we humans have been taught to only deal with phenomena that are much simpler, few scientists are sufficiently trained to deal with this degree of complexity. That is why we are tempted to reduce everything to a series of simple, separate, often linear phenomena, in the hope that their sum will somehow represent the whole. The existence of the current environmental crisis warns us that this is only an illusion (Commoner, 1972).

It is now known that here on earth, organic compounds were derived from the simple constituents of the primordial atmosphere by simple geochemical processes. Thanks to them, the organic compounds that are the basis of those that generated life appeared.

Two researchers, Oparin and Haldane, independently but almost simultaneously, issued a hypothesis that, with time, proved to be viable (Şerban, 1986). They assumed that life arose from a "soup of organic matter" that formed in the waters of the planetary ocean several hundred million years after the formation of our planet. In the first stage, simple organic molecules were formed. Over time, increasingly complex chemical reactions were triggered that led to the appearance of macromolecules. These assembled - spontaneously - into molecules such as proteins and nucleic acids by polymerization reactions (which are now carried out by specialized enzymes). But then their role was performed by the clays, by the surface of some minerals, or simply under the action of thermal oscillations. The resulting macromolecules further associate themselves into structures capable of self-support and self-reproduction.

Although Oparin's and Haldane's scenarios for the origin of life on Earth were broadly similar, there were still some differences between the two concepts. While Oparin emphasized in his theory the generation of proteins in the primary ocean and primitive metabolic processes of heterotrophic type, Haldane gave a primary role to nucleic acids and believed that the metabolism of the first life forms would have been autotrophic. Haldane later suggested that RNA may have played a central role in the origin of life. The concept of the primordial soup somehow simplified the problem of the emergence of life to a single essential event - the emergence of molecules; and then everything depended on chance, life being seen as a "frozen accident" (Ghiorghiță *et al.,* 2019).

According to Oparin, the complex organic molecules in the primitive soup self-organized forming increasingly specialized structures, which he called coacervates. After a while they began to become even more complex, eventually becoming living organisms (Oparin, 1960).

The hypothesis of the origin of living matter has been revived in laboratories. The first to make organic compounds with life-like characters were Miller and Urey. In 1952, Urey made a relatively simple experimental device, in which he tried to reconstruct the conditions from the beginning of our planet (Ward *et al.,* 2015)

For this he used a glass flask with a volume of 5 liters in which he introduced methane gas, ammonia and hydrogen. This was connected to another glass flask, which had a volume of 0.5 l and was half filled with water. The water in the small flask was heated to cause its evaporation. The water vapor could reach, by means of a glass tube, into the large flask. Here they created a system that produced continuous electrical discharges that simulated lightning in the primitive Earth's atmosphere. The large flask was connected to a cooling system, which produced the condensation of the newly obtained gaseous substances. The liquid thus obtained was further collected in a U-shaped glass tube. (Figure 37). After a day, the collected solution had acquired a pink color, and after a week, the solution turned deep red. Analyzes by Miller (and supervised by Urey) led to the identification of 5 amino acids. Later Miller performed another version of his own experiment in which he also included gases resulting from volcanic activity. In 2008, an analysis by a team of American researchers who repeated Miller and Urey's experiments (but also used samples from Miller's experiments from the 1950s). These researchers identified 22 amino acids that were spontaneously created this way!

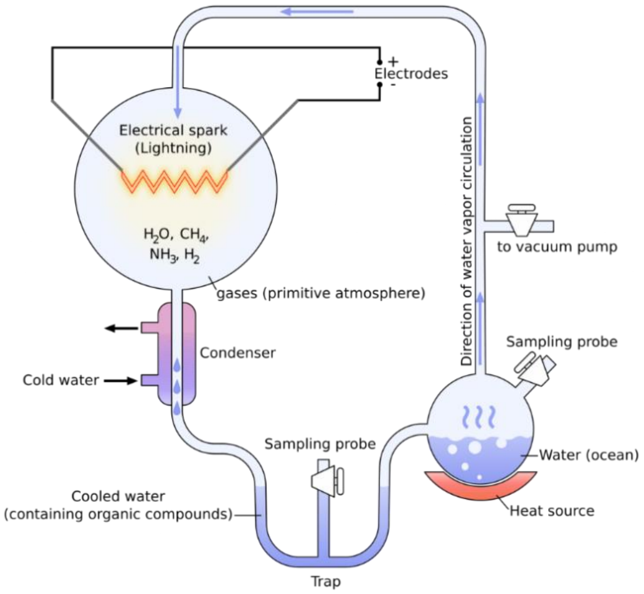

Figure 37. The Miller-Urey experiment (https://www.google.com/search?client=firefox-b-d&sca_esv=583612193&q=Experimentul+Miller-Urey&tbm)

In 1986, Walter Gilbert hypothesized that the genetic code on Earth first appeared in the form of proto-RNA molecules, and then, following evolutionary processes, DNA molecules appeared. Subsequent experiments also confirmed this hypothesis (Smith *et al.,* 2000).

In 1922 Thomas Carell demonstrated that at the basis of the appearance of proto-RNA molecules were some organic molecules with strong chemical bonds that could have survived the primordial conditions, namely some nucleotides that could attach to amino acids with chemical bonds much stronger than those that normally occur between amino acids and RNA molecules. Carell imagined an experiment in which two RNA chains had the aforementioned nucleotides placed at one end, to which an amino acid was attached. One of the RNA strands was the donor and the other was the acceptor. Originally the two RNA strands were connected to each other. By heating, the chemical bond between the amino acid and the nucleotide on the donor RNA was broken, so that on the acceptor RNA they were now paired with 2 amino acids. By successive cooling and heating of the system, more and more amino acid molecules were attached to the acceptor RNA, thus forming a peptide (ie a protein fragment). Continuing the experiments, it was later possible to obtain peptides composed of up to 13 amino acids, and further experiments identified over 80 amino acids, including 12 proteinogenic amino acids (Ghiorghiță *et al.,* 2019). Through these experiments it was proved that it would have been possible for life on Earth to have arisen spontaneously, in the environmental conditions existing on the young planet, about 3.8 billion years ago (Smith *et al.,* 2000).

Returning to the primordial soup imagined by Oparin and Haldane, the hypotheses are based on the fact that in the primordial ocean, organic macromolecules appeared in this soup that had two characteristics, which are still the basis of life: the realization of metabolic processes (so a permanent exchange of matter under the action of an energy taken from the environment) and the process of reproducing the structure and metabolic capacities of these macromolecules (so the self-reproduction capacity). These primordial "living macromolecules" carried out their metabolic processes by "feeding" themselves with the organic soup imagined by Oparin and Haldane, located in the waters of the primordial ocean (Botnariuc, 1967).

Among the hypotheses regarding the origin of life, most specialists are followers of abiogenesis, the formation of organic compounds from inorganic compounds. *"From the combination of synthons, gases and water vapors from the Earth's primary atmosphere or gases from underwater volcanism (in the area of alkaline hydrothermal springs), simple organic compounds resulted: amino acids, nitrogenous bases, carbohydrates, fatty acids, hydroxy acids, etc. On the surface of the planetary ocean, a so-called "organic soup" was formed, to the formation of which organic compounds of extraterrestrial origin would have contributed. Certain niches on Earth, such as small water basins formed after the appearance of land, underwater hydrothermal pits, etc., would have ensured the concentration of organic compounds, and some physical factors, such as clays or some minerals, would have been catalysts of some much* *more complex reactions. As a result of these reactions, the building blocks of life appeared - proteins, nucleic acids, lipids, etc., which formed molecular aggregates that separated from the environment through a membrane (consisting of fatty acids), giving rise to protocells (coacervates, proteinoids and .a.)"* (Ghiorghiță *et al.,* 2019).

And they continue: "*All organisms on Earth descend from a common ancestor - the Last Universal Commun Ancestor (LUCA), which appeared about 3.8 billion years ago (3.8 Ga). Two branches of living organisms derived from LUCA: one led to bacteria, and the other to archaea and eukaryotes*" (Ghiorghiță *et al.,* 2019).

Since free oxygen was missing, the energy needed by macromolecules to carry out chemical reactions was obtained through anoxic processes, i.e. through fermentative processes.

The first forms of life appeared when some macromolecules began to carry out their own metabolism, that is, they began to take from their environment only those substances with which, due to the taking over of certain forms of energy from the environment, they synthesized the organic compounds necessary for the development of their own metabolism. In this way, the primordial organic soup constituted the "food" of these macromolecules, and the anoxic fermentation processes represented the first energy-generating process for the functioning of these macromolecules (let's call them living macromolecules, or protoorganisms). We specify from now on that fermentation processes generate carbon dioxide.

Anoxic fermentation remained active, existed in a wide variety of forms, and still exists today in many living things. The first macromolecules - and then the first living organisms - consumed most of the primordial organic soup and, of necessity, looked for another way to obtain the energy necessary to carry out survival processes. This is how more efficient chemical mechanisms emerged that were based on the use of light energy using the processes of photosynthesis. The transition to obtaining a large amount of energy for carrying out biological processes led to the explosive development of eukaryotes, therefore of plants and then of the organisms consumed by them, animals. Photosynthesizing plants and animals first populated the waters of the planetary ocean; much later they passed into terrestrial and underground environments.

Novikov (2012) believes that abiogenesis on Earth went through three stages: *DNA world, RNA world and Protein world.* Selection acted both on abiogenesis - in the sense of promoting the most stable macromolecules, and on biogenesis (of organisms with a high degree of independence from the environment). Abiogenesis took place under conditions of dehydration, and the source of energy for chemical evolution on Earth was the thermal factor (temperature). DNA world spanned almost the entire Hadean - in extreme conditions, when the temperature was high (DNA being the most stable of polymers), RNA world appeared in the second half of Hadean and bridged the anhydrous DNA world to the Protein world (in Archean) - which required water (Ghiorghiță *et al.,* 2019).

Due to metabolic processes, the mass of living macromolecules increased and became too heavy to ensure the normal functioning of their own metabolism. That is why at some point the process of dividing too large macromolecules into two smaller ones, then even into several fragments, appeared, which, in turn, continued their specific metabolic processes and grew to an optimal size for their physiological functionality. This is how the first physiological processes appeared, that is, metabolism and reproduction.

The appearance of precellular structures produced a higher degree of independence of biochemical reactions from the environment, and the greater complexity of the biological system ensured an increased influence of mutations on the phenotype and implicitly an increased efficiency of natural selection. Life cannot be conceived without the presence and interaction of the two major categories of polymers – nucleic acids and proteins, separated from the environment by a lipid membrane, a mechanism that ensured the growth, reproduction and perpetuation of the system, its evolution towards complexity under the action of natural selection. Because DNA is a more complex structure than RNA, we are inclined to believe that in the beginning, in the precellular stage of the emergence of life, the latter was the nucleic acid that held genetic information. Life cannot be conceived without the presence and interaction of the two major categories of organic substances: nucleic acids and proteins, both of which have the ability to separate themselves from the environment through a lipid membrane (mechanism that ensured the growth, reproduction and perpetuation of the system, and then its evolution towards complexification under the action of natural selection). It is believed that later DNA, with its double-stranded structure (possibly arising from such RNA), became a much more stable macromolecule that carried most of the genetic information because it could replicate more easily; he later took over the task of "conductor" of cellular activity, a task he fulfills through DNA. Although some authors have a different opinion, we do not exclude the possibility that the three basic cellular "actors" - DNA, RNA and proteins - appeared simultaneously (Ghiorghiță *et al.,* 2019; Brack, 1991; Fox, 1973).

Protobionts possessed the important properties of a primitive cell, namely a lipid membrane, a simple metabolism, RNA with catalytic and self-replicating properties, which allowed it to detach from the mineral support and live freely.

And now living organisms have as their basic unit the cell, a unit that performs several functions: metabolism, growth/reproduction, development, chemical communication, evolution. All living organisms have in their constitution DNA, RNA and proteins (the functions of these macromolecules being the same in all the living world). They share 3 types of RNA and 34 ribosomal proteins, and the genetic code is universal. All these constitute as many arguments that they descend from a common ancestor. As the age of the universal ancestor is estimated at over 3 billion years, it means that before LUCA there were more primitive living formations that would have evolved by the same mechanisms as modern cells.

It is not known whether the universal ancestor was heterotrophic or autotrophic. If we accept that life arose from "prebiotic organic soup", then he must have been a heterotroph. Pascal *et al.,* (2006) estimate that the first organisms that appeared on the early Earth were chemolithotrophic organisms, with anaerobic respiration and probably used molecular hydrogen to procure metabolic energy (as is the case with thermophilic bacteria and current archaebacteria) (Ghiorghiță *et al.,* 2019).

The first traces of life on Earth (detected by isotopic geochemistry) are about 3.8 billion years old and were discovered in Greenland and Canada. The first definite fossils on earth (stromatolites - discovered at Warrawoona-Australia), date back to about 3.45 billion years.

The development and then the diversification of living macromolecules led to the emergence of the first ecological crisis: these proto-organisms gradually reduced the organic substances synthesized spontaneously by inorganic means, so those that constituted the primordial soup. In order for life to continue, it was necessary for some macromolecules to obtain their food not from the inorganic soup, but by ingesting and consuming small living macromolecules. This is how predatorism came about. Not only that, but this predation gradually became more selective (large macromolecules did not consume any small organic molecules they encountered, but chose certain macromolecules to take up and metabolize).

At the moment when the amount of primordial organic soup was greatly reduced, the living macromolecules entered into a crisis of resources (the geochemical reserve of organic material) and of more efficient sources of obtaining energy for the development of their metabolic and reproductive processes . Of necessity, proto-organisms had to initiate their own system of obtaining energy. For this, they took from sunlight the energy needed to convert carbon dioxide and some inorganic substances into simple molecules of fresh organic matter, which they then complexed to obtain their own macromolecular compounds. And thus appeared the first organisms capable of carrying out photosynthesis. Since then the perpetuation of life on earth has been linked to this permanent source of energy, that which comes to earth from the sun of our planetary system.

It should be noted how biochemical processes were carried out: at first they were linear, very similar to those known in inorganic and simple organic chemistry. Over time they became cyclical, which became more complicated, and later they, according to the processes now "discovered" by other sciences (especially cybernetics, computer science and artificial intelligence), the evolution of the living world became from a cyclic one in an increasingly complex and diversified one, the spiral type. These processes are not only always getting more complicated, but they are constantly being perfected (Soran *et al.,* 1985; Godeanu *et al.,* 2022).

Now there was the interdependence of vital processes, the development of interrelationships between the living and the non-living world, the repeated (almost endless) transformation of the materials that form the basis of life in increasingly complex cycles and processes of interdependence.

Modern investigations have shown that the variety of life on our planet is the result of an evolutionary process that occurred about 3.8 billion years ago (Levine *et al.,* 1994; Purves *et al.,* 1992; Starr *et al.,* 1987; Avise, 2000; Botnariuc, 2003; Fox *et al.,* 1974; Margulis *et al.,* 2000; Neagu *et al.,* 2002; Godeanu *et al.,* 2010) and which did not develop only "vertically ", starting from the simplest forms towards the increasingly complex ones, but also "horizontally", in the sense of increasing diversification of living forms as a result of an increasingly efficient use of resources, i.e. in the sense of an increasingly in the best conditions of the environment (permanently constantly changing).

Botnariuc (2003) distinguishes 10 moments that must be considered particularly important in the way life evolved (Godeanu *et al.,* 2010):

1. the emergence and diversification of prokaryotes;
2. the transition of metabolic processes from anaerobic respiration to oxyphilic respiratory reactions;
3. the emergence of symbiosis;
4. the appearance of photosynthesis;
5. the appearance of unicellular eukaryotes;
6. the appearance of the sexual process;
7. the appearance of multicellular eukaryotes.
8. diversification of levels of organization in multicellular eukaryotes;
9. the conquest and then the diversification of life forms in the terrestrial environment;
10. tendency towards social life.

To these stages, we can add a few more, the most important of which, however, is the emergence of man and the creation of the anthroposphere. It should be emphasized that the current primitive forms coexist with the more evolved forms, that all living beings, over time, have adapted to the changes and to the increasingly complex relationships with the biotic and abiotic environment (Bavaru *et al.,* 2007; Bisby, 1995; Margulis *et al.,* 2000; Mustaţă *et al.,* 2004; Purves *et al.,* 1992; Godeanu *et al.,* 2010). These moments will be presented below, highlighting their implications for the evolution of life on earth.

The emergence and functional diversification of prokaryotes (Godeanu *et al.,* 2010)

Very little is known about the first living organisms because they left no fossil traces. The first were found in old sedimentary and metamorphic rocks about 3.8 billion years old. From that time until today, the presence of the simplest organisms, those without a well-defined nucleus (prokaryotic organisms) is mentioned in various geological formations. Similar to the results of current investigations on prokaryotic organisms, we can realize that they appeared and conquered all wet living habitats, from the most common to those existing in extreme conditions (warm waters exceeding 200°C, hypersaline waters (waters with large amounts of mineral substances), or waters containing various toxic compounds. They can live at pressures of thousands of atmospheres, develop in the absence of oxygen, populate habitats with a high content of carbon dioxide or ammonia, or develop in the presence of high concentrations of inorganic acids).Until the appearance of the first more complex living forms, over a period of about 2 billion years, prokaryotes were the only living things on our planet (Margulis *et al.,* 2009; Mustață *et al.,* 2005, 2011).From a morphological point of view, their size and shape diversity is very limited: only coccoid, bacilli, spirilla and vibrios forms are known, and their reproduction is based exclusively on simple cell division (the few exceptions are reported in some representatives of cyanobacteria).

In terms of their metabolic processes, today's prokaryotes are very diverse, being able to "attack" and use any organic matter (living or non-living) or any inorganic matter existing on Earth (provided they are levogyric!) (Margulis *et al.,* 2000).

This extraordinary metabolic diversity is not recorded in other types of organisms, except for some single-celled eukaryotes. They are able to use every natural compound as a raw material for building their own body or as a source to obtain the energy needed for their metabolism. Prokaryotes carry out sulfur oxidation and reduction, nitrification and denitrification, fix free (atmospheric) nitrogen, can oxidize a wide variety of compounds belonging to a large number of chemical elements, etc. Over time, various species of prokaryotes have specialized to break down virtually all existing natural organic substances (so only the levorotatory ones), even the most resistant ones, such as resins, cellulose, lignin, crude oil, etc., and now they have adapted to also attack a very wide range of organic substances synthesized in the laboratory by humans. Currently, almost all the processes of degradation of organic substances can be carried out by bacterial activities (there are some exceptions - some fungal protoctists). We could conclude that today, without the intervention of bacteria, the biogeochemical cycles that ensure life on our planet could not take place.

Prokaryotic organisms use all the forms of energy they can take from the environment: from inorganic matter (lithotrophic organisms), from organic matter resulting from anaerobic synthesis (through chemosynthesis) or from aerobic processes (through photosynthesis), from living organic substances (through digestive organs), or from dead organic substances (by heterotrophic organisms) (Botnariuc, 2006b). Prokaryotic organisms currently have an extraordinary range of forms of respiration: they can be chemotrophs, chemoautotrophs, photoheterotrophs, photoautotrophs, anaerobic (obligatory or facultative), etc. They are able to directly or stepwise degrade any type of levogyric organic substances, even the most difficult to degrade, and are capable of synthesizing a multitude of substances, many of which are of great interest to mankind.

Because of their metabolic diversity and mobility, prokaryotes have adapted to all environments, even living in or on all other living things, either helping them (they can live symbiotically with them) or using them for their own benefit.

The transition of metabolic processes from anaerobic to aerobic respiration (Godeanu *et al.,* 2010)

Respiratory processes allow living organisms to obtain the energy needed for their current activities from the degradation of previously synthesized organic substances. In general, respiration has two purposes: first to release the electrons necessary for catabolic processes (the division of previously synthesized organic substances), and then to create molecules of ATP (adenosine triphosphate), which is a compound capable of storing energy and carrying out its conversion to cellular level, thus providing organisms with the necessary energy for the normal development of all their metabolic processes.

Respiration requires the existence of a terminal electron acceptor. For the vast majority of prokaryotes, it occurs at the level of the cell membrane and consists of the oxidation of the organic substance molecule in the absence of oxygen, producing simple organic substances (such as ethanol or lactic acid) and ATP.

Metabolic processes have passed, over time, from anaerobic respiration, based exclusively on chemical reactions similar to those that occur in the Calvin-Benson respiratory cycle, to those that take place in the presence of an oxidizing gas, oxygen, through chemical reactions that occur in the Krebs cycle (Blankenship, 2010). It produces more ATP molecules so that in the end all organic matter is reduced to carbon dioxide and water.

Anaerobic respiration takes place as follows:

- **Anaerobic respiration** occurs like this:

$C_6H_{12}O_6 + 3NO_3 + 3H_2O \rightarrow 6HCO_3 + 3NH_4$ - energy production = 2ATP
or
$C_6H_{12}O_6 + 12\ S + 12\ H_2O \rightarrow 6HCO_3 + 12SH + 18H$ - energy production = 2ATP

- **Aerobic respiration** occurs as follows: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ energy production = 36ATP

In table 8 and in figure 38, we present the modalities of operation of the two types of breathing.

Table 8. Energy efficiency of anaerobic and aerobic respirations (Wikipedia, 2022 - amended)

Parameter	Anaerobic respiration	Aerobic respiration
Breathing efficiency (%)	1	19
Total energy exchange (Kcal)	56	686
ATP synthesized from glucose	2	36
Energy stored in phosphates (Kcal)	14	252
Efficiency of energy recovered from all energy released (%)	25	37

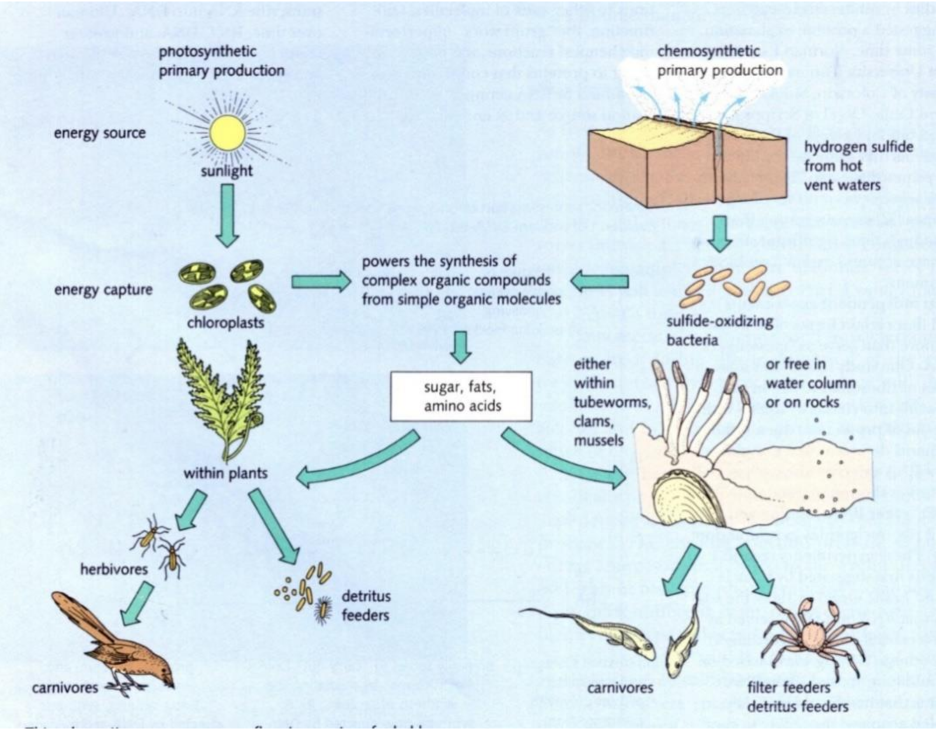

Figure 38. Comparison between the two types of primary production (Levine, 1994)

The shift to aerobic respiration has significantly increased the amount of energy available for the functioning of living organisms (Table 8), an increasing amount of energy required over the evolution of the living world (Figure 39).

The advantages of aerobic respiration were so important that it allowed the diversity of aerobic eukaryotes to be expanded so that they could more easily and efficiently obtain the energy needed for metabolic processes and locomotion. However, anaerobic processes did not disappear, since the Calvin-Benson cycle is still present in many respiratory processes.

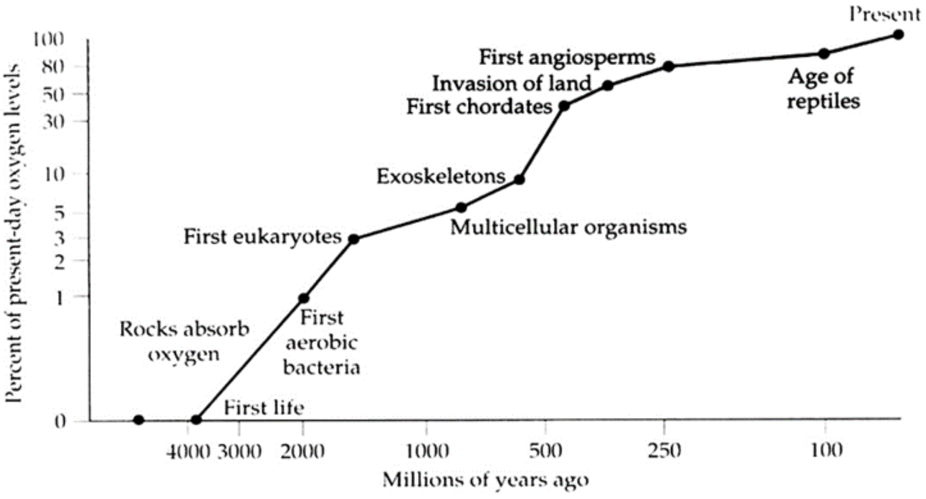

Figure 39. Percentage of oxygen in Earth's atmosphere where different organisms live. (Purves *et al.,* 1992, modified).

The emergence of symbiosis (Godeanu *et al.,* 2010)

In the course of the vital processes of different eukaryotes, many of them have achieved a relational interconnection between two species, a process that facilitates the survival of both partners, each of whom depends – more or less obviously – on one of the activities of the other. For example, a spirochete attached to one end to a bacillus or a cocoid cell allows much more movement to the partner, who in turn receives the substances necessary for living from the second. In other cases, a larger prokaryote includes (through invagination) a smaller prokaryote that is capable of producing organic substances using the process of photosynthesis; The larger partner is in this case supplied with ready-made organic substances, and the smaller prokaryote is not phagocytotized and swallowed, but kept alive in a special formation in the body of the larger partner, where it receives the necessary nutrients and is – at the same time – protected from being consumed by other teaching prokaryotes. Thus, starting from a simple mutual help, a mandatory, advantageous coexistence of both partners was reached, symbiosis (Botnariuc, 2006).

The phenomenon of symbiosis has allowed better use of nutrients and energy resources. If at first this symbiosis was limited only to prokaryotes, later this process expanded and moved to more complex and varied forms within all subsequent kingdoms. The symbiosis between a eukaryotic and different types of prokaryotes (which now appear in the form of cilia, mitochondria or chloroplasts) led to the emergence of multifunctional eukaryotic cells (Margulis, 1982; 1992).

Symbiosis led to the emergence and development of lichens – an important taxonomic group, resulting from the mandatory interaction of some fungi with photosynthetic bacteria or with some green algae (Figure 40). There are also various forms of temporary symbiosis (more details are given in chapter 3.4. Interactions between components of the biosphere).

As a consequence of the interdependence of different symbionts, a new evolutionary process occurs, "lateral evolution" (i.e. a form of diversification of species on the same evolutionary level). Botnariuc (1992, 2006a) considered polyphyly as a main feature of the evolutionary process of life. Thus, a process developed that began at the level of prokaryotes and later became an important evolutionary feature within all eukaryotic kingdoms. This process is referred to as the "coevolution process".

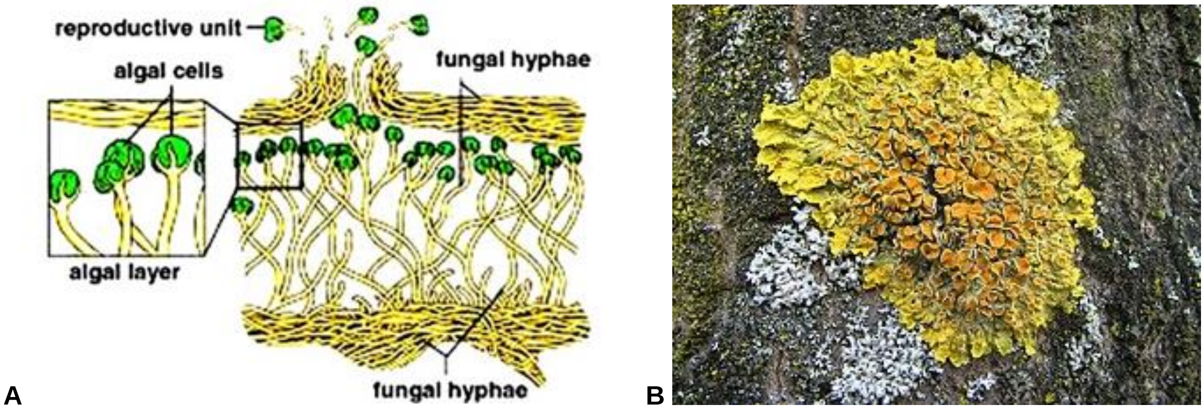

Figure 40. Lichens: cell structure (A) and plant appearance (B) (https://mppss.ru/ro/lishainiki-vidy-osobennosti-stroeniya-razmnozheniya-i-pitaniya/ and https://ro.wikipedia.org/wiki/Lichen)

The emergence of photosynthesis (Godeanu *et al.,* 2010)

The first prokaryotic organisms were osmophilic organisms, then phagotrophic ones, their food consisting of dissolved and colloidal organic substances, all of which were produced by simple chemical reactions. At some point, phagotrophic prokaryotes, still multiplying, the amount of organic matter in the natural aquatic environment that they used as food, became insufficient. As a result, the assimilation of food necessary for the proper functioning of metabolic processes was hindered by the deficiency of primary foods. In this "crisis", some of the prokaryotic organisms have approached a new way of producing their own matter faster and at the same time much more efficiently; They proceeded to synthesize their own materials from a compound common and abundant in the primitive atmosphere, carbon dioxide, using for this purpose a substance existing in large quantities, water. For this synthesis, a new source of energy was needed. Due to the fact that the one obtained by chemosynthesis was insufficient, they created a new system, based on the use of light, solar energy. That's how photosynthesis came about.

The range of wavelengths below which solar energy reaches Earth is very wide, ranging from a few nanometers to kilometers (Purves *et al.,* 1992) (Figure 41). Living organisms have become capable of using radiation between 400 and 700 nanometers, that is, visible light, located in the range of ultraviolet radiation and up to infrared. These radiations have different colors at small differences in wavelengths (Fig. 40). Moreover, living organisms have created a set of photosensitive substances, chlorophyll pigments, capable of using light energy found only in the range of certain wavelengths. Living things have created the following pigments: chlorophyll, phycocyanin, phycoerythrin, carotenoid pigments, xanthophylls and luteins (Levine *et al.,* 1994) (Figure 42).

Their variety is determined by the characteristics of water to prevent – depending on its depth – the penetration of light with a specific wavelength and by the tendency of organisms to achieve increasingly efficient photosynthesis. As a result, for different wavelengths there are certain pigments that possess maximum efficiencies only here (Figure 42).

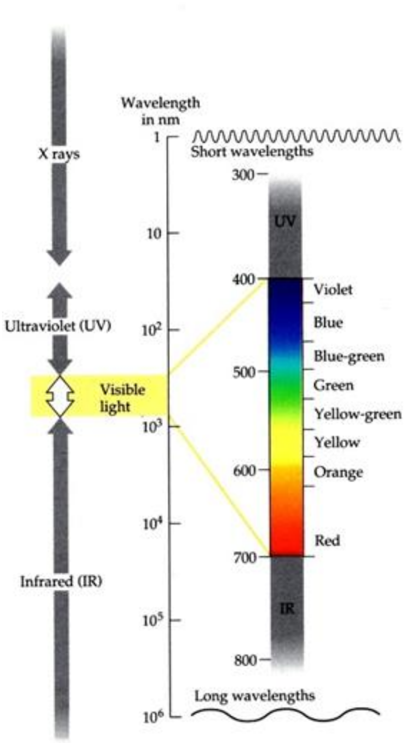

Figure 41. Wavelengths of solar radiation and the area of light waves
(Purves and Orians, 1992)

Due to the fact that terrestrial photosynthesizing organisms appeared somewhat later, they have - predominantly, then exclusively - only two types of chlorophyllene pigments, those that use a wider band of light energy use, i.e. chlorophyll a (which are capable of working at wavelengths of 400–450 nμ) and chlorophyll b (capable of working at wavelengths of 650–700 nμ), i.e. in blue-green and orange-red light, representing the extreme limits of visible light) (Figure 43).

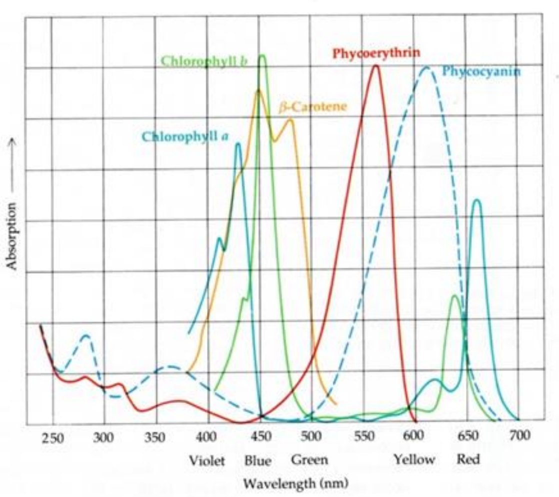

Figure 42. Efficiency of light energy absorption by different chlorophyll pigments (Purves and Orians, 1992)

In the ocean, combining the activity of different photosynthetic pigments now achieves an efficiency of 35–85%, with maximum efficiency occurring at wavelengths between 450 and 500 nµ (Figure 43).

The synthesis of organic substances under the influence of light energy is facilitated by a coenzyme that appeared in prokaryotes about 3.2 billion years ago: the coenzyme NADP (nicotinamide adenine dinucleotide phosphate) contained in nucleotides. Thanks to the action of this coenzyme, not only simple carbohydrates are synthesized (which are the basis of all other organic substances), but also allow the production of ADP (adenosine diphosphate) and ATP (adenosine triphosphate), the latter being the most important energy storer (Purves *et al.,* 1992).

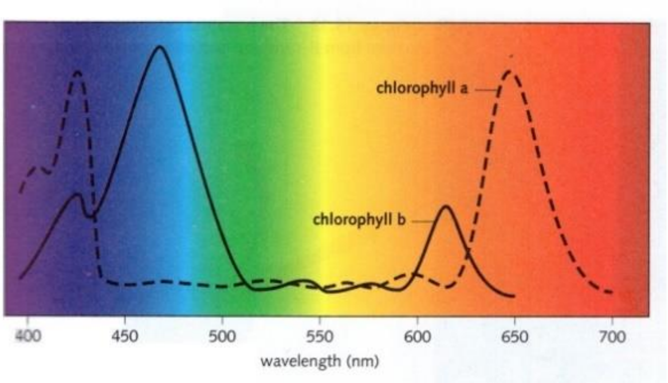

Figure 43. Rate of photosynthesis due to the action of chlorophyll a and b (Purves *et al.,* 1992; modified)

As a consequence of the ability to easily obtain energy in the aquatic environment (at all wavelengths of visible light), the efficiency of photosynthesis is, on average, only 0.2 – 6%. This level appears to be very low, but it turns out to be sufficient (or rather the most economical) to provide the necessary energy intake for all types of photosynthesizing organisms. Experiments conducted on algae (for they are the first photosynthetic organisms) have shown that algae, if kept under permanent light, photosynthesize much more than they need. As a result, excess photosynthesized organic substances are eliminated into the environment and dissolve in the water in which algae live, thus increasing the concentration of organic substances dissolved in the water around them (their living environment).

This explains the efficiency of photosynthesis, which, although apparently low, is enough for green plants to cover the planet with a rich and very diverse vegetable blanket.

The consequences of photosynthesis are numerous: on the one hand, living organisms are no longer dependent on the chemical production of organic substances, but they can sustain themselves. On the other hand, because autotrophic prokaryotes multiply more easily, they become the main food for a lot of heterotrophic prokaryotic organisms. Since photosynthesizing organisms produce oxygen during the synthesis of organic substances, it is partly used by the manufacturers themselves, to achieve their own aerobic respiration. Excess oxygen is excreted into the environment, i.e. into the water of the planetary ocean; this atomic extra-oxygen has led to the formation of oxygen molecules (O2), which have triggered the superoxygenation of the upper layers of water in the ocean. After oxygen dissolved in water has reached saturation, surplus oxygen molecules are removed into the air in the atmosphere. At the same time, hydrogen sulfide, carbon dioxide and methane are removed from the water. These three gases, but mainly oxygen, changed the chemical composition of the atmosphere over time. During the following millennia, molecular oxygen produced by photosynthesizing organisms became - as a share - the second gas in our planet's atmosphere (Soran, Borcea, 1985).

Another consequence of the increase in the amount of oxygen in the aquatic environment, many organisms have switched to aerobic respiration, and they have become more and more numerous, populating the aquatic environment now well oxygenated. Organisms that maintained their anaerobic respiration type gradually withdrew to habitats where oxygen concentration is low, or live in areas where some chemical reactions rapidly consume oxygen. Here the environment becomes anoxic, so only living things that perform chemosynthesis or have anoxic respiration can live here.

Under the action of free oxygen, oxidative chemical processes accelerated. Part of the molecules of bivalent oxygen under the action of cosmic rays formed in the atmosphere ozone molecules, which over time made a strong shield against ultraviolet radiation, radiation that is harmful to living organisms. As a result, the amount of ultraviolet radiation coming from the sun decreased to less than 5% compared to the previous level, which obviously facilitated the subsequent transition of living organisms from the aquatic environment to the terrestrial one and, later, covering the surface of all continents on the planet with photosynthesizing autotrophic plants.

The emergence of photosynthesizing organisms has led to a more complex structure of food chains, which are now based not only on osmotrophic and chemotrophic organisms, but on photoautotrophic ones.

Diversification of prokaryotes (Godeanu *et al.,* 2010)

Returning to the examination of the first stage of the process of diversification of the biosphere, one can note the consequences of switching to aerobic respiration, the emergence of symbiosis and photosynthesis.

Since there are very few known fossils from the Precambian, and most of the rocks formed then were deeply metamorphosed, we can only infer the consequences of the processes that occurred and assume the path to the current level of diversification of prokaryotes (Margulis *et al.,* 2000; Neagu *et al.,* 2002).

Before the emergence of eukaryotic organisms, life on Earth was represented only by microscopic prokaryotes that inhabited the planetary ocean (possibly also in brackish waters or pools with temporary waters located in the vicinity of the ocean). Some of them consumed by osmosis organic substances dissolved in water or those that were present in the colloidal state. Others were "predators" (that is, they fed on smaller prokaryotes, which they captured by amoeboidal movements/or by forming invaginations in a special area of the body called pseudostoma, through which they took prokaryotes that served as food and then digested them in vacuoles that became digestive vacuoles. One category of prokaryotes remained autotrophs (they produced the nutrients necessary for their existence).

Prokaryotes developed by diversifying the degradation of dead organic matter. This evolution was carried out not by a single bacterium, but by creating chains and networks of consumers (which formed a succession of functionally different bacteria). In this way, they could sequentially decompose extremely complex organic substances. In the same way, most of the organic substances synthesized by photosynthesized bacteria were subsequently attacked.

Although parasitism and symbiosis also exist in prokaryotes, these two modes of nutrition developed most after the emergence of eukaryotes, which are larger and easier to deal with (Margulis *et al.,* 2009; Mustață *et al.,* 2004; Neagu *et al.,* 2002).

As for the relationship between anaerobic and aerobic organisms, they did not exclude each other, but coexisted, each of them occupying specific ecological niches and different places in the food chains and networks that were always constituting and complexing in the biocenoses to which they belonged. Prokaryotes are neither primitive organisms nor "living fossils", because they have evolved permanently, adapting to all changes in the characteristics of the environment, be it abiotic or biotic. Even today prokaryotes are the most versatile forms of life, best adapted to the changes now produced by various destructive human activities (see the adaptability of pathogenic bacteria to antibiotics created to destroy them and to the emergence of notosomal bacteria!). Moreover, anaerobic bacteria are the main organisms that carry out the degradation of dead organic matter, releasing the energy stored in them; They are still the fundamental step in the smooth running of biogeochemical cycles on our planet.

Emergence and diversification of unicellular eukaryotes (Godeanu *et al.,* 2010)

Based on fossil data, it is believed that the first eukaryotes, the unicellular ones, appeared about 2 billion years ago, also in the primordial ocean. They were very small (microscopic in size) and did not have a rigid shell; this explains their absence in sedimentary rocks (Botnariuc, 2003; Neagu *et al.,* 2002).

Regarding the transition from prokaryotes to eukaryotes, the currently generally accepted theory is the so-called symbiotic theory elaborated by Lynn Margulis (1982). According to him, the eukaryotic cell arose from a prokaryotic one, because their DNA was protected by a protective membrane (which clustered in the central part of the cell), but also by the inclusion in the cytoplasm of the cell, through symbiosis, of a number of small, highly specialized prokaryotes, which have now become flagella, mitochondria or chloroplasts (Figure 44). It is possible for other cellular structures to occur in the same way (such as thylakoids or the Golgi apparatus).

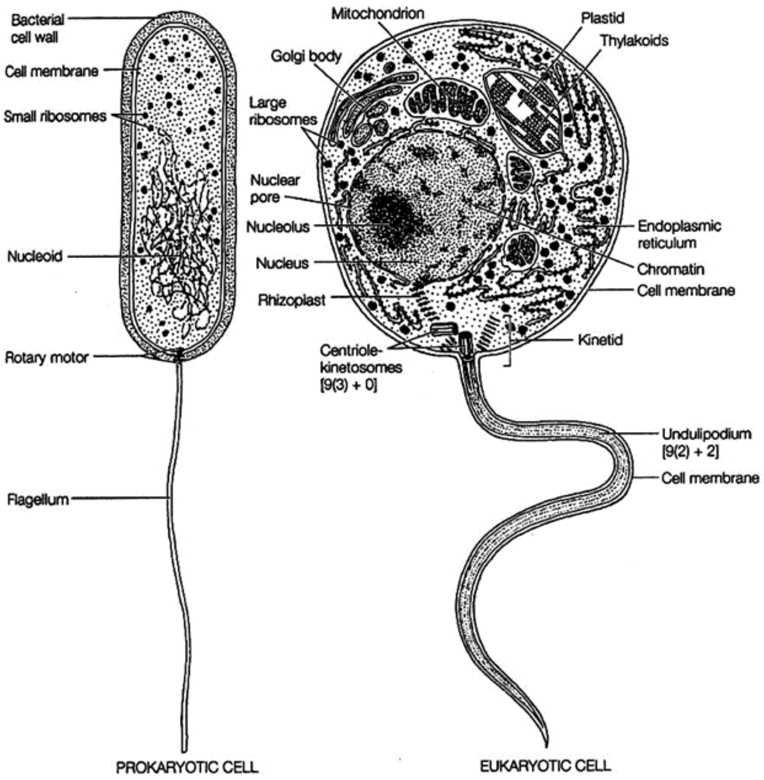

Figure 44. Diagram of a prokaryotic cell and a eukaryotic cell (Margulis and Schwartz, 2000).

The new organisms represent the very important leap that determined the improvement of the information storage system, but also that of multiple intercellular symbiotic processes. In this way new organisms acquired new potentialities, very important for their metabolism. At the same time, their morphological characteristics, modalities of nutrition or locomotion have diversified enormously. To these adaptive processes is added a new mechanism for more accurate transmission of biological information to offspring through the emergence and diversification of forms of sexual reproduction.

Like single-celled prokaryotes and eukaryotes, they live in almost all possible environments, they relentlessly adapt to the needs of their specific activities, and often, although they retain their morphological characteristics (as observed in sediments remaining in the form of fossils in sedimentary rocks of that geological period in which they lived - for example, there is "globigerine sludge", "sand with foraminifera" or "silt with radiolari" - etc). Moreover, related to the subsequent evolution of living forms, certain single-celled eukaryotes became highly specialized parasites on plants and animals (thus on eukaryotes that appeared much later on Earth). Like prokaryotes, single-celled eukaryotes evolved continuously. We do not know how primitive the current forms are, how much, when, and in what way they evolved to reach their current state of development.

As for the cells of protoctists (unicellular eukaryotes), they are found today in a multitude of forms and have all the physiological characteristics of multicellular eukaryotes: inside their cells appear specialized formations for nutrition, for excretion, for reproduction, there are very varied and at the same time very specialized locomotion systems (which are very versatile), there are areas with great sensitivity that react to different stimuli (such as be vibration, light, movement, temperature), there are forms that live in aerobic or anaerobic conditions; can have endo- or exoskeletons (lorics, plates, sheaths, discs, cocolites, trichocysts, axopods, microtubules, etc.), develop a large scale of movement forms (by simple or pennate flagella, cilia or cirri) and have a high capacity for survival and self-protection in case of unfavorable conditions in the environment in which they live (periods of drought, extreme temperatures, etc.), So they create spores, resistance cysts, etc.

The emergence and diversification of the sexual process in unicellular eukaryotes (Godeanu *et al.,* 2010)

All prokaryotes have a unique type of reproduction – by cell division (single or multiple). Since the separation of intracellular DNA from the rest of the cellular components (after the appearance of the nucleus), its role is very well and clearly established: in it are grouped all cellular components that serve to transmit to the descent, with the highest fidelity, the genetic information of the species.

Asexual reproduction continues to exist in the vast majority of single eukaryotes. It comes in many forms, such as sporulation, binary division, budding and parthenogenesis (Margulis, 2009; Purves *et al.,* 1992).

Concomitant with the mode of asexual reproduction, 1.1 billion years ago sexual reproduction appeared. The chromosomes of two individuals of the same species perform recombinations of their nuclear DNA, which are transferred to their offspring in the form of recombinant DNA. This resulted in a surplus of very accurate and specific information, particularly useful for the species. The sexual process has evolved enormously and now comes in an extraordinary variety of forms. It can be said that after its appearance, it has undergone a real explosion of the ways in which it occurs (Margulis *et al.,* 1986; Mooney *et al.,* 1996) and which is not found in the other kingdoms of multicellular eukaryotes – plants, fungi or animals – in which subsequently took place - at most - a process of. simplification and specialization).

The most common forms of sexual reproduction in protoctists are: isogamy (in chitridiomycetes, green algae, brown algae, labyrinths, granuleticulates, diatoms, plasmo dio fore), anisogamy (in diatoms, red algae, brown algae), oogamy (in oomycetes, green algae, xeno ampophores), apogamy (in brown algae), heterogamy (in red algae), or conjugation (in ciliates, diatoms and some green algae) (Levine *et al.,* 1994, Purves *et al.,* 1992, Starr *et al.,* 1987).

Emergence and diversification of multicellular eukaryotes (Godeanu *et al.,* 2010)

Multicellular eukaryotic organisms appeared about 600 to 570 million years ago, as a result of the tendency for a number of daughter single-celled organisms (either in the form of aggregates, spheres or filaments) to remain undivided. They evolved from representatives of several unicellular eukaryotic phyla, which continued to refine their genetic, morphophysiological and ecological characteristics (Margulis *et al.,* 2009; Mustață *et al.,* 2003; Botnariuc, 2003).

If in Protocysts each cell was an organism that realized all its needs for survival and reproduction on its own, in multicellular eukaryotes the various physiological functions are performed by specialized groups of cells (which thus form certain organs). In tracing phylogenetic processes in multicellular eukaryotes, one can observe how component cells begin to differentiate for certain functions (as cells with a role in reproduction, digestion, excretion, nervous role, etc.).

If in primitive multicellular eukaryotes, a single cell is able to regenerate a new individual using an asexual process; In evolved eukaryotes, regeneration can only be done at the level of one organ (or group of well-defined organs). Embryological studies have shown that gradually, with cell division, starting from the multiple potential of the first cells, their specialization increases permanently (Levine *et al.,* 1994).

The transition to multicellular organisms is the result of the process of increasing the efficiency of metabolic processes. The role of sensory cells and those that transmit information is emphasized; It also increases the role of protective cells. Cells appear with special functions – producing self-defense substances, storing nutrients or producing energy. A very important role is played by cells that transmit genetic information (species-specific only) to descendants in reproductive cells; in the most evolved forms of plants and animals, these cells are protected and served by specialized cells that form reproductive organs.

From the multitude of species belonging to Protocysts, the transition to multi-celled organisms was made in three different ways; this led to the emergence of three kingdoms of multicellular organisms: Plantae, Fungi and Animalia.

Among photoautotrophic Protocysts, some have made their way to the state of multicellularity by forming very little morphologically and physiologically differentiated thallus (such are some representatives of the phylums of Protocysta Chlorophyta, Rhodophyta and Phaeophyta) In their offspring, sexual reproduction is quite primitive. All photoautotrophic multicellular eukaryotes are organisms that still live in freshwater or humid aquatic environments (Briggs *et al.,* 1997).

With the transition from habitation in aquatic habitats to dry habitats, their body underwent major changes, which, in part, caused spectacular developments. From them appeared representatives of the kingdom Plantae: first, ferns (phylum Pteridophyta), appeared in the Mesozoic, and flowering plants (phylum Anthophyta) – in the Cretaceous and Quaternary. It is assumed that the evolution to the multicellular state was initially carried out by organisms close to green algae (Margulis *et al.,* 2009; Mustache *et al.,* 2004; Botnariuc, 2003).

From osmotrophic heterotrophic protoctist organisms (more precisely – from Cytridiomycetes) three phyla of fungi developed. The differentiation of these new groups of autotrophic organisms was not achieved as "explosively" as in the other groups of heterotrophic multicellular eukaryotes(animals), since the transition to the multicellular state did not result in an increase in morphological and physiological diversity, but in a biochemical one.

Another group of heterotrophic organisms that developed to the multicellular state is the one with holozoic nutrition and which were characterized by mobility. This way of feeding involved differentiating cells to form a distinct digestive system, and sexual reproduction became specialized, taking place only through copulation. Most scholars believe that representatives of the kingdom of Animalia derive from colonial forms of protoctists similar to those that are now part of the phylum Zoomastigota (and especially representatives of the class Choanoflagellata). They resembled colonies of *Proterospongia haeckeli* (Margulis *et al.,* 2000). Initially these colonies were homonomous, of the type *Sphaeroteca,* then cells of the type *Proterospongia*, which led to the appearance of sponges (Mustață *et al.,* 2004; Margulis *et al.,* 2009). From these colonies with poorly specialized cells derived ancestral planuloid metazoans, with or without celloma, and from the latter came later protostomians and deuterostomians. At the same time with this diversification of animals, there were many morphological fluctuations, increasingly specialized organs for different functions. However, some forms of morphophysiological regression caused by parasitic feeding mode have also been recorded (in several genera and species). Currently, in the kingdom of Animalia, belonging to a particular class or phylum can only be determined by tracing their ontogeny. Sexual reproduction has also diversified. Sexual reproduction now takes many forms (for example, increasingly complex and sophisticated copulatory structures, such as copulatory parts in insects and chelicerates). Moreover, the process of sexual reproduction was improved by the appearance of specific sensory cells, and – in some cases – organisms also began to produce chemical compounds (attractants) to sensitize and attract representatives of the opposite sex.

The appearance in the kingdom of Animalia of different planes of cell structure and differentiation (Godeanu *et al.,* 2010)

Embryological studies have shown that in bilaterally symmetrical animals that had three layers of embryonic cells, the cells constituting the mesoderm evolved in three main directions (Purves *et al.,* 1992; Levine *et al.,* 1994). This ontogenetic evolution determined the evolution of animals on three fundamental structural planes that still exist today (Figure 45).

1 In one of these directions the mesoderm remained as cellular masses, from which the internal organs were formed – digestive, excretory, reproductive and nervous systems. They are grouped into so-called acelomate-type organisms and are found in representatives of the phylums Platyhelminthes, Gnatostomulides, Ortonectides and some of the Nemertians.

2 In others, mesoderma cells form in empty spaces (voids) filled with hemolymph; in these organisms there is a schizocele. In the event that between the ectoderm and endoderm appears a cavity filled with hemolymph, in which mesodermal cells develop, a pseudocele appears, in which internal organs are located. Such a type of pseudocelomate organisms are some Nemertians, to Nematodes, Nematomorphs, Rotifers and Gastrotrichi, as well as to representatives of other smaller phyla.

3 If the mesoderm forms a general cavity in which all internal organs are contained, a cellomic cavity occurs. That is why animals that have such a cavity are called Coelomates. Organisms in which the cells that form the cellomic cavity originate from the region of the oral orifice are included in the group of cellomatated protostomyans. All organisms in which cells forming the cellomic cavity in the lateral vaginae of the posterior endothelium have formed form the group of cellomate deuterostomians (Figure 45).

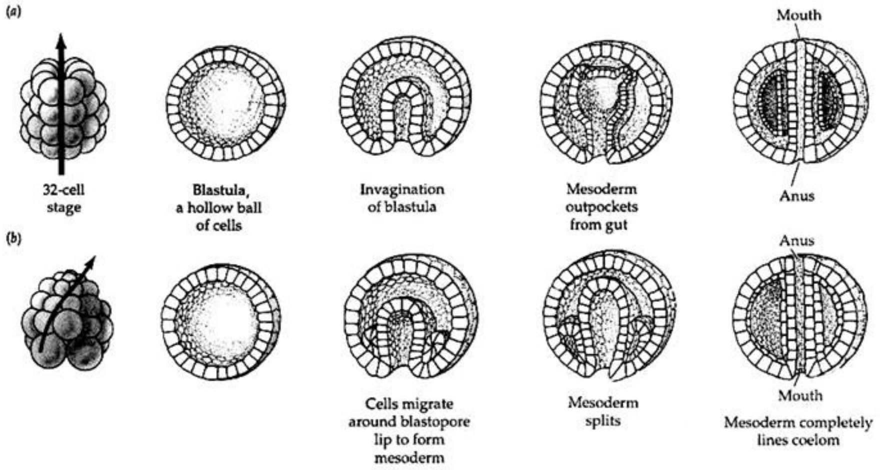

Figure 45. Early stages of primary embryological development in deuterostomians (a) and Protostomian (b) (Purves *et al.,* 1992; modified)

Emergence and diversification of multicellular eukaryotes (Godeanu *et al.,* 2010)

Currently, all representatives of the kingdom Plantae live fixed to a substrate and have photoassimilating pigments of chlorophyll type; they produce starch – which is a storage compound – and have cell walls usually of cellulose nature. The first representatives of this kingdom appeared about 400 million years ago, when autotrophic organisms began to conquer the terrestrial environment (only real aquatic macrophytes returned to the water, and most of them now live in the freshwater environment). As terrestrial organisms, they had to create antigravity resistance structures to emerge from the substrate that would be able to withstand air movements (wind) and any type of atmospheric precipitation. They have created protective structures capable of coping with the physical action of all climatic factors.

All plants form organs for sexually reproducing gametes in gametangs. The zygote resulting from fertilization allows the development of the embryo, which is protected by the female gametophyte. In more primitive phyla, the gametophyte stage is dominant.The evolved sporophyte stage is dominant in more evolved phyla (Mustaţă *et al.,* 2004; Briggs *et al.,* 1997).

The current representatives of the Fungi kingdom are heterotrophic organisms whose nutrition is based on osmosis. They are consumers of organic substances (mainly decaying organic matter (necromass), but they are also species that use organic substances from living organisms (which they parasitize). True fungi are aerobic organisms, which secrete exoenzymes used to dissolve food extracellularly, which they then absorb by osmosis. The cell wall of fungi contains chitin, and their spores are always devoid of flagella. All cells of fungi have 2 nuclei (there are no uninucleated fungi). Representatives of this kingdom appeared about 500 to 450 million years ago in the Ordovician. The most primitive fungi are protoctists from phylums Myxomycetes, Oomycetes and Hyphochitridiomycetes.

All multicellular fungi reproduce both asexually and sexually (through two types of conjugation – either hyphae conjugation or nuclear fusion). In both cases spores result, which may have either a mitotic origin or a meiotic origin. New hyphae appear from spores; Their aggregation forms a mycelium. During the reproductive period, part of these mycelia unite, forming specific organs of fruiting. All fungi have a similar development cycle, in which their offspring do not have an embryonic stage (Groombridge *et al.,* 2000; Margulis *et al.,* 2009; Mustață *et al.,* 2004). The emergence and diversification of representatives of the kingdom Animalia occurred in the aquatic environment. Only the most dynamic forms of a few classes of Protostomen and Deuterostomians have passed into the terrestrial environment.

Paleontological research has revealed that the emergence of multicellular organisms led to the so-called explosion of biological diversity in the Cambrian (Purves *et al.,* 1992). This exhibition appeared after a major extinction of primitive organisms that occurred about 500 million years ago (Figure 46). That's when all the major groups of animals appeared. In the Lower Cambrian (about 570-770 million years ago) diblastic metazoans appeared, and shortly after them (about 540 million years ago) triblastic metazoans appeared (Mustaţă *et al.,* 2004).

This evolution has happened neither uniformly nor slowly, but has been stimulated by several crucial moments that have led to today's biodiversity. It was carried out despite important more or less known vicissitudes, which caused several mass extinctions of many groups of organisms (Figure 46). These accentuated disappearances not only endangered the existence of life on Earth at the time, but also strongly influenced the course of subsequent evolution, pointing it on new paths (which can be considered as progresi ve leaps). They allowed the evolution of only the most adapted forms of life to new environmental conditions, so only those forms that were most efficient in using energy and procuring substances necessary for their own biosynthesis.

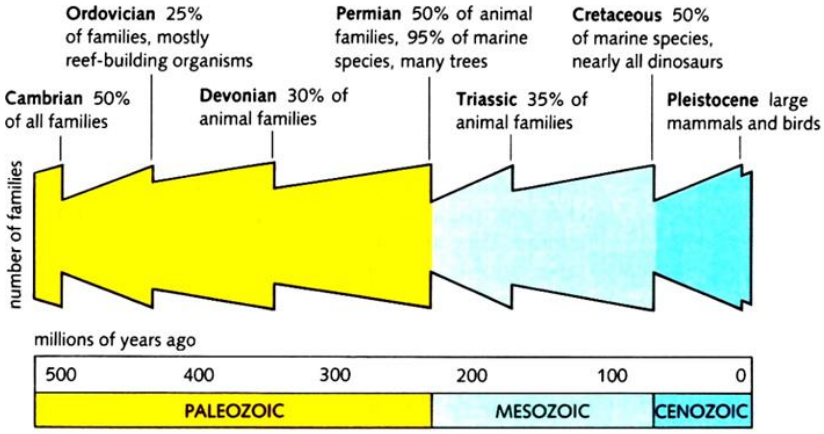

Figure 46. The seven mass extinctions of animals over geological ages
(Purvis and Orians, 1987, modified).

The oldest heterotrophic multicellular eukaryotes belong to the kingdom of Animalia. It is believed that the first animals appeared about 1.5 billion years ago, in the Proterozoic. Representatives of this kingdom are characterized by a great diversity of sexual reproduction, different types of eggs and forms of their segmentation, different ways of achieving gastrulation, various forms of further evolution of embryonic cells, and then a great diversity of embryonic development paths (this is based on the postulate of Baier, the founder of embryology, that "ontogeny repeats phylogeny") (Figure 47) and the existence in adult individuals of various forms of symmetry of their body.

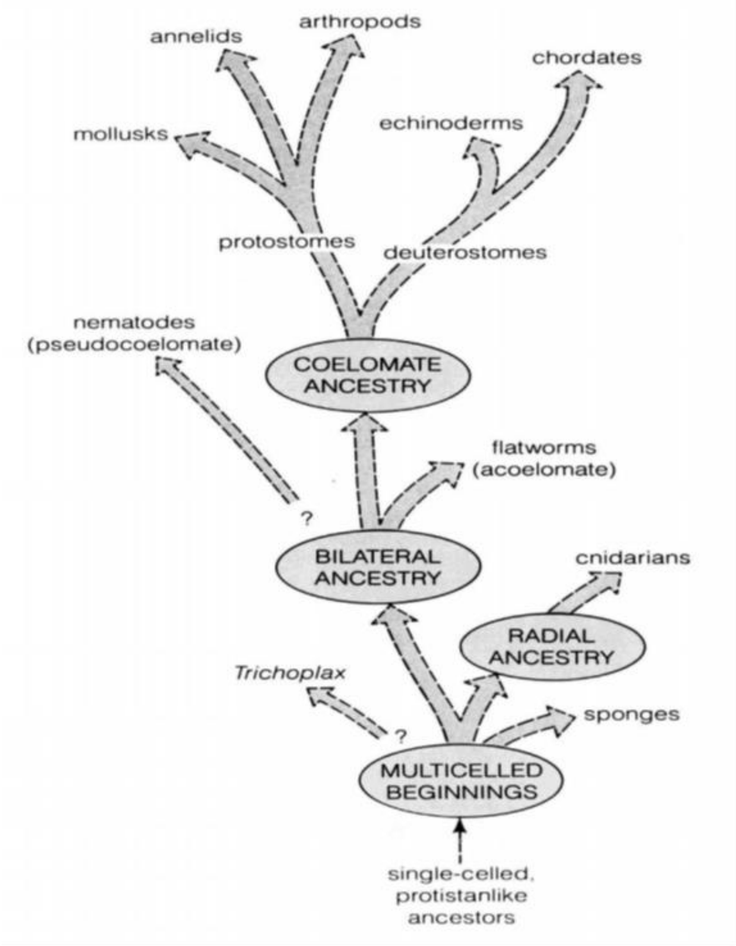

Figure 47. Evolution of the animal kingdom based on body symmetry and the specifics of space development between ectoderm and endoderm (Starr and Taggart, 1987)

Animals have three types of symmetry:

- dissymmetric – which can be homopolar or heteropolar;
- bilateral – which can be: in the sagittal plane (dorso – ventral) in the lateral plane (left – right) and in the transverse plane (anterior – posterior),
- radial – which can be pentaradial (in Echinoderms), hexaradial (in some Cnidars), or octoradial (in other Cnidars).

In animals, heterotrophy stimulated the diversification of feeding forms, starting with the emergence of very varied ways of capturing food, continuing with the creation of different types of digestive apparatus, and sometimes even returning to the osmotic type of feeding (as in the parasitic forms of flatworms and in some of the chelicerates or mandibulates). Like the digestive system, animals today have a wide variety of types of respiratory and excretory apparatus.

Animals possess specialized relationship systems that allow:

- have systems for detecting the quality of living and non-living factors in their living environment – sensitive organs;
- have systems for transmitting information from the sense organs to the nervous system;
- have adequate systems for achieving reproduction – the existence of individuals with distinct/separate sexes, but also some who are hermaphroditic;
- possess ways to protect themselves from potential predators – the existence of an inner or outer skeleton, or secrete repellent or poisonous substances, etc.

Conquest of the terrestrial environment (Godeanu *et al.,* 2010)

Between 500 and 450 million years ago, life occurred only in the marine aquatic environment. From one time, all biotopes of marine ecosystems were occupied by various associations of organisms. Rivers flowed into the seas, but their waters lacked the salts existing in marine waters, salts that are indispensable for marine organisms. This absence of mineral salts was for a long time an osmotic obstacle difficult to overcome, but by gradually adapting various eurioic marine organisms to life in brackish waters, this obstacle was eventually overcome (Botnariuc, 2003, 2006b; Briggs *et al.,* 1997; Margulis *et al.,* 2009).

An important ecotone area was the saltwater basins and swamps in the vicinity of the seas and oceans. During storms, and especially if they occurred concurrently with high tides, marine salt waters, along with coastal flora and fauna, entered these habitats. After the interruption of contact with marine waters, the water level of these basins and marshes dropped significantly, but not entirely, so that the bodies-brought by marine waters were forced to find opportunities for survival until new waters came from the sea, during which time puddles and pools with paramarine water remained in place and the water level in them decreased (through evaporation, or by slow infiltration into the substrate).

Therefore, the organisms arrived here had to either switch to atmospheric respiration and protect their bodies from drying out, bury themselves in salty mud, or die. In the mass of dead plant and animal organisms in these shallow water basins, or in wet habitats, degrading bacteria were the first to find favorable conditions to thrive. They contributed to the formation of a sludge rich in organic substances, and then participated in its transformation into an environment conducive to the protection of aquatic organisms from drying out and to avoid direct solar radiation.

In these semi-salt marshes gradually settled a characteristic flora and fauna, which at first was a semi-liquid or very humid medium, and then a humid terrestrial environment, which later became increasingly dry. This is how a plant and animal biota appeared, which could live in the air environment for a more or less long period, but which at first always returned, at least in certain periods of their lives (especially for reproduction), in the aquatic environment. This air environment required many organisms to switch to atmospheric respiration (which was done either through specialized organs for atmospheric respiration or through the skin); As for plants, the air environment has led them to create protection systems against drying on their exteriors. For the growth of plants in the terrestrial environment, differentiation was necessary in order to create antigravity growth systems (there was no need in water, the mass of the plant body swaying in shallow waters near the banks, as a result of wave movements). All organisms that have left the aquatic environment currently have gametes and embryonic and larval stages that develop either in a natural aquatic habitat, and if they have not found it, this environment they created themselves (in eggs in reptiles and birds, and in mammals in the placenta there is amniotic fluid). The plants fixed their rhizoids in the sludge, and then they gradually transformed into the current roots that allow the individual to fix and support the lifting of their body outside the water, so in the aerial environment. Subsequently, these rhizoids turned into roots that serve them not only for fixing to the substrate, but also for supplying from the substrate on which they grow part of the mineral salts necessary for the process of synthesis of their own organic substances. These roots can also absorb, by osmosis, simple organic substances which, metabolically, are then incorporated into their own living matter.

As the marshes became clogged, the organic sludge at their bottom lost water, became stronger and, mixed with the sand resulting from the collapse of rocks, produced by water or wind, turned into soil. Subsequently, the ways of soil formation were improved so that they now form a shell of the planet, the pedosphere (see chapter Terrestrial Ecosphere).

The first organisms to colonize terrestrial and semiterrestrial habitats were plants. Because nothing is lost in nature, as a result of plants, phytophagous and scavenger organisms came out of the water. Of these, a more important role was played by scavenger and leaf-consuming mandibulates, pollen and nectar (hence insects). Between flowering plants and pollinating insects, a process of coevolution was established, which, constantly improving, is still present today. Of course, predators of phytophagous animals came out of the aquatic and semi-aquatic habitat, then the first biocenoses were established in the terrestrial environment, which, over time, became more and more complex, they are precursors of current complex terrestrial biocenoses.

The occupation of the terrestrial environment by living things has determined the appearance of morphological and physiological changes related to living in the atmosphere (respiration, locomotion, resistance to air currents and precipitation). In this way, living associations were formed, very different from those existing in aquatic habitats. There was gradually an extension of life in drier and drier areas as the soil improved and diversified. Young soils were characterized by very varied environmental conditions, which required new organisms to adapt. Among these, it is worth mentioning first of all the creation and adaptation to the living of plants in the soil, which becomes substrate and also trophic base for plants.

The terrestrial environment was populated by representatives of the most advanced groups of living things: among photosynthesizing organisms, especially mosses, ferns, conifers and flowering plants, and among animals – by annelids, molluscs, chelicerates and mandibulates (among protostomicians) and only by craniates (among deuterostomians). Fungi appeared and developed only in the terrestrial environment, on the necromass produced by other terrestrial organisms.

Currently, less than 5% of representatives of phyla that exist on Earth live in terrestrial habitat. However, this habitat has allowed tremendous development of many species, so that today, of the 1.9 million known species, almost 1.5 million are terrestrial forms.

Transition from individual to social life (Godeanu *et al.,* 2010)

Among living organisms, most species are represented by individuals who live as isolated beings and establish relationships with other representatives of the same species only during breeding periods – and not always directly (it can also be through water, wind or other organisms).

Researchers have observed rudiments of social life in autotrophic colonial protoctists, in some animals – cnidarii – and now, especially, in mandibulates and craniates.

In recent decades, various sociobiological investigations have developed. They revealed very varied forms of social life in representatives of cephalopods (cuttlefish and octopuses, insects), but also in some skulls (birds and mammals). This way of life allows for a certain division of labor and the development of a more efficient life, both materially and energetically. Social life creates opportunities for functional and reproductive differentiation and fosters the development of instincts, communication and intelligence (and in humans also consciousness).

This new way of life is believed to offer extraordinary prospects for the future of this planet.

Man, thanks to his conscious way of life, also realizes things that are favorable to life on a planetary level. He can induce, voluntarily or involuntarily, a stimulation of the development of Eurioic and cosmopolitan forms, and now he is creating new organisms. That is why we believe that the current anthropogenic extinction will indeed disturb the planetary biota very strongly. He will have an important role in the evolution of life both in new ways and in new conditions.

We summarize what is presented in this chapter in Table 9 and figure 48. Hopefully they don't need any further comment.

Table 9. Chronological table of how life appeared and diversified on Earth

Period	What processes occurred during geological eras
4.54 billion years	Formation of planet Earth
4.4 billion years	Lithosphere and hydrosphere formation
4.28 billion years	The first traces of life appear (the first pseudoprokaryotes)
3.8 billion years	The first cells of primitive living organisms appear in the waters of the planet at temperatures of +40 - +800C
3.7 to 3.45 billion years	The first stomatoliths and anoxic chemosynthesis appear
2.45 billion years	Oxygen-based biosynthesis occurs
2.4 billion years	Intensification of the process of oxygen production and its release into the primitive atmosphere. Photosynthesis acquires the main role in the biosynthesis of living substance; The first planetary glaciation occurs (Huronian glaciation)
2.2 billion years	The emergence of eukaryotic protoctistis
2.1 billion years	The first multicellular organisms appear
1.5 billion years	The emergence of sexuality

575 million years	The explosive development of life in the Ediacarian
500 million years	The appearance of chordate animals
480 million years	The appearance of land plants
475 million years	The Great Extinction of the Ordovician and Silurian
400 million years	The appearance of insects, angiosperm plants and sarcopterigiens (pulmonate animals)
370 million years	The Great Devonian Extinction
365 million years	The appearance of tetrapod animals
360 million years	Karoo glaciation, the appearance of amphibians
330 million years	The appearance of amniote animals
252 million years	The Great Permian-Triassic Extinction
230 million years	The appearance of dinosaur reptiles
220 million years	Triassic extinction; The first mammals appear
200 million years	The Great Extinction Between Triassic and Jurassic
150 million years	The appearance of birds
135 million years	The appearance of gymnosperm plants
66 million years	Great extinction between Cretaceous and Paleogene
0.01 million years	The appearance of primates
0.0002 million years	Homo sapiens *appears*
40 000 years	Human social life appears

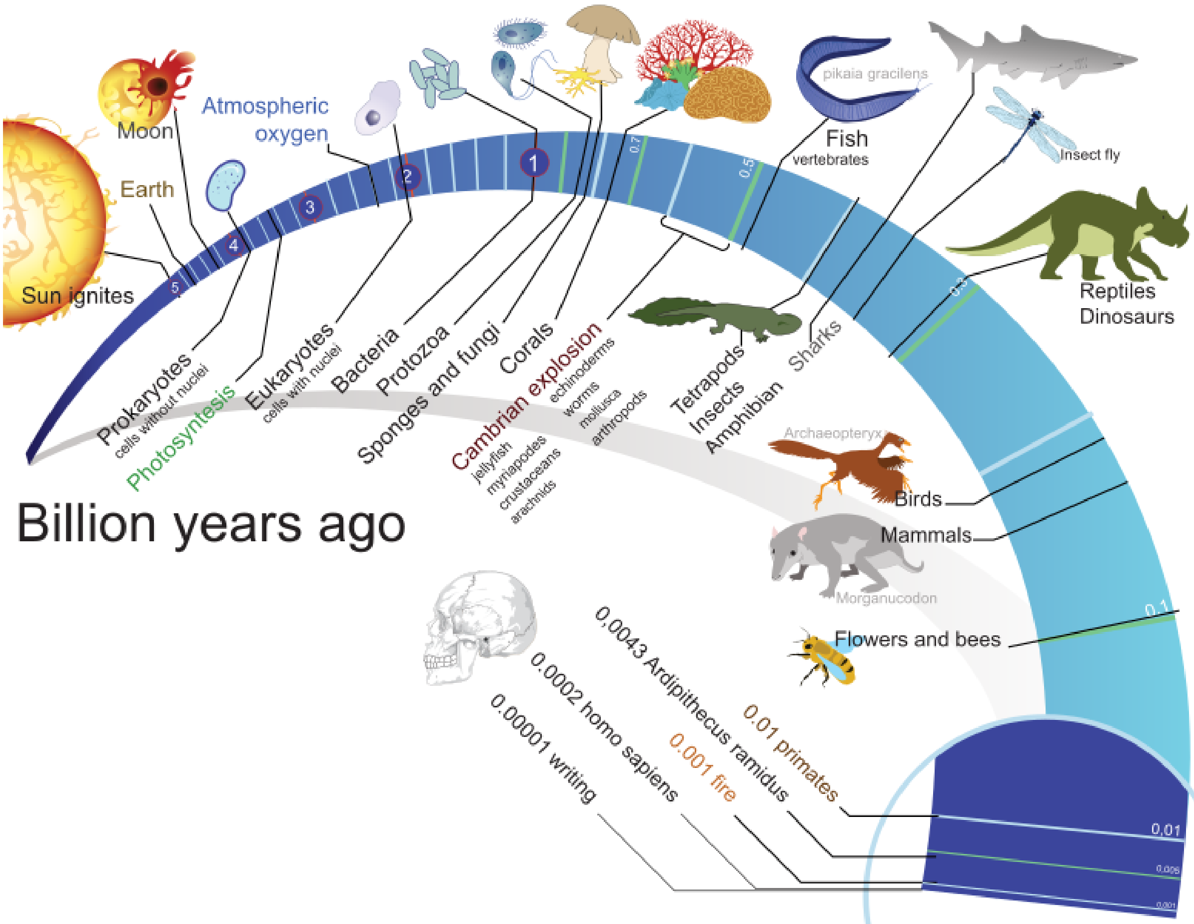

Figure 48. Diagram of chronology, development and diversification of life on Earth (https://commons.wikimedia.org/wiki/File:Timeline_evolution_of_life.svg)

3.2 Determinants of the evolution and diversity of the living world

3.2.1 Ways of evolution of the living world

At the level of the living world, several types of evolution can be distinguished: informational, energetic, physiological, morphological, population and social, geographical and ecological. Let's follow the different forms through which they manifested (Godeanu and Popa, 2022):

A. **The informational evolution** will be presented in chapter 4.1.1. from the Ecosphere
B. **The evolution of energy** will be presented in chapter 4.1.1. from the Ecosphere.
C. **Physiological evolution** at the level of living organisms (Godeanu and Popa, 2022)

Physiological evolution occurs after informational and energetic evolutions have started. It is the third most important and oldest form of evolution.

Four main stages can be distinguished (Table 10):

Stage 1 – diffuse physiological processes occur especially in the most primitive organisms, in some prokaryotes, but they now also exist in many eukaryotes (eg the way embryonic cells and stem cells function).

These physiological processes are morphologically undifferentiated. Thanks to them, not only do the organisms that use them function perfectly while the organism is alive, but they can sometimes remain active long after an individual on a higher level of evolution has died (this is the only way to explain why, for example in humans, organs can be taken from individuals who are clinically dead, to be transplanted into other individuals). This situation is all the easier when the organisms are on a lower stage of evolution (attention! because when the organ is taken over, the relevant biological information is also taken from the donor!!!)!

Physiological evolution took place at the beginning at the pre-cellular level (biochemical changes took place even in the spherules of organic macromolecules that formed in the primordial soup). This is where the first forms of absorption, metabolism (intra-individual biochemical reactions) and excretion appeared, and then, after their size reached a critical mass, the reproduction of these macromolecules by division took place. From a biological point of view, it was also during this period that the functional differentiation of these macromolecules began.

A special situation occurs with some macromolecules, which, entering other living precellular organic formations, behaved like parasites. They gave birth to viruses, which, through specialization and regressive selection, now "live" on different prokaryotes or eukaryotes.

Stage 2[3)]– physiological processes carried out in specialized organelles within a cell. From the moment when living matter passed to unicellular life, physiological processes led to new intracellular specializations, namely the differentiation of organelles that perform precise physiological activities. In this way, the efficiency of most physiological processes increased exponentially: mitochondria for managing energy inflows, digestive and excretory vacuoles for carrying out metabolism at the cellular level, chloroplasts for photosynthesis of primary organic matter, etc. Somewhat later, the nucleus appeared, with a role in protecting the DNA intended for the preservation and storage of information and the transmission of the genetic information of each species to the offspring, and ribosomes (for the protection of RNA). Eukaryotic cells have only recently appeared.

At the level of eukaryotic cells, movement organelles and cell formations appeared with a sensitive role that are signaling and transmitters of sensations related to the influence of environmental factors on these cells. Such organelles can currently be best observed in ciliates.

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[3] From this moment the physiological evolution takes place simultaneously with the morphological evolution

At the level of unicellular eukaryotes, distinct species of producers, consumers and decomposers appear and are perfected, the first species with the ability to lead a social life, as well as those with defense systems.

Stage 3 – the one in which the physiological processes end up taking place at the level of strictly specialized cells or organs (or organ systems).

Stage 4 – in species that have a social life at the family level, certain physiological processes end up being carried out only by certain individuals. In social insects (ants, termites, bees) there are specialized individuals possessing special morphological and physiological characters (see table 10). This morpho-physiological super-specialization does not exist in vertebrates, although here too the social way of life appeared - but it manifests itself in other forms (for example in wolves, when they live in packs, the dominant male reproduces only with a female - which is the only one who makes cubs, and the other females in the pack take care of the cubs of the dominant female).

Mustață believes that all physiological and morphological characters, once acquired, are functionally perpetuated, in one form or another, throughout the evolution of all forms of life (Mustață, 2005, 2011, 2015; Mustață and Mustață, 2011).

Table 10. The main stages of the physiological evolution of living organisms (Godeanu *et al.,* 2022)

Degree of complexation	**Types of processes**	**Types of organisms**
Stage 1. Physiological processes occur throughout the cell diffusely	- all the physiological activities necessary for living indefinitely	protoorganisms, prokaryotes, some groups of unicellular eukaryotes
Stage 2. Physiological processes take place in organelles	- specialized intracellular components to perform certain functions **A**- to all cells (internal and/or external membrane), flagella, cilia, cirri, cytoskeleton, nucleus, nucleolus, centriole, cytoplasm, vacuoles (digestive, excretory, pulsatile), ribosomes, mitochondria, endoplasmic reticulum (smooth, rough) , Golgi apparatus, liposomes. **B**- in specialized cells [microfibrils (in muscle cells), neurofibrils (in nerve cells), Nissl corpuscles (in nerve cells), chloroplasts (in photosynthetic cells), microtubules (in locomotor cells, in ciliates, in flagellates)]	uni- and multicellular eukaryotes
Stage 3 A. Physiological processes take place in specialized cells	nervous, reproductive, bone, muscular, photosynthesizing, excretory, producing reserve substances (biologically active substances, fats), poisonous substances, etc.	plants, animals
Stage 3 B. Physiological processes take place in organ systems	Cells grouped together to carry out certain physiological processes - leaves, stems, branches, roots (in plants) - gills, brain, liver, endocrine glands (genitals, thymus, pineal gland, adrenal glands, etc.), heart, intestine, ovary, pancreas, lungs, spleen, stomach, testicle, uterus, bladder (biliary, urinary), etc. (in animals)	multicellular eukaryotes (plants, animals)
Stage 3 C. Physiological processes take place in organ systems	circulatory, digestive, endocrine, excretory, lymphatic, locomotor (muscular, bone), nervous, reproductive, respiratory.	multicellular animals
Stage 4. Physiological processes occur in specialized individuals	- in morphological and physiological insects (workers, soldiers, food tank, males, queen) - in vertebrates by ethological means	social insects vertebrate

D. The morphological evolution of living organisms (Godeanu and Popa, 2022)

Morphological evolution is the most well-known because, until the genetic codes were deciphered, it was (and practically is) the basis of the oldest field of biology, taxonomy.

This evolution consists in the refinement of external and internal morphological characters (adults and/or some of their juvenile stages) (Figure 49).

Morphological evolution is what from the beginning was the basis of the concept of species as a clear, distinctive unit of all types of organisms. Based on the establishment of morphological characters, biologists came to distinguish one species from another, then analyze their physiological, ethological and ecological characteristics (at the population level).

From a morphological point of view, the following stages can be distinguished (Fig. 48):

1. Plasmodium stage – organisms lacking a cell membrane that can have at most one interface of substance and energy exchange with their environment;

2. The cell stage - when a distinct structure appears - the membrane - which separates the living body from its surrounding environment;

3. The stage of existence at the cell level of the 3 essential components: a membrane, a cytoplasm and a nucleus, each with clear physiological functions;

4. The stage of the existence inside the cell of some organelles with the role of carrying out certain physiological processes;

5. The stage of adaptation of the external morphology of the body to the variety and fluctuation of environmental conditions.

6. The brain stage of internal organ systems - in multicellular organisms;

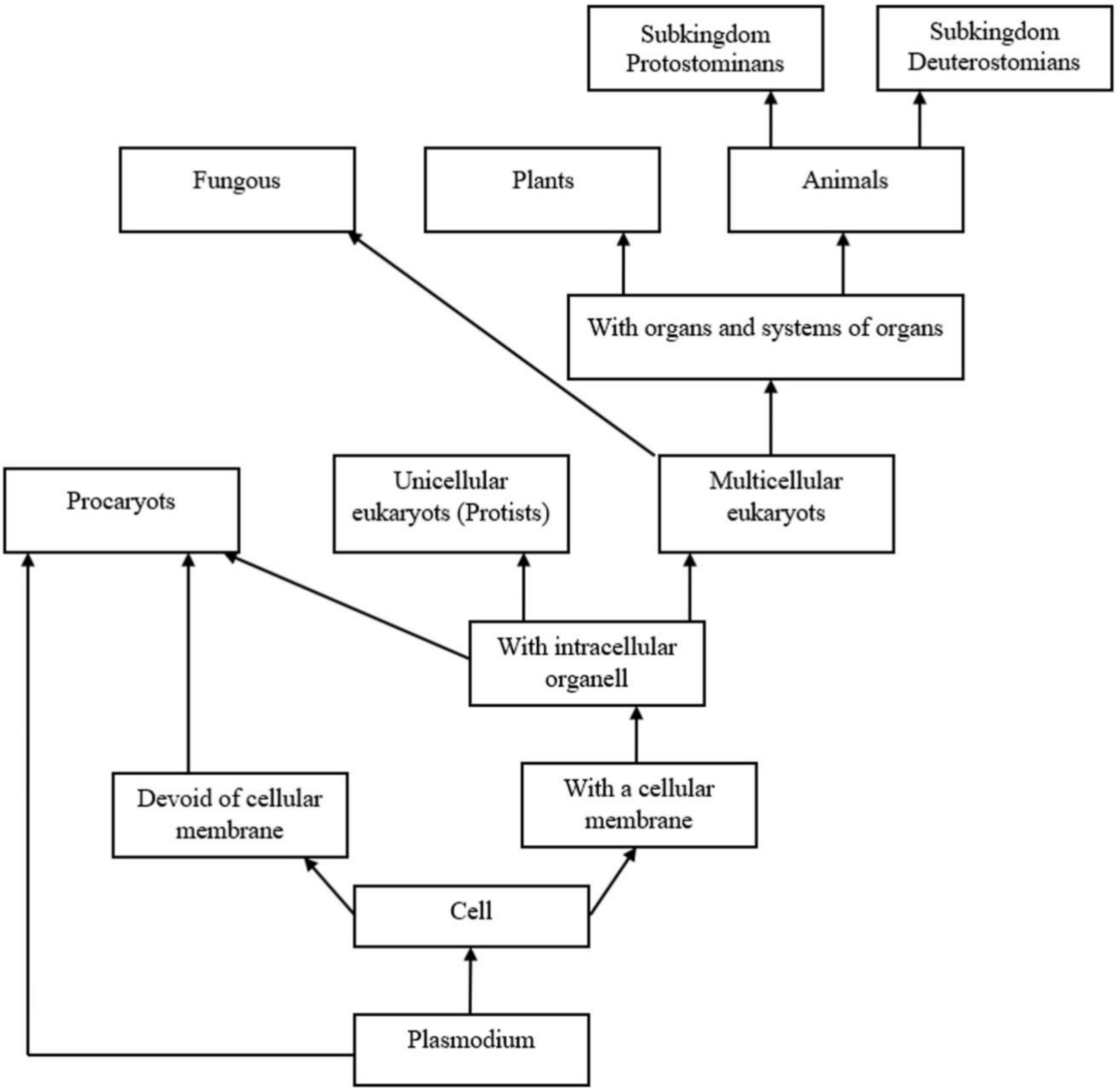

Figure 49. The morphological evolution of living organisms and their main kingdoms (Godeanu *et al.,* 2022)

Morphological evolution continues today, as part of ecological evolution, at all its levels of superpopulation organization (Mustață, 2009, 2015). How this morphological evolution will evolve is difficult to appreciate, although there have been attempts at prediction.

E. **Populational and social evolution** (Godeanu and Popa, 2022)

Looking at the patterns of intraspecific organization in the various living things today, it can be seen that it goes through several situations, which are complex throughout the evolution of the living world (Table 11). In prokaryotes there are only stages of separate individuals, in the form of amorphous groups, in strings, or forming various zoogeal forms. In unicellular eukaryotes there is a great diversity of patterns, as if living organisms developed and diversified exponentially in all directions: isolated individuals, colonial individuals, individuals grouped by 2, 4, 6, 8, 16 or more (groupings that can take radial, flat or spherical shapes, individuals forming long strings that are joined only at two ends, etc.).

Table 11. Ways of organizing life in living organisms (Godeanu and Popa, 2022)

Way of life	Type of organization
individually	* Sexually undifferentiated individuals * Individuals of different sexes
In groups of the same species	* Groups of individuals of the same age * Groups of individuals of different ages
In groups of individuals from different species	* Temporary multi-specific groups * Permanent multi-specific groups * Non-specific - simple - specialized groups * Groups with a certain hierarchical organization
Familial	* Families with specialized individuals, of different sexes and ages * Families with specialized individuals with distinct activities

In some multicellular eukaryotes (fungi), immediately after the morula stage, single individuals and individuals with network-shaped underground mycelia appear, from which fruiting formations rise above the ground - which give the impression of singularity (in reality it is about "wheels" of fructifications of fungi of the same species, which have a single common underground mycelium). Parasitic fungi are organized in the same way (it seems that such networks of underground roots are also found in many plant species).

In higher plants there are singular individuals or, most often, grouped in characteristic associations (phytocenoses). There can also be groups of monospecific individuals (seaweed, beech, oak forests), groups of plurispecific individuals (most forests and herbaceous plant associations in the terrestrial environment). In some plants the male and female gametes are on the same individual, but there are also species that possess only monogamous individuals.

In animals there is the greatest diversity of forms in which these creatures can live. There are hermaphrodite forms, which have a singular way of life (individuals of different sexes seek each other at most during the breeding season, in order to achieve cross-breeding). In some species there is a very wide range of forms of association (from those that form groups only during breeding periods, to those that form monoparental or biparental seasonal or permanent families, uni- or plurispecific associations, groups of individuals of the same age or of different ages etc.). The most evolved forms of grouping occur in distinct families, which have individuals differentiated for particular activities. For example. in termites there are reproductive and working individuals, in ants there are in addition to those found in termites and soldiers and even individuals with the role of food storage, in wolves the grouping of individuals is made up of individuals of different sexes, in some birds that live in uniparental families nest aggregation systems exist for the breeding season, and families may be seasonal or stable throughout life. And the examples can go on. This system of differentiation and specialization of the grouping of individuals becomes more complicated as organisms move higher up the evolutionary ladder.

The forms of social life represent the higher way of life of living things.

The higher form of grouping is the multispecific one, determined by obtaining food, the grouping system in biocenoses, which become characteristic if they are constituted in certain conditions determined by the abiotic environment, thus creating the basic ecological systems, ecosystems (see ecological evolution chapter).

F. **Ecological evolution** will be presented in chapter 4.2 of the Ecosphere

3.2.2. The Great Leaps in the Evolution of Living Systems (Godeanu and Popa, 2022)

The formation of the hierarchy of living systems occurred through the evolution of the ways in which life manifested itself and through vital processes in three large categories of hierarchical systems: individual (organisms), multi-individual (species, biocenoses) and multicenotic (biolandscape, bioregion, biozone, biosphere) (Doniță, 2022, Donita *et al.,* 2020).

As a result of these forms of evolution, the present hierarchy of living systems was realized.

The extraordinary variability of carbon-based molecules **determined the first diversification of matter, the chemical one.** Proof that this is so is the ability of modern science to create, artificially, an infinity of organic compounds with different properties - from plastics and polymers, to the astonishing diversity of pharmaceuticals and biochemicals.

At the level of **organic macromolecules**, matter, under the action of information, made **the second leap of diversification**: a new process appeared, called **metabolism** by biologists, composed of two mechanisms with opposite functions, assimilation and disassimilation, through which macromolecules take different chemical compounds from the environment , they self-replicate, grow and change their composition.

After the emergence of metabolism, the first individual, unicellular systems (prokaryotes) appeared.

From assimilation and disassimilation (so from the self-maintenance of these **individual systems**), we moved on to their **growth** and later to their **division**. In order to maintain the molecular structure, **the stability and protection** system appeared in the face of the existence of variable conditions of environmental factors. It represents the **third leap - called by ecologists autecology** (autecology of organic macromolecules, of probiotic microorganisms).

As a result of the maintenance and multiplication of these individual systems, cenoses were formed, which selectively took from the environment the compounds necessary for their self-maintenance and survival - and which at the same time returned the de-assimilation substances to the surrounding environment. These coenoses acquired a new quality – they not only endured and adapted to the environmental conditions they were in, but began to modify **the environment from a physico-chemical point of view**. It is therefore the first action of living systems equipped with metabolism on the environment. This is the **fourth jump.**

These chemical processes were initially linear (cause-effect type). They implicitly led to a profound change in the informational processes related to organic macromolecules, as well as to their interactions with the environment.

Later, informational and material processes become cyclical and begin to be characterized by **self-improvement,** a phenomenon that is characteristic only of living matter. **This is the fifth jump.**

All evolutionary processes are characterized by a succession of short, explosive moments, which are followed by long periods of refinement, during which the diversity that has taken place is stabilized and chiselled.

Seen globally, life has become increasingly complex, and the process of life's evolution has gradually accelerated, more evidently in the last 600 million years (after the transition from prokaryotes to eukaryotes). At the same time, the ways of perpetuating life were perfected, during which the informational processes in living matter became the co-donor factor of all living and non-living processes at the planetary level.

In the course of their evolution, living things went in the direction of making the way of procuring, processing and - finally - returning the materials extracted from the environment more efficient.

The levels of organization of living matter that we currently recognize are: cell, species (through its populations), biocenosis, biolandscape, bioregion, biome, and biosphere (Figure 50). The first two levels constitute the biological, individual stage of the organization of living matter and are studied by all branches of biology. Higher species levels appeared after living organisms, organized in forms clearly dependent on abiotic factors, are studied both by biologists and by specialists in other fields of natural sciences (especially ecologists and geographers). These levels of organization of living matter are in the ecological stage of organization of living matter (that of the integration of the living with the nevi) (Botnariuc, 1976; Ceapoiu, 1988; Cogălniceanu 2007) (Figure 50 and 51).

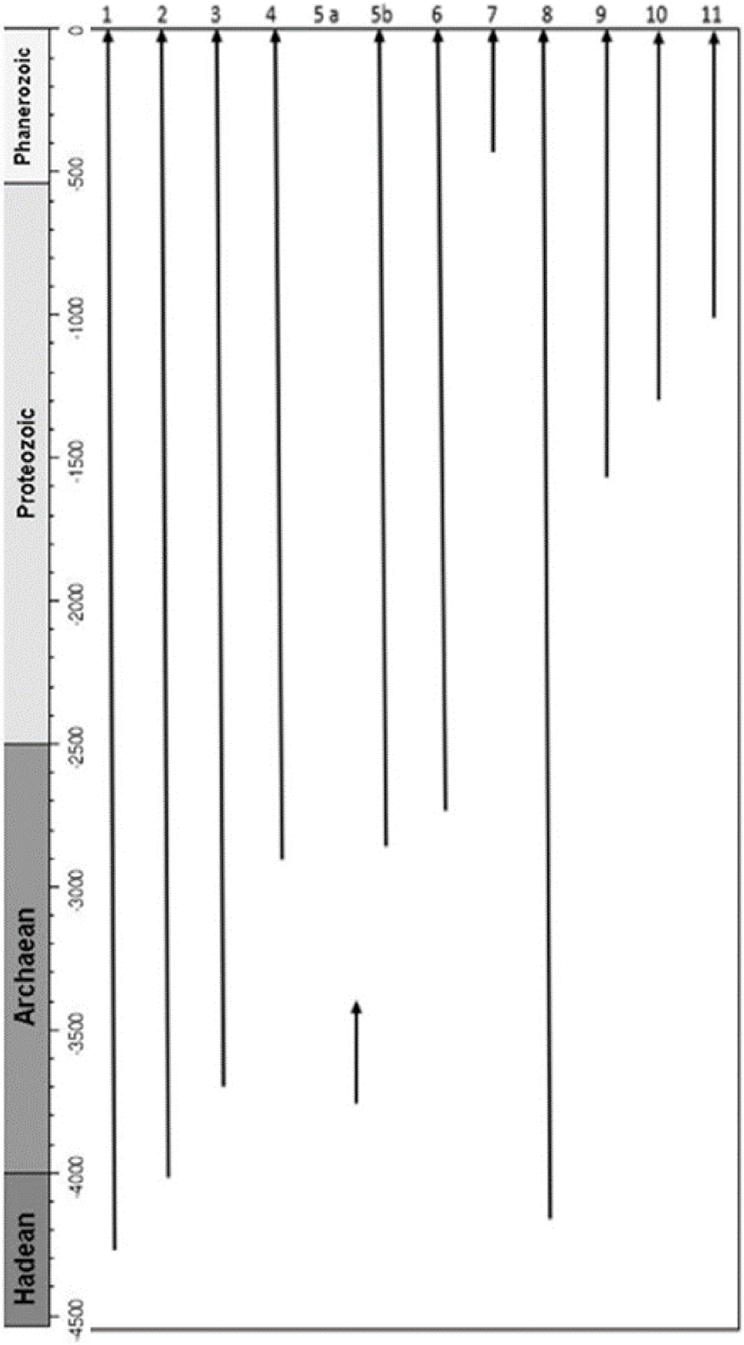

Figure 50. The great leaps in the evolution of living systems: 1- the appearance and development of metabolic processes, 2- the appearance and diversification of unicellular organisms, 3- the appearance and diversification of unicellular eukaryotic organisms, 4- the appearance and evolution of multicellular eukaryotic organisms, 5- the formation of the first types of ecosystems/cenoses (5a-associative and 5b-expansive), 6- diversification of phylogenetic evolution, 7- homeostasis of the biosphere, 8-Life in the seas and oceans, 9-Life in fresh waters, 10-life in the terrestrial environment, 11-life in the underground environment (Godeanu *et al.,* 2022)

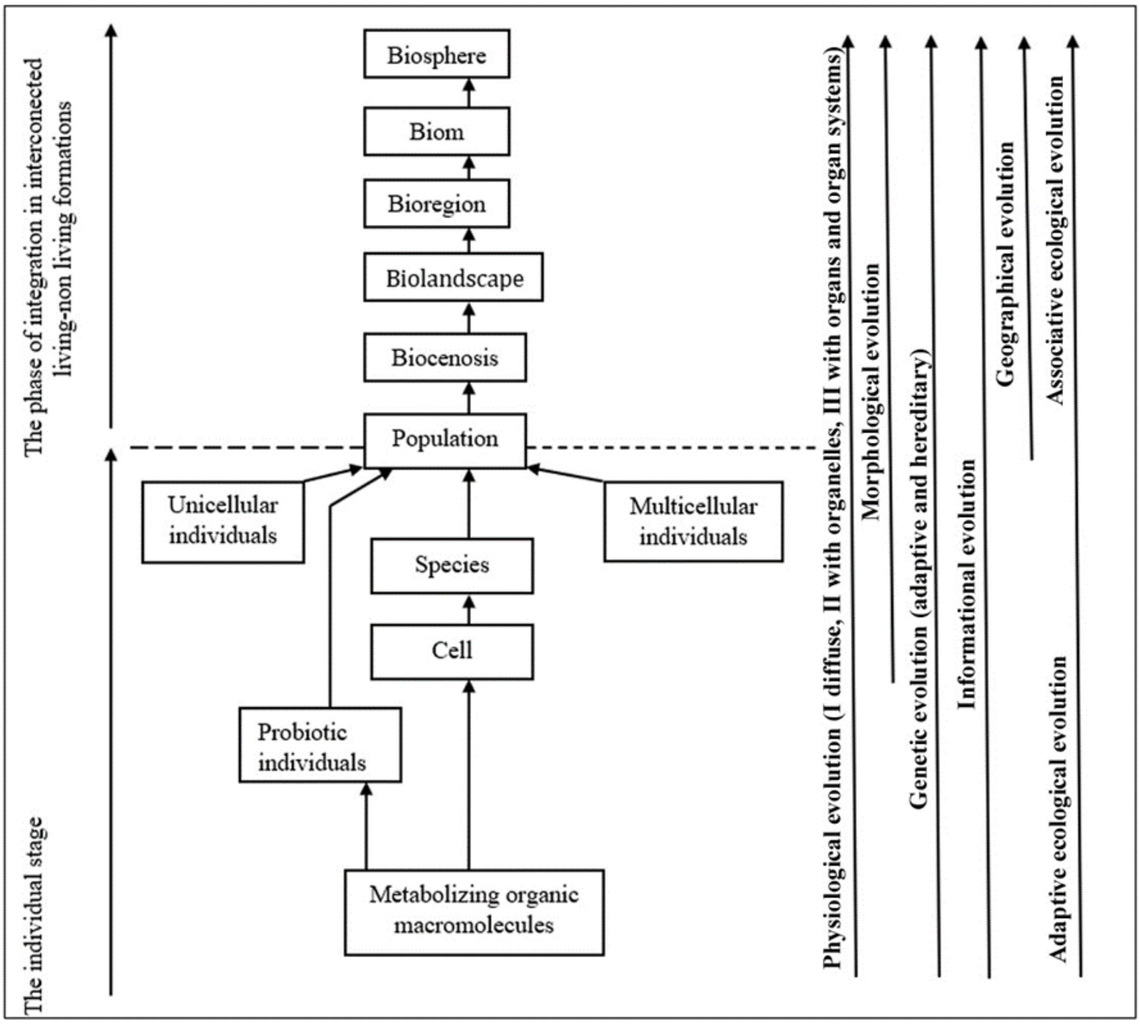

Figure 51. The different forms of the evolution of living matter over time on the principles of systemic theory applied in ecology (Godeanu *et al.,* 2022, modified)

3.3 The current state of the biosphere

The research of living organisms from most points of view is handled by a science that has now become "old" and which is very complex, Biology. They are added to the research carried out in other theoretical or applied fields, such as paleontology, biogeography, bioastronomy, ecology, ethology, biosociology, bioeconomy, nature protection, but also medicine, agronomy, animal husbandry, fish farming, forestry... and many others.

However, the current state of the biosphere is still not fully known, because, on the one hand, no special studies have been undertaken in this regard, and on the other hand, because the disturbing factors (natural, anthropogenic or synergistic ones) are very numerous and extremely different. Currently, the most important thing for us, people, with all the regret, is the satisfaction of needs, but especially of immediate economic and personal interests. Mankind created the so-called anthroposphere, which has now become an artificial but real ecosphere at the planetary level, created by the egocentric actions of humans. It will be discussed in more detail in the next chapter of this book - the ecosphere.

What we can mention now is the fact that we can currently speak of two types of biospheres: one, the natural one, which created, developed and diversified all life forms on our planet over 3.5 billion years, and the second is the one created by man to satisfy his needs, which is now being organized (the so-called anthroposphere) and which started about 40,000 years ago. This is an artificial biosphere and consists of the world of organisms that man has created or modified in order to satisfy his needs for food (agriculture and animal husbandry), to create artificial (or artificial) environments such as human settlements and industrial parks, in which different varieties of agricultural plants, domestic animals, edible or medicinal fungi (to obtain antibiotics) and even micro-organisms (intended to satisfy a wide range of purely human interests, such as artistic, cultural, medical, or , unfortunately, military).

From the natural ecosphere have passed - or have been passed - permanently into the anthroposphere a wide range of organisms that have found here more varied sources of food and that compete for this purpose with the interests of humans. They are currently booming. Because they go against human interests, they are considered "harmful"; that is why man has created an ever wider and at the same time ever more varied range of synthetic biocides, whose long-term effect - both for mankind and for the anthroposphere - is unknown.

What can now be known with certainty is the fact that the capacity for redundancy and resilience of the natural biosphere is increasingly seriously affected, that there is discussion in the scientific world of the existence of some disturbances with still unknown effects, the consequences of which are unpredictable for the stability of the biosphere and of the natural planetary ecosphere. These are still discussed, plans are made, but unfortunately, short-term economic and political interests always prevail, a fact that leads to the permanent postponement of decisions aimed at restoring the balance between the biosphere and the toposphere, that is, the entire ecosphere on the planet ours (Godeanu *et al.,* 2020; Godeanu *et al.,* 2021; Godeanu *et al.,* 2022).We will return with details in the Anthroposphere chapter.

3.3.1 The diversity of life forms on Earth

The diversity of the composition of the living things that make up the biosphere (in terms of the number of species, their morphology and physiology) is extremely high. Life is represented by many types of organisms, from plants, animals or fungi, which can be easily observed in nature, to the multitude of tiny, mostly unknown creatures that we know as algae, protozoa, bacteria or archaea.

The microbiome (derived from the Greek words micro, meaning "small" and biotic, meaning "pertaining to life") is a massive system made up of trillions of microorganisms. Incredibly, about 40,000 species of bacteria, 300,000 species of parasites, 65,000 species of protozoa, and between 3.5 million and 5 million species of fungi now live in the environment around us (and many of them live in or on the body human). This complex world of microorganisms is constantly accompanied by a lot of viruses, which serve as a kind of communication network for bacteria, parasites, protozoa and fungi. And as we will soon discover, these viruses have always been here to help us, not to hinder us. In other words, they are life-affirming, not death-inducing!

Calculations regarding the estimated number of species currently living on our planet have been made by many authors, but they can only be considered very approximate. There are many more prokaryotes and it is almost impossible to estimate, not even with a great approximation, they differ not only morphologically, but especially functionally (so from a physiological and biochemical point of view). That is probably why they are - at least - as many as eukaryotes, but they are all microscopic and differentiating some from others is done according to totally different taxonomic criteria. They are the first living beings to appear, they have permanently adapted to the changes of abiotic and biotic environmental factors, so that they are the oldest and at the same time, even now, the best adapted living beings on our planet.

Living things can be found in every type of habitat on Earth – underground, on land, in lakes, rivers and oceans, from sea level to the highest mountains, and in the form of spores or seeds, and in the atmosphere , and thousands of meters in the air (by altitude). Although all these organisms are very different from each other, they all have two things in common: they all descend from a common ancestor, and they are all living organisms.

The main chemical compounds that make up living things

When atoms, the basic units of all chemical elements, combine into chemical compounds, they form molecules. All organisms have many different types of molecules, from water and simple salts to complex organic molecules (so based on carbon compounds) such as carbohydrates, fats, proteins and nucleic acids. For example, only hemoglobin, the protein that carries oxygen in the blood, contains atoms of 6 different elements - carbon, hydrogen, oxygen, nitrogen, sulfur and iron.

The complexity of molecules in living things is due to the ability of carbon atoms to bind different types of atoms in different proportions and in extraordinarily varied combinations.

Three other commonly encountered elements, oxygen, hydrogen, and nitrogen, are also important in the structure and functioning of living things. In the human body, for example, these elements, together with carbon, account for about 96% of the body's weight.

Oxygen and hydrogen are very important in the processes of any organism to obtain and use the energy needed to carry out metabolic processes. Water, a compound made up of one oxygen atom and two hydrogen atoms, also plays a very important role in absolutely all life processes. Large amounts of nitrogen are found in proteins or in many organic compounds.

Calcium is found in the shells of crustaceans, insects and worms, but also in the skeleton of many living beings.

Phosphorus is indispensable to life. It is part of many molecules, such as adenosine triphosphate (ATP), which plays a key role in energy transfer, and nucleic acids in DNA, which carry genetic information. Phosphorus is a critical component of bone and cartilage in vertebrates and in the exoskeletons of some invertebrates.

Basic functions of living organisms

To be considered a living organism, it must perform the following main functions:

1. Movement - Living things have the ability to move without outside help, at least during certain periods of life, and in their cells many of the existing components (cell organelles) must circulate throughout their lives. Movement may consist of the flow of material within the organism or manifest externally (as a whole or as parts of the organism).

2. Sensitivity - Living things respond to the variety of stimuli in the environment around them. Green plants grow towards the sun, certain micro-organisms contract into tiny balls when something touches them, and human beings blink when light enters their eyes.

3. Respiration - All living organisms must be able to release the energy stored in food molecules through a chemical process known as cellular respiration. In aerobic respiration, oxygen is taken in and carbon dioxide is released. In unicellular organisms, the exchange of these gases with the environment takes place through the cell membrane of the organism. In multicellular organisms, gas exchange with the environment is somewhat more complex and usually involves a type of organ specially adapted for this purpose, the respiratory organ or apparatus. Multicellular animals must breathe oxygen, which diffuses from the lungs into the body's bloodstream. The arterial system carries the oxygen needed for breathing to all the tissues and cells of the body, where the process of oxidation of organic compounds takes place and results in carbon dioxide, a cellular waste product that must be transported back to the lungs and then expelled into the air. Plants also breathe, but they do it through some skin slits (stomata), then circulate dissolved in the intercellular juice, diffuse through the walls of the cells inside them; here the oxidation process of chemical compounds takes place, and then, the resulting carbon dioxide, resumes the path through which the oxygen came and is eliminated through the stomata (or is reused in the photosynthesis process). Certain types of bacteria and archaea use a type of cellular respiration, called anaerobic respiration, in which the role of oxygen is fulfilled by other reactants. Anaerobic respiration can use carbon dioxide, nitrate, nitrite or sulfate ions and allows the organism to live in an anoxic environment.

4. Nutrition - Living things need energy to survive. Energy is obtained from nutrients or the food that living organisms feed on. Green plants, algae, but also certain archaea and bacteria can produce food from water and carbon dioxide through photosynthesis. Leguminous plants can produce protein by taking up nitrogen provided by bacteria living in nodules on plant roots. Animals, fungi, protozoa, many archaea and bacteria must obtain food from an external source. They do this in different ways, all of which depend on physical adaptations specific to each type of organism. Regardless of how nutrients are obtained—or, in the case of autotrophic organisms, manufactured—each organism will use nutrients in its own unique way. Some of the nutrients can be used for structural repair; another part can be used to provide energy, which the body needs to function.

5. Growth - Living things grow by making their body components from new materials and/or constantly recycling some of their older components. A special type of growth causes the regeneration of living structures damaged for various reasons. Shrubs and trees repair wounds by covering them with younger bark and adding new layers of wood. Crabs grow new legs when old ones are lost (for various reasons).

Human beings can regenerate their skin and tissues damaged by various factors, or even repair fractured bones.

6. Reproduction - When living things reproduce, they create new organisms similar to those from which they came. This is true even for the simplest microorganisms, which can reproduce by simply dividing into two others. Each new individual is capable of moving, feeding, growing, and performing all the other functions of the living things from which they came. This type of reproduction is called asexual because it can be carried out without the need for a mating partner. There are other forms of asexual reproduction. It is most commonly found among so-called lower organisms such as bacteria and many types of protozoa and fungi. They are called "inferior" not because they are unimportant or simple, but rather because they evolved earlier than the "higher" complex organisms, which reproduce only sexually (that is, by exchanging reproductive material between two partners of different sexes , possessors of almost similar genes). We mention the fact that there are also "higher" organisms capable of reproducing asexually (certain plants, some amphibians or reptiles).

7. Excretion- All living organisms create waste during their metabolic processes. Most waste comes from ingested and undigested food. Others result in their course from activities that living individuals carry out while they live. If these wastes remained in living things, they could poison the body, or cause disease or death. That's why living organisms must have a way to eliminate waste. The process of removing waste from the body is called excretion.

Cell – the basic component of any living being

Cells are the fundamental, binding elements of the living world. All living things are made up of one (unicellular) or several cells (multicellular). All the basic functions of living organisms take place inside the cells. Cell activities are controlled by biological information, which is represented by the cell's genetic material - its DNA, which is concentrated in the nucleus. In cells, all basic functions take place in some specialized formations - cell organelles (Figure 52). For example, photosynthesis is carried out in chloroplasts, digestion and removal of toxins in lysosomes, obtaining energy for cell operation in mitochondria, protein synthesis in ribosomes and in the endoplasmic reticulum, excretion in the Golgi apparatus, etc.

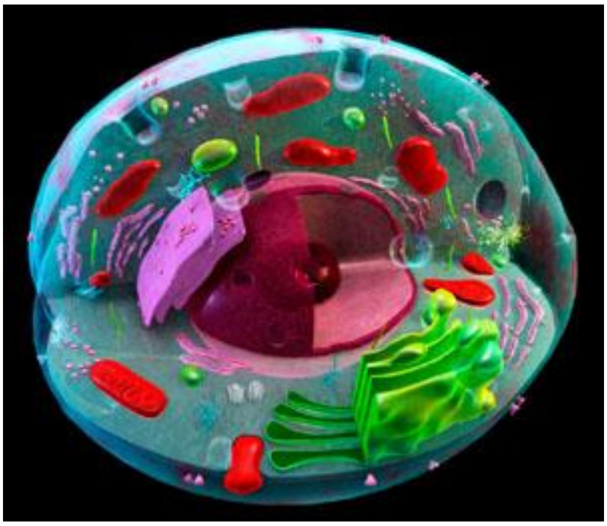

Figure 52. A diagram of the organelles inside a cell in eukaryotes (https://www.descopera.org/celula-un-mic-univers/)

Specialization of living things

Unicellular organisms may have specialized parts inside their cell, such as flagella or cilia, which are used for locomotion, food enters the body through a pseudostome, and is digested within the body in digestive vacuoles; undigested remains are eliminated through excretory vacuoles, light sensitivity control processes are carried out through eye spots, photosynthesis is carried out in chloroplasts, etc.
Multicellular organisms have tissues and organs in which the cells themselves are superspecialized. So are roots, leaves, and flowers in plants, and the digestive, respiratory, excretory, nervous, and sense organs are examples of organs that perform the basic functions of animal organisms.

Specialization is carried even further, from the level of organs, to whole organisms. Cacti live only in extremely harsh environments (very dry, desert, but, in order to live, they store a lot of water in their bodies; instead, submerged aquatic plants can only live in a lot of water; if they don't have it, they dry up. In seas and oceans there are fish that live only in the water mass (sardines) and others only on hard substrates (guvids). Termites feed on wood cellulose through symbiosis with some highly specialized protozoa that live in their gorse, and some ants create chambers in that grow fungi on decaying plant material, fungi that they then feed on. And the examples go on.

A much broader form of specialization is the adaptation of organisms to their living environment. Every living thing is adapted to its environment - to sea or ocean water, to fresh water, to times in land, or even to life in or on other organisms. During the 3.8 billion years that living things have lived on Earth, they have adapted to all kinds of conditions in the process known as evolution by natural selection. Today there are millions of different combinations of organisms and their environment. Those who do not adapt, perish.

Gheorghe Mustață issued a new law of evolution in 2015: "Evolution does not erase its traces, but keeps them functional" (Mustață, 2015). He believes that evolution is a historical process made up of a series of its own evolutionary processes, which take place on different levels, according to strict laws and rules, depending on the ecological conditions in which the respective organisms live. Biological evolution is achieved through a complication and specialization of biological structures and processes. Its basic elements remain fixed in the genomes of all species, they continue to undergo new, adaptive adaptations, but they remain fundamentally functional and are found in all organisms living today (Mustață, 2015).

3.3.2 Classification of the living world[4)]

Some scientists estimate that there are about 14 million species on Earth, although only about 1.9 million have been identified. For centuries, scientists have divided living things into two kingdoms - plants and animals. Most organisms classified in the plant kingdom had chlorophyll and cellulose. The animal kingdom consisted of species that had no chlorophyll or cellulose and fed on other living things. This classification system was formalized in the 18th century by the biologist Carl Linnaeus.

Linnaeus' system was based on similarities in body structure and was completed more than a hundred years before the work of Charles Darwin, whose theory of evolution showed that similarities and differences between organisms could be seen as a product of evolution naturally.

As 20th century biologists learned more about microorganisms and fungi, they recognized the need for a different classification system based on the evolutionary relationships between organisms. The five-kingdom taxonomic system began to be adopted in the 1970s. In addition to plants, animals, and fungi, yet another kingdom, Protista, was delineated.

In the late 1970s, using molecular technology to examine the evolutionary relationship between several groups of prokaryotes, researchers noted that one group had distinct differences in its genetic code that set it apart from other prokaryotes. Thus it was found that there is another form of living life, previously unrecognized, which has been named Archea.

Most biologists now consider archaea to be one of three distinct branches of life that formed early in the development of life on Earth. The three main branches, called domains, are Archaea, Bacteria, and Eukarya (the domain Eukarya includes all eukaryotes, namely Protista, Fungi, Plantae, and Animalia) (Godeanu *et al.,* 2010).

The basis of the classification of living organisms is the species, with its subunits (subspecies and infraspecies) and its superunits (family, order, class, phylum and kingdom) (Figure 53).

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[4] See also the last part at the end of chapter 3.2.2.

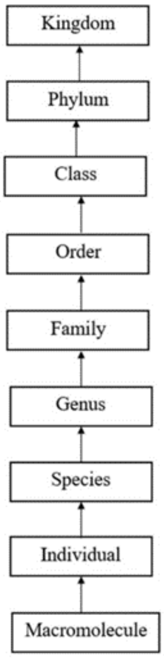

Figure 53. The modern system of taxonomic classification of living organisms (Godeanu *et al.,* 2022)

The species is the distinctive unit for all types of living and fossil organisms. It is the result of the evolution of the living world under the influence of environmental factors and their interspecific relationships. It consists in a selective synthesis of all the information that has accumulated in a certain way in the matter they have structured (Simpson, 1951; Zawadsky, 1961; Mayr, 1957 1982; Ghiselin, 2002; Botnariuc, 1967; Doniță *et al*., 2020; Godeanu *et al*., 2010, 2021, 2022; Godeanu *et al.,* 2022).

”Species is represented by a multitude of individuals which have the same biochemical, genetic, morphologic, physiologic and behavioral peculiarities, which are living under the same environmental conditions and form populations in which they live and reproduce. For biologists, the species is a taxonomic category composed by individuals which are identical from a lot of respects (see above the definition of the species). For ecologists the species is represented by populations composed by individuals of the same species, characterized by a pronounced fidelity for the living in certain biocoenoses, which live under specific environmental conditions, with which they constitute a specific hierarchical unit, called ecosystem.” (Doniță *et al.,* 2019).

Taxonomy is a system of classification created by humans in order to order living things in a way that is as close as possible to their natural evolution throughout the history of our planet.

From its beginnings taxonomy was based on external and internal morphological aspects. Genetics only appeared in the 19th century. Morphological evolution is maintained even now, along with genetic classification, in unicellular prokaryotes and uni- and multicellular eukaryotes (less so in degrading organisms – unicellular fungi – in which physiological mechanisms have maintained their most important role).

Over time, taxonomy was able to order the variety of life forms on the planet by grouping different types of similar individuals into species and higher taxonomic units (Figure 52). So, taxonomy arose out of the need to distinguish different living things by morphological, physiological, ecological, and now genetic methods [Heywood, 1995; Margulis *et al.,* 2000 (Figure 53); Cavalier-Smith, 2007 (Figure 55); Adl *et al.,* 2019 (Figure 56)].

The original Linear system was modified over time as follows (Table 12):

Table 12. The main moments in the classification of the living world

Linnaeus, 1735	**Haeckel, 1866**	**Whittaker, 1969**	**Woese *et al.*, 1990**	**Cavalier-Smith, 1998**	**Cavalier-Smith, 2015**
2 kingdoms	3 kingdoms	5 kingdoms	3 areas	2 areas, 6 kingdoms	2 areas, 7 kingdoms
(untreated)	Protista	Monera	Bacteria	Bacteria	Bacteria
			Archaea		Archaea
		Protista	Eucarya	Protozoa	Protozoa
				Chromista	Chromista
Vegetabilia	Plantae	Plantae		Plantae	Plantae
		Fungi		Fungi	Fungi
Animalia	Animalia	Animalia		Animalia	Animalia

In figures 54-57 we highlight the speed with which the classifications of the living world changed in the first two decades of the 21st century.

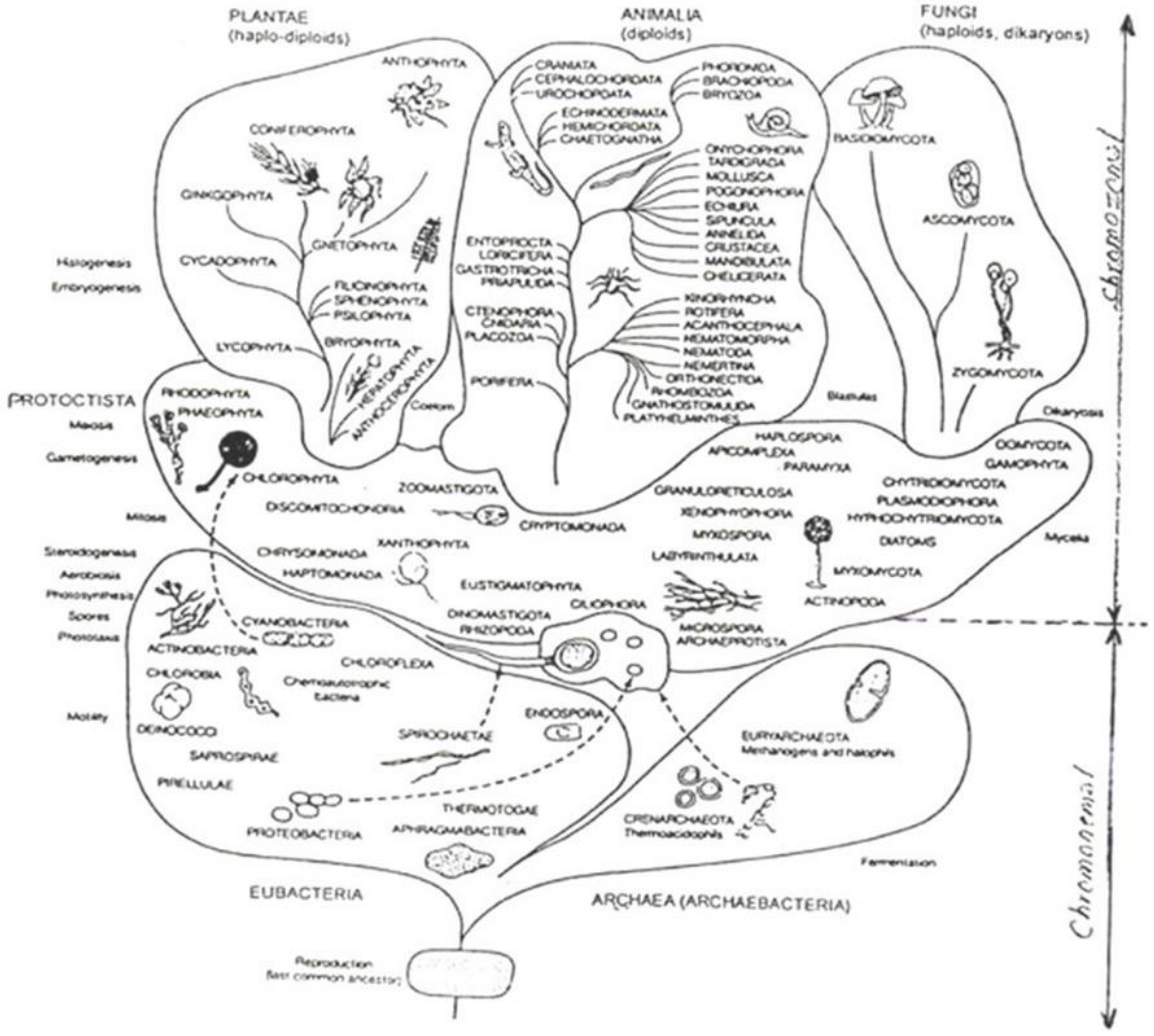

Figure 54. Classification of the living world (Margulis *et al.,* 2000)

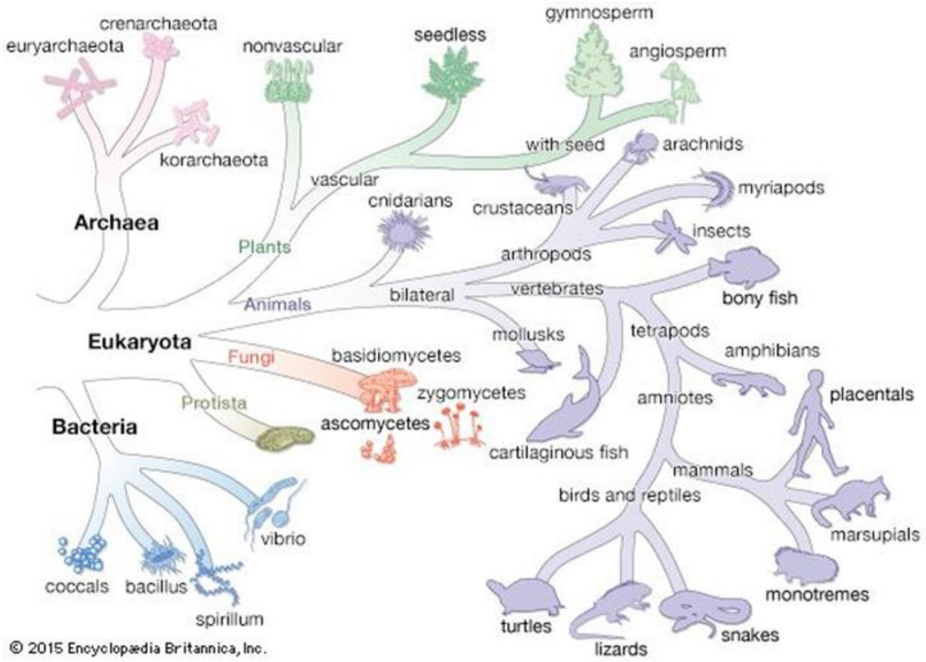

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Figure 55. The classification scheme of the living world (Encyclopaedia Britannica, 2015)

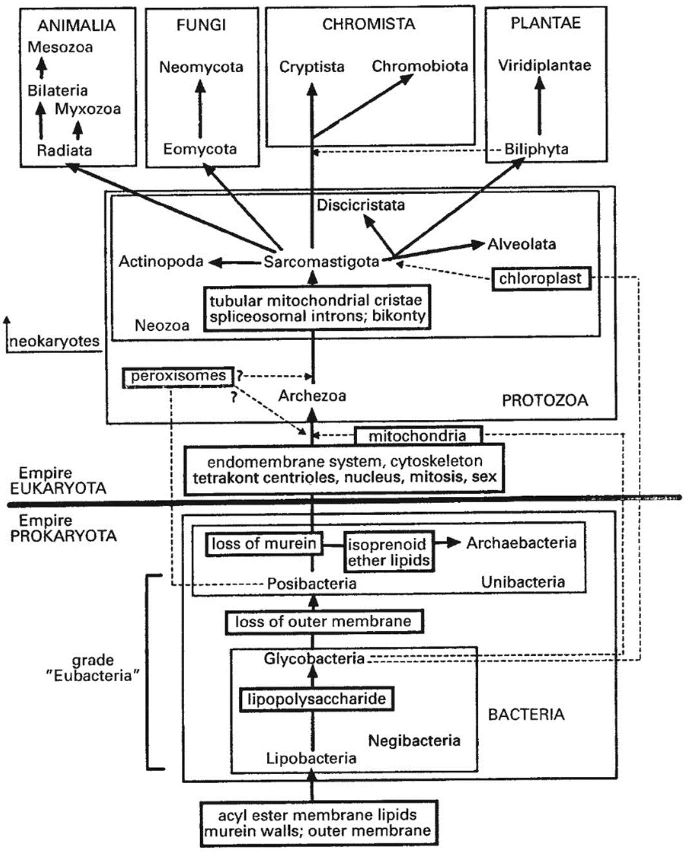


Figure 56. Classification of the living world on genetic bases (Cavalier-Smith, 2007)

In 2019 Adl, together with many collaborators, based on the latest knowledge in the field of genetics, carried out a modern review of the phylogeny and systematics of all living organisms currently on our planet (Figure 57).

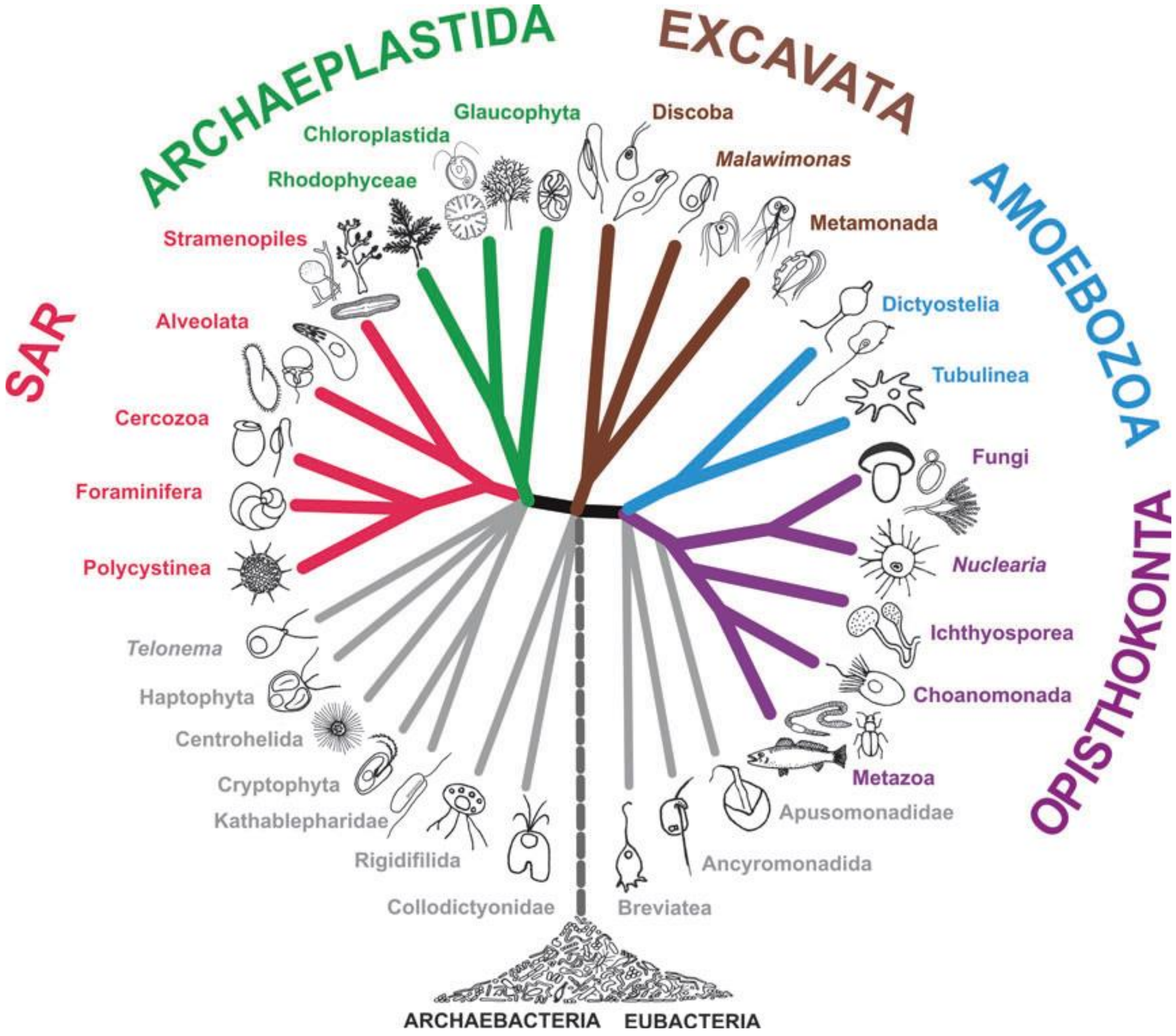


Figure 57. Current phylogenetic classification of eukaryotes (Adl *et al.,* 2019)

Below we present a brief characterization of the main areas of the living world.

Archaea – Organisms in the Archaea group are unicellular prokaryotes. Their external appearance is similar to that of bacteria, but they differ from them from a genetic and biochemical point of view. For example, the cell wall of archaea does not contain peptidoglycan, and the way they process DNA is more complex. Although many archaea live in a wide variety of habitats, including oceans and soil, a notable characteristic of some species is that they can thrive in environments that are deadly to all other types of living things (Figure 58).

Many archaea are only found in deep pits on the ocean floor (ocean vents) or in hot springs, where temperatures far exceed +93°C. Other extremophilic species of archaea live in pools of very acidic or salty water. Methanogenic archaea live in environments such as swamp mud or cattle rumen (where there is no oxygen) and the pH is 2 or 3. They take carbon dioxide and hydrogen from the environment and create methane gas (as a byproduct of their metabolism) . Archaea occupy those habitats where there are strong similarities to some of the conditions on early Earth, such as hot springs, or in habitats that have an oxygen-deprived atmosphere. The ability of archaea to thrive in such extreme conditions suggests that they adapted to them long ago, and the pattern of their genetic code suggested that they were probably among the most primitive forms of life on Earth. Archaea are able to make nitrogen from the atmosphere available to plants. Unlike bacteria, no species of archaea have been found to use chlorophyll for photosynthesis, and no archaea have been identified that cause disease in humans.

Archaea are difficult to identify and study because most cannot be grown in laboratory cultures. However, advances in DNA techniques make it possible to analyze them directly from the environment to identify their DNA and RNA.

Figure 58. Various types of Archae

Bacteria - are unicellular prokaryotes (organisms whose cells are without nuclei or lack distinct organelles). Virtually all bacteria have a rigid cell wall that contains a peptidoglycan. Typical forms of bacterial cells are cocci, bacilli, filaments and spirilla. Some bacteria have flagella that they use to move around. Based on genetic studies, experts believe there may be about 1 million species of bacteria of which only about 4,000 have been identified (!!!).

Bacteria are very diverse. Some bacteria are aerobic and some are anaerobic. Some, such as cyanobacteria, contain chlorophyll and can therefore synthesize their own food, so they are autotrophs. Cyanobacteria have no flagella and often live several together, forming either chains or clumps of cells that are covered by a gelatinous substance. Although they are usually autotrophs, in the absence of light and under certain conditions, they can also take their food from other sources. Most bacteria are heterotrophs (including those that break down necromass (organic matter from decaying organisms). Many bacteria can cause disease, or convert atmospheric nitrogen into compounds that plants can use (Figure 59).

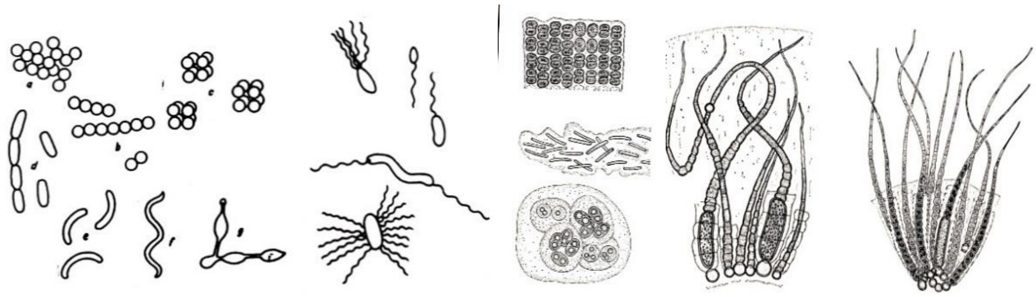
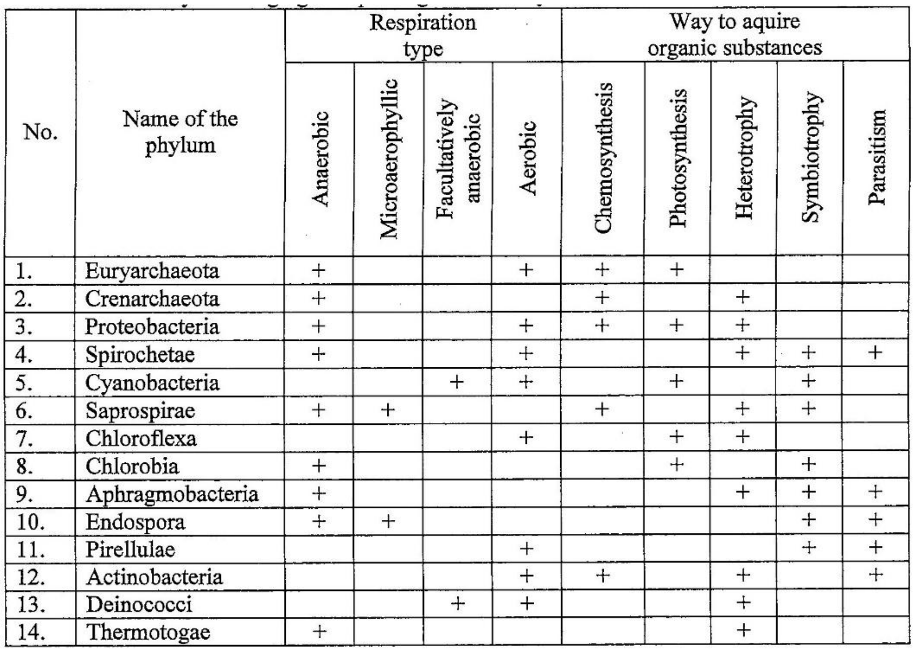


Figure 59. Various types of bacteria

Table 13 shows the current phyla of prokaryotic organisms and highlights some of their main features.

Table 13. The phyla of the superkingdom Prokaryotae (Godeanu *et al.,* 2010)



No.	Name of the phylum	Respiration type				Way to aquire organic substances				
		Anaerobic	Microaerophyllic	Facultatively anaerobic	Aerobic	Chemosynthesis	Photosynthesis	Heterotrophy	Symbiotrophy	Parasitism
1.	Euryarchaeota	+			+	+	+			
2.	Crenarchaeota	+				+		+		
3.	Proteobacteria	+			+	+	+	+		
4.	Spirochetae	+			+			+	+	+
5.	Cyanobacteria			+	+		+		+	
6.	Saprospirae	+	+			+		+	+	
7.	Chloroflexa				+		+	+		
8.	Chlorobia	+					+		+	
9.	Aphragmobacteria	+						+	+	+
10.	Endospora	+	+						+	+
11.	Pirellulae				+				+	+
12.	Actinobacteria				+	+		+		+
13.	Deinococci			+	+			+		
14.	Thermotogae	+						+		

Protists (Protista) - are a group of very diverse, unicellular organisms that have a nucleus (they are uninucleate eukaryotes) and may have specialized organelles for certain functions. They are not considered to belong to the animal, plant or multicellular fungal kingdoms. They can live either as solitary individuals or form colonies and can be autotrophic or heterotrophic. Some protozoa have flagella or cilia with which they move, acquire food, or avoid predators. Autotrophic species possess chlorophyll granules and produce their own glucose, but in the absence of light they can become phagotrophs again (they can obtain food by capturing other microorganisms, forming a vacuole around them in which they then secrete the right enzymes and digest them). Green algae are autotrophic and produce their food through photosynthesis. A number of protists can be parasites (the flagellate *Trypanosoma* causes sleeping sickness in humans and *Amoeba dysenteriae* causes amoebic dysentery).

Many protists live in oceans or freshwater. They can have a heterotrophic, autotrophic or saprophagous diet. The best studied are euglenoids, ciliates, diatoms and amoebae (radiolars and foraminifera). By comparing genetic information from many types of protists, the need arose to create new phyla in order to be classified as well. There are currently estimated to be around 600,000 species, but only 80,000 species have been well described (Figure 60).

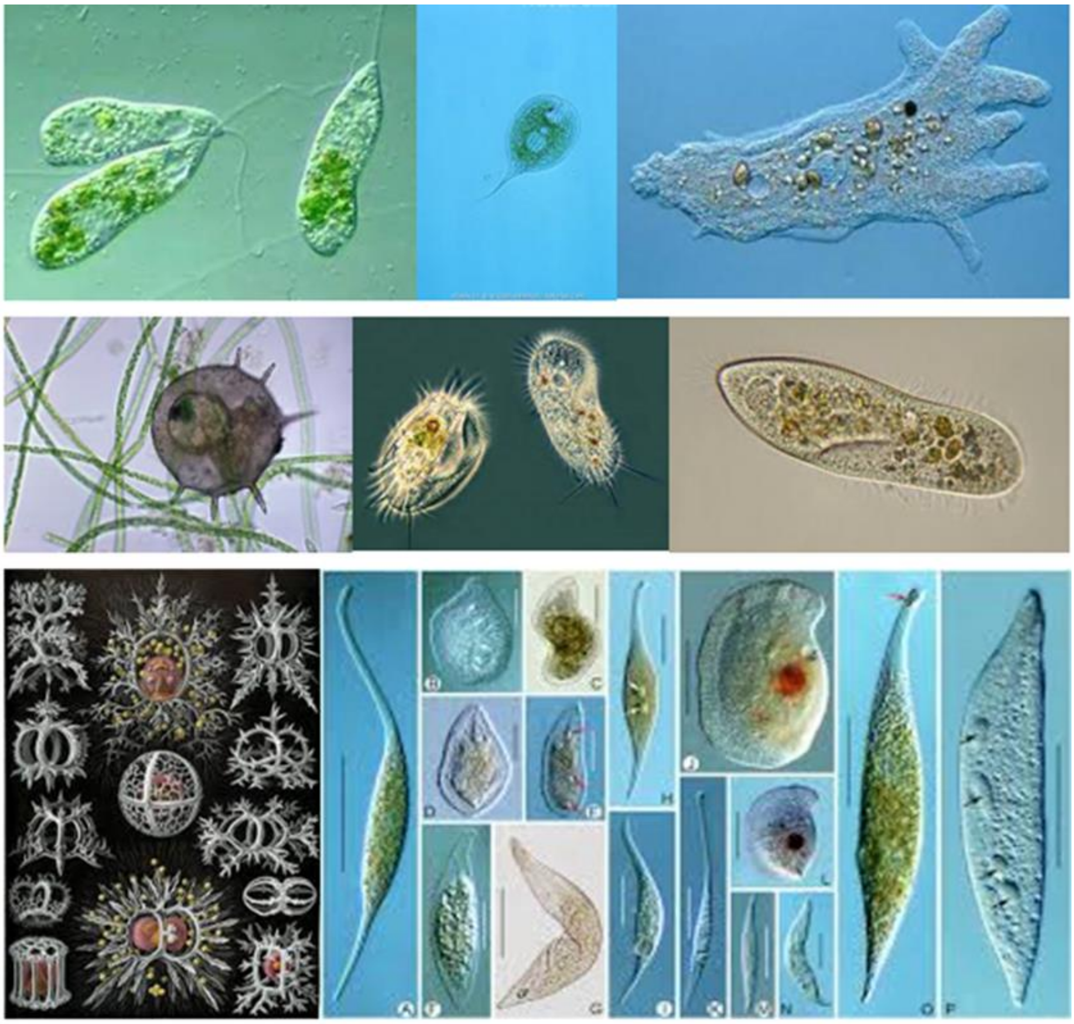


Figure 60. Protists

Table 14 shows the current phyla of protists and highlights some of their main features.

Table 14. The tusks belonging to the Protoctista kingdom; A = no mitochondria; CA = flat crista mitochondria; CT = mitochondria with tubular cristae; CD = mitochondria with discoid cristae (Godeanu *et al.,* 2010)

No.	Name of the phylum	Sp. no.	Way of nutrition				Repro-duction		Mitochondrial^1 type	Type of respiration	
				Heterotrophic							
			Autotrophic	Free iving	Symbiont	Parasite	Asexuate	Sexuate		Anaerobic	Aerobic
1.	Archeprotista				+	+	+		A	+	
2.	Microspora	800				+	+		A	+	
3.	Rhizopoda	2000		+		+	+			+	+
4.	Granuloreticulosa	400		+	+		+	+	CD		+
5.	Xenophyophora	42		+			+	+	CD		+
6.	Myxomycota	500		+			+	+			+
7.	Dinomastigota	4000		+	+				CT		+
8.	Ciliophora	10000		+	+	+	+	+	CT		+
9.	Apicomplexa	4600			+	+	+	+	CT	+	
10.	Haptomonada		+		+		+	+	CA		+
11.	Cryptomonada		+	+			+		CA		+
12.	Discomitochondria	800	+	+	+	+	+				+
13.	Chrysomonada		+				+				+
14.	Xanthophyta	600	+	+			+	+			+
15.	Eustigmatophyta	9 genera	+				+				+
16.	Bacillariophyta/Diatomea	10000	+				+	+			+
17.	Phaeophyta	900	+				+	+			+
18.	Labirinthula	8		+				+			+
19.	Plasmodiophora	29			+	+	+	+		+	
20.	Oomycota	100		+	+	+	+	+			+
21.	Hyphochytridiomycota	23		+		+	+			+	
22.	Haplospora	33				+	+		CA	+	
23.	Paramyxa	6				+	+		CA	+	
24.	Myxospora	1100			+	+	+		CD		+
25.	Rhodophyta	4100	+				+	+			+
26.	Gamophyta	6000	+					+			+
27.	Actinopoda	4000		+	+		+	+			+
28.	Chlorophyta	16000	+				+	+	CT		+
29.	Zoomastigota			+	+	+	+				+
30.	Chytridiomycota	1000		+		+	+	+		+	

Mushrooms (Fungi). The kingdom of fungi contains a very diverse group of organisms, ranging from yeasts to molds to the hat mushrooms we all know. All fungi have two nuclei in each cell. A fungus is a heterotrophic eukaryotic organism with cell walls. All fungi are multicellular. Fungi do not have chlorophyll or chloroplasts; they cannot synthesize food by themselves, so they must depend on other organisms, or they can have symbiotic relationships with them (this is the case of lichens). Like animals, fungi must digest their food before absorbing it, but unlike animals, fungi digest their food outside the body.

To do this, fungi secrete appropriate enzymes into their external environment. With their help, food degrades or decomposes until it reaches the level of small molecules, which are adsorbed and then absorbed by the mushroom cells. According to scientific estimates, there are about 1.5 million species of fungi on Earth, although only 80,000 are well classified. Figure 61 and table 15 show the three phyla of multicellular fungi.

Figure 61. Hyphae and fruiting bodies of fungi

Table 15. Current fungi belonging to the kingdom Fungi (Godeanu *et al.,* 2010)

No.	Name of the phylum	Sp. no.	Sporiferous organ	Type of nutrition				Micelia	Dicariotic mycelia
				Saprophytic	Osmotrophic	Symbiotic	Parasite		
1	Zygomycota	1100	Sporangiofor sporocistofor	+			+	Unicelular, sifonal	Absent
2	Ascomycota	30000	Asca	+		+	+	Pluricelular hifae septatae, penata	For a short time
3	Basidiomycota	22250	Bazidia	+	+	+	+	Pluricelular hifae septateae with dolipora structure	For a long time

Plants (Plantae) - are multicellular eukaryotic organisms. Members of this kingdom range from simple mosses to enormous trees (such as the Sequoia). Biologists believe there are about 300,000 species of plants. Of these, about 10% have not yet been identified, as most of them live in tropical forests.

Virtually all plants contain chlorophyll and are autotrophs. Some plants are vascular, meaning they have specialized tissues that transport water and nutrients to all parts of their body. Vascular plants include flowering plants, trees, and the more familiar land plants. Other plants are non-vascular; they have no roots, stems and leaves and are usually aquatic, or live in moist environments. Some land plants, including mosses and liverworts, are usually small in size, and do not have sap transport channels (they are non-vascular plants). The lack of a vascular system limits the amount of nutrients that can be transported to the cells of their body. Some species of plants no longer have chloroplasts in their cells and have become parasites, and others are carnivores (they have a special system for catching insects, in order to obtain from their bodies the nitrogen and minerals necessary for the synthesis of their own organic substances). Figure 62 shows some plant species, and table 16 shows the main phyla of the Plantae kingdom (in previous eras, representatives of other phyla also lived, but which disappeared during evolution) (Briggs *et al.,* 1997, Neagu *et al.,* 2002, Godeanu et al., 2010).

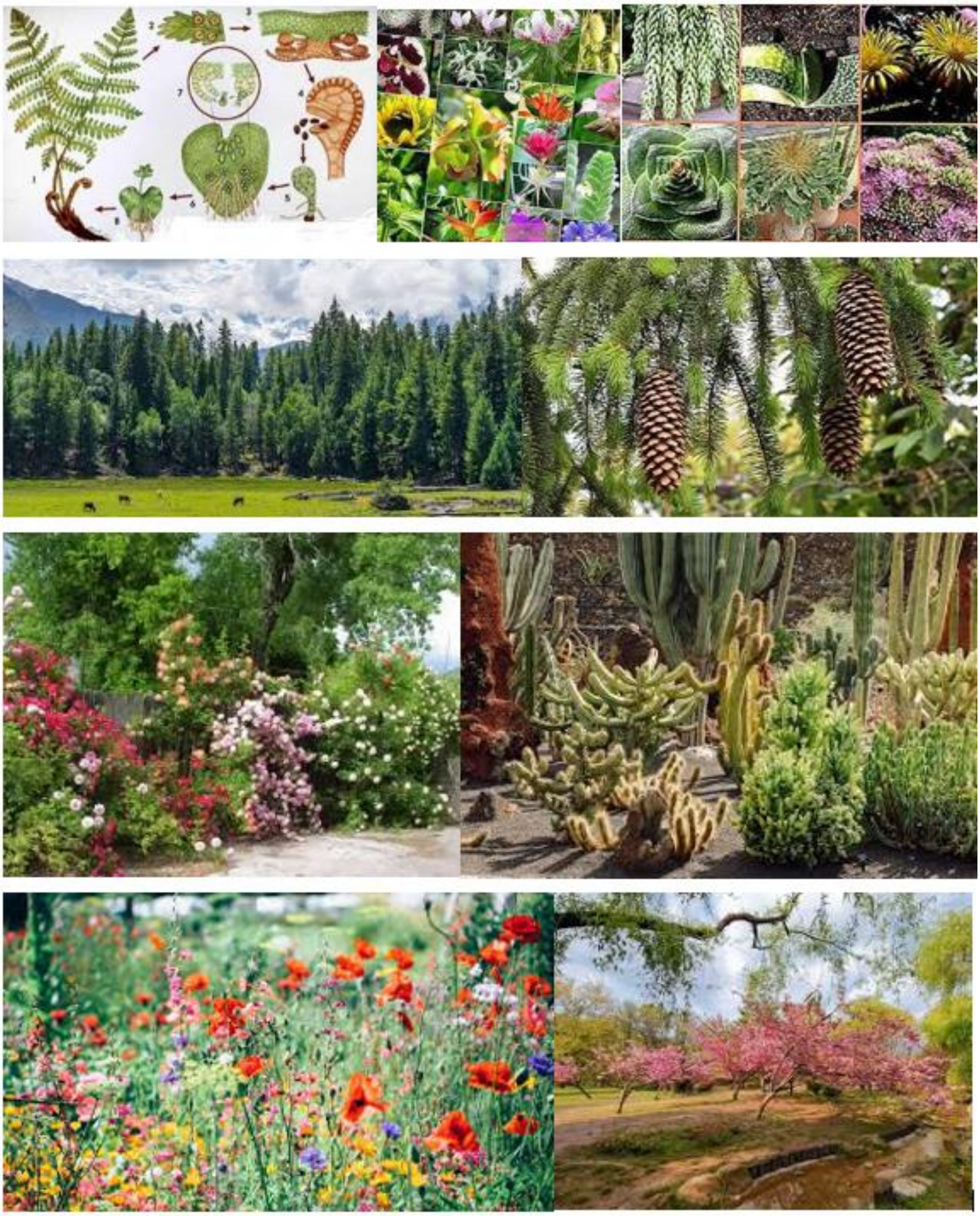
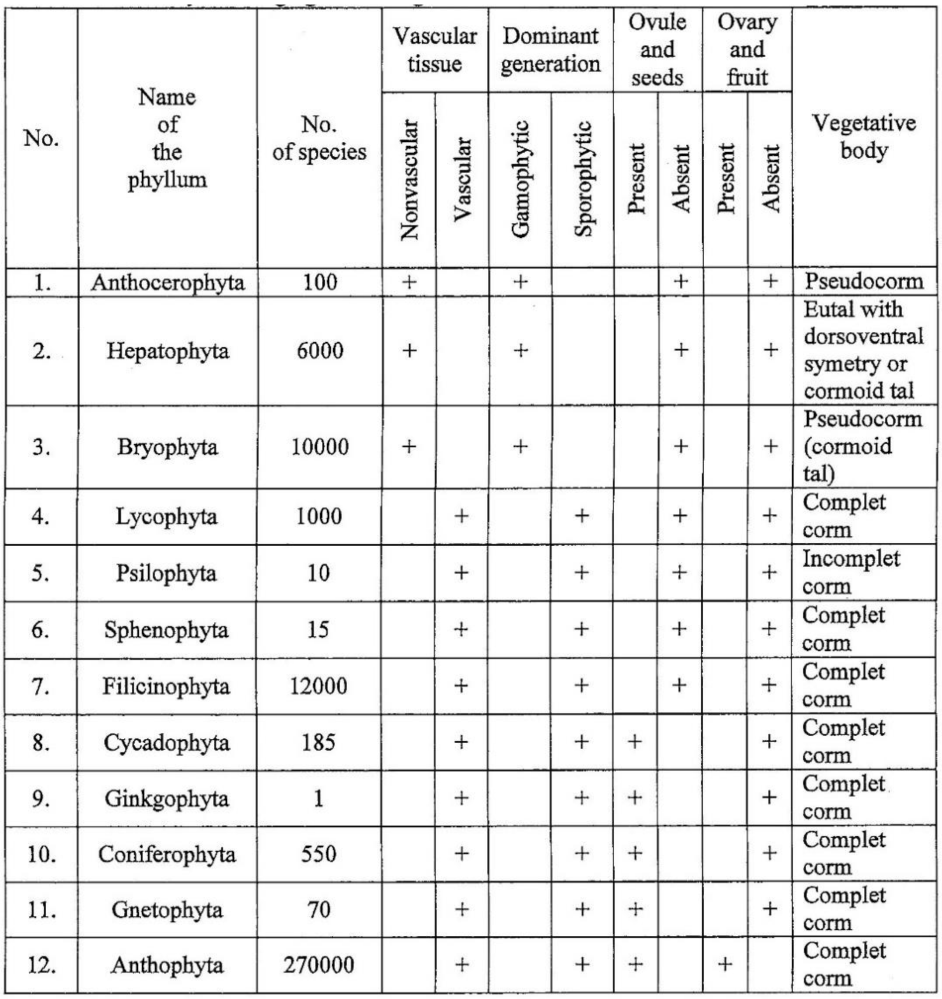


Figure 62. Different types of plants

Table 16. Current phyla of the kingdom Plantae (Godeanu *et al.,* 2010)



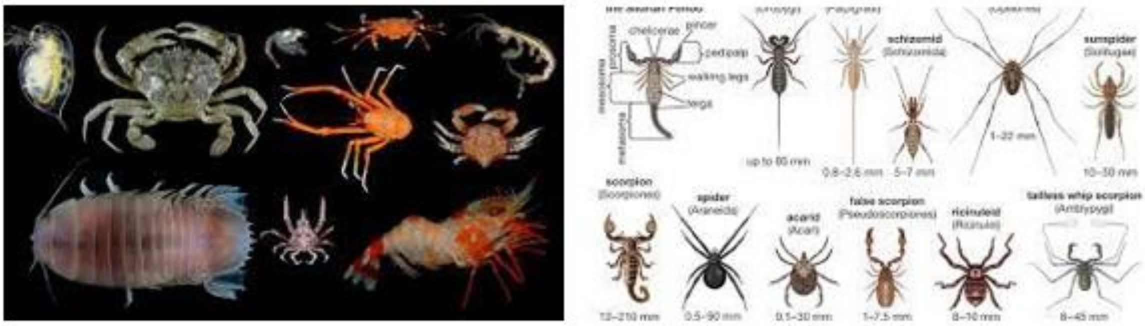
No.	Name of the phyllum	No. of species	Vascular tissue		Dominant generation		Ovule and seeds		Ovary and fruit		Vegetative body
			Nonvascular	Vascular	Gamophytic	Sporophytic	Present	Absent	Present	Absent	
1.	Anthocerophyta	100	+		+			+		+	Pseudocorm
2.	Hepatophyta	6000	+		+			+		+	Eutal with dorsoventral symetry or cormoid tal
3.	Bryophyta	10000	+		+			+		+	Pseudocorm (cormoid tal)
4.	Lycophyta	1000		+		+		+		+	Complet corm
5.	Psilophyta	10		+		+		+		+	Incomplet corm
6.	Sphenophyta	15		+		+		+		+	Complet corm
7.	Filicinophyta	12000		+		+		+		+	Complet corm
8.	Cycadophyta	185		+		+	+			+	Complet corm
9.	Ginkgophyta	1		+		+	+			+	Complet corm
10.	Coniferophyta	550		+		+	+			+	Complet corm
11.	Gnetophyta	70		+		+	+			+	Complet corm
12.	Anthophyta	270000		+		+	+		+		Complet corm

Animals (Animalia). All organisms classified in the kingdom Animalia are heterotrophic multicellular eukaryotes. They have a body made up of different types of tissues and can usually move freely. Animals are sometimes called metazoa, to distinguish them from such protozoa (heterotrophic protists), which are unicellular.

Animals can be divided into two main groups: invertebrates and vertebrates. Invertebrates may have an exoskeleton and have a scalariform nervous system. Vertebrates have an internal skeleton (a vertebral column), and a nervous system that possesses an area where many nerve cells are concentrated, which coordinates the animal's sensitivity and reaction to the action of external stimuli, called the brain.

The animal kingdom is by far the largest kingdom of eukaryotes. Experts believe that more than 10 million species of animals live today; but of these only about 1.3 million species have been identified. The largest group in the animal kingdom are insects (there are reportedly about 8 million species of insects, but only about 1 million have been identified or described). The best known of the animal groups are birds and mammals (about 10,000 species of birds and 4,500 species of mammals have been identified). In figure 63 some representatives of this kingdom are shown, and in table 17 the phyla of the kingdom Animalia are listed, with their main characteristics.

Cefalopoda Gasteropoda Lamelibranhiata



Crustacea Arachnida

Miriapoda Insecta

Echinoderma Vertebrata

Figure 63. Some images regarding the variety of representatives of the animal kingdom

Table 17. Current phylla of the Animal kingdom (Godeanu *et al.,* 2010)

No	Name of the phylum	Sp. no.	Embrionic strata			Organization plan			Body symmetry			Reproduction	
			Monoblastic	Diblastic	Triblastic	Acoelomata	Pseudocoelomata	Coelomata	Disymmetrical	Bilateral	Radial	Asexuate	Sexuate
1.	Monoblastozoa	1	+			+				+		+	
2.	Porifera	10000		+		+			+			+	
3.	Cnidaria	9400		+		+					+	+	+
4.	Ctenophora	100		+		+			+		+		+
5.	Placozoa	2 g.		+		+				+		+	+
6.	Mesozoa	50	+			+				+		+	
7.	Plathelminthes	20000			+	+				+			+
8.	Gnathostomulida	80			+	+				+			+
9.	Orthonectida	20		+		+				+			+
10.	Nemertea	900			+	+	+			+			+
11.	Nematoda	25000		+			+			+			+
12.	Nematomorpha	250		+			+			+			+
13.	Acanthocephala	1000		+			+			+			+
14.	Rhombozoa	65	+			+				+		+	
15.	Rotifera	2000		+			+			+		+	+
16.	Kinorhyncha	150		+			+			+			+
17.	Priapulida	17		+				+		+			+
18.	Gastrotricha	400		+	+		+			+			+
19.	Loricifera	100			+		+			+			+
20.	Cycliophora	1					+						
21.	Entoprocta	150			+		+			+			+
22.	Vestimentifera	20						+P	+				
23.	Pogonophora	120			+			+P		+			+
24.	Phoronida	14			+			+P		+			+
25.	Bryozoa	500			+			+P	+				+
26.	Brachiopoda	350			+			+P	+				+
27.	Annelida	17000			+			+P		+			+
28.	Sipunculida	320			+			+P		+			+
29.	Echiura	140			+			+P		+			+
30.	Mollusca	70000			+			+P		+			+
31.	Tardigrada	750			+			+P		+			+
32.	Onychophora	100			+			+P		+			+
33.	Crustacea	42000			+			+P		+			+
34.	Chelicerata	75000			+			+P		+			+
35.	Mandibulata	<1 mil.			+			+P		+			+
36.	Echinodermata	7000			+			+D			+		+
37.	Chaetognatha	70			+			+D		+			+
38.	Hemichordata	90			+			+D	+				+
39.	Cephalochordata	25			+			+D		+			+
40.	Urochordata	200			+			+D	+				+
41.	Craniata	52000			+			+D		+			+

In figure 64 we illustrate the diversity of current life forms on Earth, and in Table 18 we compare the three major domains of organisms now living on our planet.

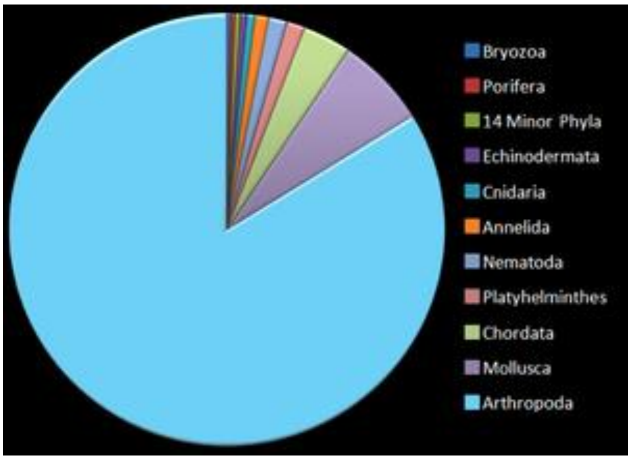


Figure 64. Percentage of major groups of organisms currently known on Earth (https://www.google.com/search?client=firefox-b-d&sca_esv=583604382&q=-+Procentul+principalelor+grupe+de+organisme&tbm)

Table 18. The main characteristics of the three domains of the living world

Characteristics	**Archaea**	**Bacteria**	**Eucaryota**
Cell membrane	ester-linked lipids	ester-linked lipids	ester-linked lipids
The cell wall	pseudopeptidoglycan, glycoproteins, or with the S-layer	Peptidoglycan, with S-layer or no cell wall	different structures
Gene structure	circular chromosomes, translation and transcription is similar to that of eukaryotes	circular chromosomes, translation and special transcription	multiple, linear chromosomes, translation and transcription is similar to that of archaea
Internal cell structure	the organelles and the nucleus are membrane-less	the organelles and the nucleus are membrane-less	organelles and the nucleus possess a membrane
Metabolism	varied, with heterotrophy, has a methanogenesis specific to the Archea group	varied, they can be autotrophs, heterotrophs and photosynthesizers, aerobic and anaerobic respiration (through fermentation)	photosynthesis, cellular respiration and ferment,
Reproduction	asexual, horizontal gene transfer	asexual, horizontal gene transfer	sexual and asexual
The start of protein synthesis	Methionine	Formylmethionne	Methionine
RNA polymerase	One	One	Many
EF-2 / EF-G	sensitive to diphtheria toxin	resistant to diphtheria toxin	sensitive to diphtheria toxin

3.3.3 The distribution of the biosphere and the factors on which it depends

Because life is characterized by the existence of a multitude of species, the various forms of life on planet Earth are found everywhere, from the north pole to the south pole, from the top of the highest mountains, to the deepest depths of the ocean trenches, in geysers, where hot water comes out of the vicinity of terrestrial magma, to vents on the bottom of the oceans, where extremely hot gases and water come out of the depths of the earth. It is also present in the atmosphere, (some forms of resistance - spores or cysts can be carried by air currents hundreds of kilometers, and some microorganisms can also be found in underground waters, so in the lithosphere, hundreds or even thousands of meters deep. Every part of the planet has a certain kind of life. Recent advances in microbiology have shown that some bacteria live deep below the Earth's surface, and the total mass of microbial life in the so-called

"uninhabitable zones" alone can, as biomass, exceed all animal and plant life on the surface . The actual thickness of the biosphere on earth is impossible to measure.
Microorganisms, under certain test conditions, have been observed to survive through their forms of resistance in the vacuum conditions of outer space. The mass of prokaryotic microorganisms (which includes bacteria and archaea but not nucleated eukaryotic microorganisms) could be as much as 0.8 trillion tons of carbon, while the total mass of the biosphere has been estimated at 1–4 trillion tons. Barophilic marine microbes have been found at a depth of 11,034 m in the Mariana Trench (the deepest place in Earth's oceans). Other researchers have found that some microorganisms thrive inside rocks down to depths of -580 m, while in oceanic sediments they can be found beneath the seafloor at depths greater than 2,590 m. Cultivable thermophilic microbes were extracted from cores drilled from above 5,000 m (in Sweden), from rocks whose temperature was 65–75 °C. It is now known that the highest known temperature at which microbial life can exist is +122 °C (*Methanopyrus kandleri*).

The distribution of the biosphere is not uniform; it depends both on the conditions of cosmic factors and on abiotic factors (climatic, geographical, pedological, physico-chemical), on biotic factors (the interactions and associations of organisms at different levels of their systemic organization), and on small factors (of all the previously mentioned types), but which mutually intercondition. On the other hand, organisms themselves can change their environment under the influence of climate. The highest concentration of living organisms is in the terrestrial environment in the equatorial and warm temperate zones, and in the oceanic environment in the shallow coastal zone (on the so-called continental shelf), and the least in the waters of warm ocean currents .
Terrestrial biodiversity is up to 25 times greater than oceanic biodiversity. Forests contain the greatest terrestrial biodiversity. Forests provide habitats for 80% of amphibian species, 75% of bird species and 68% of mammal species; about 60% of all vascular plants are found in tropical forests. As for the real diversity of microflora, microfauna and microbiota of the planet, modern data cannot give us even an indicative one.
Mangroves provide spawning grounds and nurseries for numerous species of fish and crustaceans and help trap sediment that might otherwise adversely affect seagrass beds and coral reefs - which are habitats for a wide variety of marine species.
Forests cover about 1/3 of the earth's mass and host about 80% of the planet's biodiversity. Currently, the concerns regarding the protection of nature have managed to save large areas of forest from destruction. Currently over 700 million hectares of forest in the world are officially protected. The biodiversity of forests varies considerably depending on various factors, such as the type of forest, the geographical area in which it is located, the prevailing climate, the types of soils and especially the degree of exploitation for human needs. Most forest habitats in temperate regions support relatively few species of animals and plants, and these tend to have wide geographic distributions, while in the montane forests of Africa, South America, and Southeast Asia, but also in the forests of lowlands of Australia, the coast of Brazil, the Caribbean islands, Central America and peninsular Southeast Asia have extremely many species, but characterized by narrow geographic distributions. Areas with dense human populations and heavy agricultural land use, such as Europe, parts of Bangladesh, China, India and North America, are less intact in terms of their natural biodiversity. In North Africa, south Australia, coastal Brazil, Madagascar and South Africa there are now areas of astonishingly high losses of biodiversity integrity.

Some species of animals are limited to a certain continent (the giraffe is found only in Africa, some rare species of monkeys live only in South America or only in Madagascar). There are plants and animals that have an extremely limited range (such as *Sequoia trees* in California), and the rough ones (the fish *Romanichthys valsanicola*) lives only in Romania in 2 mountain tributaries of the Argeș River! Other species, on the contrary, have an extremely wide range: coconut plants (*Cocos nucifera*), are found in all tropical areas, water hyacinth (*Eichhornia crassipes)* is now present in the entire tropical equatorial zone *,* and spruce (*Picea abies)* is the predominant tree in temperate and boreal Eurasian zones. Other species have discontinuous ranges. Living organisms that are found in large areas are considered cosmopolitan organisms, and those that have restricted areas are called endemic species.

In the following, **the main factors that create the current biodiversity on our planet will be reviewed.**

The cosmic factors

The revolution movement of the planet around the sun, carried out in about 365 days, leads to the appearance of the seasons, therefore conditions the life cycles of all organisms in the temperate and cold areas of the planet. In the equatorial zone there are no distinct seasons, because the action of solar radiation is relatively uniform in intensity throughout the year.

The rotational movement of the planet around its axis in 24 hours causes a periodic alternation (day-night) of the light radiation that reaches the planet. Since the rotation of the Earth is carried out similar to that performed by a spinning wheel, this rotation determines during the revolution movement of the planet around the sun greater or lesser durations of the presence of solar rays at the poles and at the equator. That's why there are also different lengths of time in the northern and southern hemispheres (so when it's summer in one hemisphere, it's winter in the other hemisphere). It is normal for these differences to be reflected in the seasonal and circadian rhythms of living things. The movement of the planet around the sun is the main factor that directs the life cycles of organisms in the terrestrial environment.

In general, there is an increase in biodiversity from the poles to the tropics. Natural areas at low latitudes have more species than those at higher latitudes. This difference is called the latitudinal gradient. Several ecological factors can contribute to the gradient, but the most important factor is the higher average temperature at the equator compared to the poles, because it depends on the degree of inclination of the sun's rays falling on the earth's surface. This characteristic of terrestrial biodiversity does not it is also found in marine and oceanic aquatic ecosystems, because here the currents that run through them are the coordinating factor. In marine waters, photosynthesis is carried out by algae. The organic matter produced in excess serves as the nutritional base for many of the biotic components of food chains starting from bacteria. Similarly, the latitudinal distribution of parasites does not seem to obey this rule either.

The geographical factors

In the **seas and oceans** of the planet, the limiting factors for the development of photosynthesizing organisms are the degree to which solar radiation penetrates (in optimal cases up to -100-200 m), the amount of nutrients available to carry out photosynthesis by algae, the currents that cross these waters (cold currents are richer in nutrients and often rise along the continents and reach close to the equator, so there is a greater wealth of living organisms in them). Other limiting factors are the depth of the water basins, the degree of salinity (this is lower in the vicinity of the mouths of the large rivers that bring fresh water), the width of the continental shelves, the temperature of the waters (it is higher towards the surface and decreases towards the depth, where it reaches that huge volumes of water have temperatures close to +40C, which leads to their population with a reduced number of organisms), the nature of the substrate that serves as a life support for many animals, etc.

The largest inhabitants of the ocean swim freely (seals, penguins, whales, walruses, dolphins, fish, etc.). Crustaceans, molluscs, worms live predominantly on the bottom of the oceans and seas. Planktonic organisms live only in the water mass, benthic ones only on or in the upper layers of the substrate . Plankton is the main food for nektonic fish and mammals, while at considerable depths, there are far fewer planktonic organisms that could support the life of abyssal nekton. Extremely many living organisms live near hydrothermal vents on the bottom of the oceans (Figure 65), where certain worms and crustaceans, all having an anoxic way of life, which do not exist in the other places of the planetary ocean, are particularly attractive to them. There are many bacteria that, similar to photosynthetic plants, produce abundant organic matter, but through anoxic pathways.

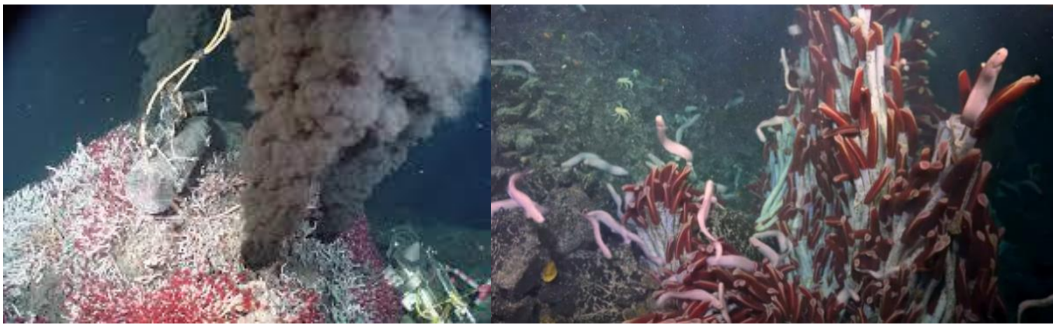


Figure 65. Abundance of living organisms in oceanic hydrothermal vents (https://www.miamiherald.com/news/nation-world/world/article278076452.html)

In continental freshwaters, living things exist throughout the water mass, from the surface to the bottom of water bodies, including in their mineral or organic sediments. Life is in streams, rivers and rivers, in lakes of all depths, in ponds and swamps, but only in liquid water (in glaciers, in snow or icebergs there can be forms capable of life, but in different forms of resistance (eggs, or spores). They become active only when the water passes from the solid to the liquid phase.

The density of freshwater organisms is higher in waters with average temperatures of +20 - +35 ^{0} C. Above or below these limits the number and the intensity of their vital processes decreases significantly.

The category of continental waters also includes waters with a high salt content ; they are called mineral waters (chlorinated, borated, sulphurous, etc.). Sometimes stagnant basins become salt lakes or seas (Dead Sea, paramarine salt lakes, or those formed in areas where salt comes to the surface from deposits formed in the past on the shores of inland seas, or which at some point broke off their connection with the great oceans of the globe). Even in these waters there are life forms (only here do halophilic organisms develop).

In the terrestrial environment the variety of organisms is the greatest. About their vertical distribution was written before. They are permanently in contact with the atmosphere, populate all types of soils (which constitute the pedosphere), infiltrate through cracks in the upper layers of the lithosphere and live in all moist environments within the earth's crust.

The altitude is a particularly important factor in the distribution of living things in the terrestrial environment. The density and variety of living organisms is higher at lower altitudes and in hilly areas and decreases with increasing altitude, until the climatic conditions and the absence of soils lead to a sharp decrease in the biosphere (a factor that is also favored by the longer duration of the conditions cold climate, but also the presence of water in the form of snow and ice - in the high mountains are the so-called eternal snows and glaciers.

In the underground environment there is a rich life. Small forms are predominant here. Also here, species that cannot withstand competition for food from the surface of the earth's crust thrive and retreat to more stable and implicitly more stenotic ecological systems, such as those in the underground environment. That is why relict forms abound in the underground environment. Most of them have limited areas, their density is much reduced, their food is poor, because it consists mainly of the necromass brought by the waters that infiltrate from the surface. They possess highly developed sense organs, are small in size and have longer lifespans than their relatives living on the surface of the earth's crust. Animals and fungi are especially common in the underground environment. Autotrophic forms are not present unless they have arrived accidentally and are able to temporarily feed heterotrophically (such as some protists).

The pedological factors

For plants, the type of soil is a major factor in conditioning the type and variety of species that grow in a certain area, because the necromass, the amount of minerals resulting from its decomposition, the water content and the microorganisms that carry out pedogenesis differ from one type of soil to another. The soil is a combination of various dead and inorganic organic matter, populated by living organisms specific to this reducing-dominated environment, often semi-anoxic, but always moist.

While clay soil can hold more water but less air, black soil (chernozem) is ideal for plant growth, having conditions to keep their air and water holding capacities relatively constant. Soil pH helps plants absorb nutrients. If the soil is poor in water and acidic, desertification can occur and reduce the chances for plants to grow on them.

Soil is a favorable environment for necrophagous organisms and small luciferous predators. Photosynthesizing organisms, represented by different types of algae, are found only in the superficial layer (below 5 cm). Physiological processes are predominantly oxyphilic, for although oxygen is present, it is in smaller quantities. Soil organisms are small in size, they differ from one type of soil to another, depending on the availabilities they find in the water content and the ability to find their specific food. The soils richest in living organisms are those rich in organic compounds, and the fewest organisms are found in soils rich in mineral compounds and lacking in liquid water. Soil is essential for photosynthesizing plants, because their upper part - the stems and leaves - rise above the ground and live in the atmosphere, while their roots are fixed in the soil, from where they extract the nutrients that are the basis of the photosynthesis that takes place in the air. More data on soils will be presented in the next chapter, where a special covering of the planet, the pedosphere, is treated more extensively.

The physico-chemical factors

1. Air. All living things need air in order to breathe the oxygen in it. When the air pressure is low, especially at higher altitudes, many find it harder to breathe because of the insufficient amount of oxygen they get i can procure Oxygen and carbon dioxide are very important to both plants and animals: oxygen is essential for respiration, while carbon dioxide is necessary for plants to photosynthesize.

2. Water. In the terrestrial environment, water enters the soil in the form of precipitation (as snow, sleet, rain or hail). Precipitation is one of the determining factors (along with temperature) in how living organisms are spread and develop on Earth. Terrestrial organisms (which inhabit predominantly dry environments), semi-aquatic (which can live permanently or part of their life in the aquatic environment), aquatic (live permanently, obligately or randomly in aquatic environments – fresh, salty, brackish or marine) and underground (live in cracks or cavities in the lithosphere). To populate these environments, organisms have acquired a series of adaptations - some strict, some facultative - to be able to live comfortably in them.

In terrestrial desert environments living things have created very varied systems to survive, either saving water, storing it, or changing their circadian rhythms. Many plants have few leaves, or they are even missing (thus reducing their transpiration); they have green, fleshy stems and swollen, waxy leaves to absorb and store large amounts of water during the rare periods when precipitation falls from the atmosphere in the form of fog or rain. In many plants, the roots are very long to reach the vicinity or even to the ground water layer. Other plants have created barrel-like formations in the soil in which they store large volumes of water in the form of vegetable juice. Animals have long legs, so that during the day, when they run, they stand above the hot ground; others can bury themselves in the sand during the day and stay there during periods of hot air and soil. Some animals can have water storage formations in their bodies, or they switch to a nocturnal life (because when the temperature drops they can more easily look for food), etc.

3. Nutrients. To synthesize food, all plants need to take nutrient salts from the environment. They need nitrogen to create proteins, enzymes, nucleic acids and vitamins, phosphorus to synthesize their phospholipids, etc. Depending on the amount of nutrients that the chemo- and phorosynthesizing organisms can take, life develops more or less intensively, it presents itself in the most varied forms on the different types of soils (in the terrestrial environment); or in different waters (especially those where the water creates true nutrient-rich ocean currents). In fresh waters and in acidic marshes, therefore poorer in nutrients, many plants

4. Temperature. Temperature is an important physical factor because life is active only within certain limits. The ability to survive extreme temperatures varies greatly from one organism to another.
Plants are not able to protect themselves to escape high or low temperatures when they act on their living environment; in this case, photosynthesis in plants slows down or stops when temperatures become too high or too low. Tree leaves can lose heat through excess evapotranspiration (water loss through the stomata on the underside of the leaves). However, some plants may have stems and leaves covered with small hairy formations that help them withstand low temperatures. They may have certain solutes in their cytoplasm to lower the freezing point, while other plants have a shorter stature, grow very close to each other to withstand low temperatures and wind. Most plants in the temperate zone shed their leaf mass in the cold season, and their photosynthesis is drastically reduced. Their branches and stems contain canaliculi through which capillary water and juices are more well protected from temperature drops and do not freeze, although in the cold season they appear to be dry or dead.
Animals respond to temperature variations both physiologically and behaviorally. With the exception of homeothermic animals (birds and mammals), all other organisms are heterothermic, so their body temperature depends on the temperature of the environment in which they live. Or, if the water freezes, they can no longer live (for some, in order to get through the cold season, certain ways have been created to prevent the crystallization of water in the body by increasing the concentration of salts in the cells). Others retreat into the soil, into cavities of the lithosphere or into the mud/sediments at the bottom of the waters, where the temperature drops, but not below the freezing point of water and then enter hibernation (they return to active life after the ambient temperature rises above that of water freezing).

Some organisms (prokaryotes, eukaryotic protists and fungi) die, but save their species and offspring by pre-forming spores or different forms of resistance.

5. Light. Light is a particularly important physical factor used by photosynthetic organisms for the synthesis of organic matter. For animals, light becomes a conditional factor of their circadian and seasonal activities. Fungi, being osmotrophic organisms, are not influenced by the presence or absence of light.

Biotic factors

There are a number of adaptations of organisms that can influence their distribution and diversity. To understand how the various biotic factors act, we specify that from the point of view of spatial distribution and adaptive ecological qualities, there are three types of organisms: cosmopolitan, normal and endemic.

Cosmopolitan species are those that, having wide ecological potentialities (they are eurioic), are able to live in varied environments from all points of view (altitude, various climatic and pedological factors, fluctuating water quantities, large temperature variations, increased resistance to competition other organisms on the same trophic level, etc.).
Normal species are those that have the ability to live within average living limits, do not enter into fierce competition with species at the same trophic level and withstand average fluctuations of all environmental factors.

Endemic species are those species that support a relatively reduced range of fluctuations in environmental factors and in competition with other living things, factors that corresponded to the moment at which they were formed during evolution, but which, over time, have also changed whose too wide fluctuations I can no longer cope with. They have narrowed their range and can no longer face the competition of the other eurious and normal species with which they coexist. They are a kind of species in physiological agony, so they become relict species. Usually they withdraw into life environments with more stenotic characters.

Interspecific competition. Competitive interactions have been considered to be one of the major factors that diminish the populations of living organisms in their habitats; they compete for space, for reproduction, feeding, movement, etc. There is also competition for access to more resources such as food, water and energy. All of these can affect how a species is distributed. Because of the more limited access to the resources of the environment in which they live, populations can be distributed in different ways.

Competitive interactions with non-native species. This type of interactions always exists between species on the same trophic level. They are normal in order to maintain the ability of any species to exist and compete "honestly" with other living things in the ecological system of which they are a part.

Competitive interactions with invading Euryonic species. This type of interaction serves the struggle for existence, the maintenance of the ecological balance both of the population of the respective species, and of the ecological balances at the level of the ecosystem of which it is a part, because any invader does not cause negative effects at the level of the species, but at the level of the biocenosis and implicitly of the ecosystem in which the invader seeks to enter. The invader has a great asset: its great Euryopia. It causes disorder, restructuring and functional disturbances at the level of ecological systems and always has a negative effect on the usual biotic components of the ecological systems it tries to enter. The effects of invasive species are all the greater, as now human impacts are disrupting the local ecological balances formed over thousands of generations and which are currently in an increasingly unstable balance.

Competitive interactions with endemic species. If the competition of some invasive species is with relict species, since they are older species with less evolutionary potential, they are anyway at the lower limit of interconnection with the other species in the biocenoses of which they are a part, so they have chances greatly reduced survival rates. An invading species is a multipotent Euryonic species, which in the fight with any other species has several chances to win (even more so with a relict). If the ecosystem and biocenosis of which it is a part is affected by anthropogenic impacts, its chances of survival decrease a lot and its extinction threshold increases significantly.

Competition for food. All living things must have food to survive, because without food they die. This is one of the foundations of the differences in limitation of plants, animals in different locations of the world. Food availability is a major factor in the number of animals living in an ecosystem. Areas such as tropical forests with abundant food supplies have more species than other areas such as deserts and polar regions where there is less food.

Predatoryism. Predation affects the global distribution and abundance of species in any natural or anthropogenic ecosystem, but also the strength and direction of energy flow within a system and the diversity and composition of ecosystems. Predators always play a big role in evolution, because they weaken the self-regulating capacity and resilience of the biological system where the upper trophic level is strengthened, so the pressure on the lower trophic level is greatly overloaded.

In an ecosystem the arrival of new predators can have a devastating effect. In balanced ecosystems, predators and prey have long coexisted and evolved together. Predators can feed on prey to survive (but not too much to risk reducing their own nutritional needs in the long term). The arrival of a new predator can upset this balance, causing a rapid decline in prey numbers, which then reduces the food available for all other existing predators.

Diseases and parasites. Plant diseases can be fungal, bacterial, viral or of animal origin. They can also be caused by insects or invasive weeds. These diseases affect agricultural crops (anthropogenic artificial ecosystems), causing significant losses to farmers and threatening human food security. The development of diseases and parasites can cause huge losses to crops and pastures. If the population of primary producers will obviously decrease, then they facilitate the emergence of new diseases. Herbivorous animals may suffer from disturbances in the intensity of the consumption process of the plants they feed on, and their production will, in turn, be weaker. So there is a deregulation in the chain of all the trophic links. In natural systems, diseases and parasites occur quite rarely, because ecological balances are more stable; here biological and ecological processes have a stabilizing role. If diseases or pests occur, they affect the balance of any ecosystem. This is seen in the occurrence of changes in the global distribution of animals and plants, as well as in their behavior. These changes will cause the population to decline. And if a population becomes sick, the population of consumers at the upper level of the food chain of which they are a part will also be affected and disrupted. The negative effects will manifest more intensively first at the ecosystem level, and then at the landscape level.

When some organisms enter the biocenoses of certain ecosystems, they often bring new pathogens. They can affect existing balances because their hosts are not prepared to deal with them - and so the consequences will be negative and unexpected. There are cases when pathogens were introduced intentionally. Myxomatosis is a disease that affects rabbits. It is caused by a parasitic protozoan and infected rabbits develop skin tumors and can go blind. In the 1950s myxomatosis was deliberately released in Australia to reduce the rabbit population. The effect? More than 99% of the rabbits died, and then, after the surviving rabbits became immune to the disease, the population returned to previous levels.

Anthropogenic factors

Humans can influence populations of organisms in various ways, causing them to migrate from their natural habitat to a new environment.
When people occupy land to build houses and buildings, they cut down trees and change the habitats of animals and plants. Some animals, such as the skunk, raccoon, mouse and rat, can adapt, but other animals cannot - and their populations will decline as a result.

Pollution can affect both animal and plant populations.

Excessive hunting and fishing can affect populations of terrestrial or aquatic animals.

Man contributes to the global distribution of plant animals through urbanization, the creation of communication routes, through various agricultural or mining activities. As human activities have removed both local animals and plants from their natural habitats, many species will have to live in an environment new for them, which they cannot always cope with and therefore they can disappear permanently.

Complicating/Associating Factors

The distribution of species depends on the interactions between abiotic and biotic factors in the environment. Abiotic factors such as temperature, moisture, and soil nutrients, along with biotic interactions within and between species, can all have strong, synergistic influences on the spatial distributions of plants and animals. Complex factors are difficult to detect; therefore, appropriate measures can only be taken with great difficulty to restore their ecological balances; in addition, there is also a greater degree of uncertainty in obtaining the expected results.

Biodiversity hotspots

A biodiversity hotspot is considered a territory or region with a high level of endemic species that have suffered high habitat loss. The term "hotspot" was introduced in 1988 by Norman Myers. These hotspots are spread around the world; most of them are forest areas and are located in the tropics.

Brazil's Atlantic Forest is considered one such hotspot, containing about 20.000 plant species, 1.350 vertebrates and millions of insects, about half of which are found nowhere else.

The South American state of Colombia is characterized by high biodiversity, with the highest rate of species per unit area in the entire world and has the largest number of endemic species. About 10% of Earth's species can be found in Colombia, including over 1,900 bird species (that's more than in Europe and North America combined). Colombia alone has 10% of the world's mammal species, 14% of the world's amphibian species and 18% of the world's bird species.

In Madagascar, dry deciduous forests and lowland tropical forests possess a high number of endemic species. Since the island separated from mainland Africa (66 million years ago), many species and ecosystems have evolved independently and endemic species have multiplied.

Indonesia's 17.000 islands cover 1.904.560 km2 and contain 10% of the world's flowering plants, 12% of mammals and 17% of reptiles, amphibians and birds. Almost 240 million people now live in these islands.

Many regions with high biodiversity and/or rich in endemic species originate from specialized habitats that require unusual adaptations. Accurately measuring differences in biodiversity can be difficult. Selection biases among researchers may contribute to biasing empirical research for modern and actual estimates of their biodiversity.

Human impacts today are endangering this hotspot of planetary diversity. The fact that most humans are still unaware of their actions on living things is a cause of the serious dangers that can arise in such hotspots.

The distribution of biogeographic zones and biomes on Earth

To be better understood, I repeat the definition of the biosphere that I presented at the beginning of the chapter on the biosphere:

"The **biosphere** (Figure 36) is the covering of the planet made up of living organisms that occupy and interact physically and functionally with the four major components of the toposphere: the lithosphere, the pedosphere, the hydrosphere and the atmosphere".

In the last three hundred years, relatively homogeneous terrestrial and aquatic territories of different sizes have been determined, the composition of their flora and fauna has been inventoried and specified. A volume of scientific data was collected that led to a better knowledge of the living world.

The living world is extremely diverse morphologically and functionally and is characterized by an extraordinary adaptability to the constant fluctuation of the environmental factors that constitute the toposphere. Nature has found various forms by which this diversity of living forms have grouped and reorganized themselves throughout the history of the planet, so that at present a hierarchy of forms of association of living things could be established that is quite clear from a historical, geographical point of view , climatic, ecological and ethological, hierarchy jointly established by geographers and biologists.

In this immense biodiversity there is an order, an extraordinary organization, which ensures the sustainability of life in ways that allow continuous adaptation to the changes that the environmental factors present on the surface of the earth suffer (solar radiation, atmosphere, climate, water, rocks, forms of relief, soil types).

The biosphere is the only shell of the planet that carries out a permanent and highly organized exchange of information, energy and matter with the living and non-living environment and influences it in a wide variety of ways. The uniqueness of our planet lies in the fact that it is the only one in the Solar System where life exists. The appearance of life is the consequence of the existence of three essential elements: solar energy, water and air (Doniță *et al.,* 2019).

Currently, living organisms can be grouped into a wide range of living associations - bioregions, biomes, biolandscapes, biocenoses - which form, together with their related components from the toposphere, several types of complex covers (living-living) that are spread on most of our planet. These are, in hierarchical order, from top to bottom - ecosphere, ecozones, ecobiomes, ecolandscapes and ecosystems (Botnariuc, 1967; Godeanu, 2016, 2019; Godeanu *et al.,* 2010).

Bioregions (Biogeographic zones) are large regions of the globe characterized by groups of biomes with different characters, but which are viewed by geographers especially from a climatic and spatial point of view; they are surrounded by sea/ocean waters, occupy entire continents or large portions of them with similar climatic conditions, etc.

Biomes are large ensembles of ecosystems characteristic of a certain geographical area, in which all living things, throughout the history of the earth, have adapted and are now considered specific to that geographical area. Biomes are distinguished from cold and warm climatic zones, altitude or plains, fresh or marine waters, arid or humid zones, etc.

Biolandscapes are the living component of smaller portions of territory (landscapes), with relatively uniform climatic, geographic and pedological characteristics, in which a group of functionally different ecosystems coexist and are functionally interconnected.

Biocenoses are the living components of some ensembles of environmental factors that make up a so-called biotope, with which they create a stable and sustainable functional unit - the ecosystem, in which the processes of evolution of the living world take place.

Biogeographic areas

A geographic area is described as a unique combination of plants, animals, rock types, climate, and waters, a space defined by natural boundaries and distinct living communities that make each bioregion different from its neighbors. Natural forms and living communities, including humans, become descriptive features of each bioregion.

In biogeography a biogeographical zone designates a land area that is relatively homogeneous in terms of climate and ecology. Geographers speak of biogeographic area as a system of general classification of land from an ecological point of view. Biogeographical regions are territories whose borders are not politically defined. They must be large enough to maintain the integrity of their various biological subregions and to support important ecological processes such as nutrient cycling, migration and vapor flow, etc.

On the dry land of our planet, 6 large biogeographic zones can be distinguished (Figure. 66)

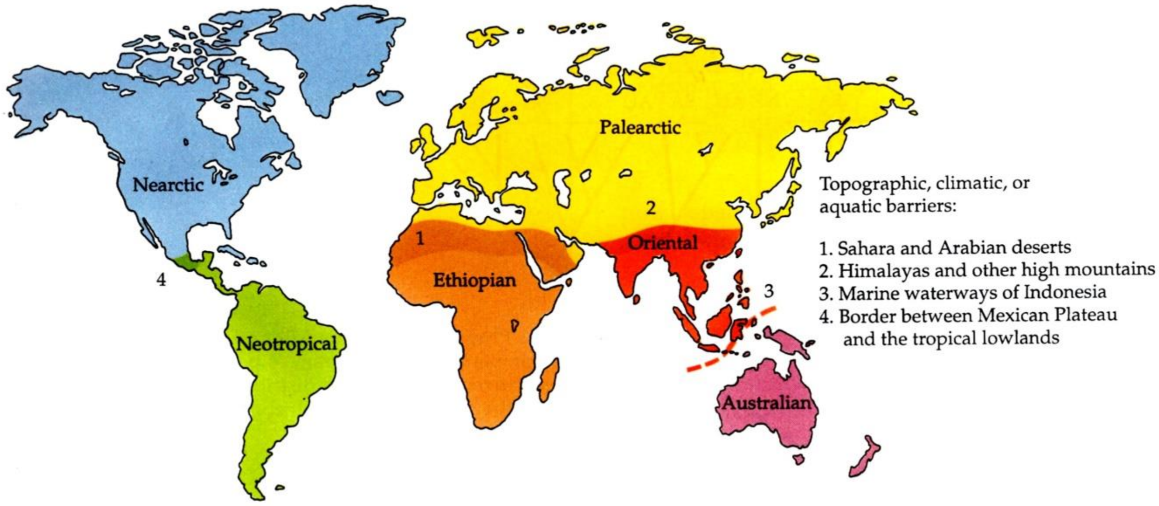


Figure 66. The biogeographic areas of the planet (Purves *et al.,* 1992)

1. **The Nearctic bioregion.** This region covers most of North America, Greenland and the mountainous areas of Mexico. It includes the Canadian Shield, eastern North America, western North America and northern Mexico. When the ancient supercontinent of Pangea split in two 180 million years ago, North America remained attached to Eurasia as part of the supercontinent Laurasia, while South America was part of the supercontinent Gondwana. North America later separated of Eurasia. It was connected by land bridges to Asia and South America, which allowed for a long time an exchange of plants and animals between the continents.
2. **The Palearctic bioregion.** The Palearctic is the largest of the six bioregions that make up the earth's surface. It consists of Europe, North Asia, the Himalayan Mountains, North Africa, and the northern and central part of the Arabian Peninsula.
3. **Afrotropical bioregion**. It was also known as the "Ethiopian zone". It includes Africa south of the Sahara, the southern and eastern parts of the Arabian Peninsula, the island of Madagascar, southern Iran, the extreme southwest of Pakistan, and the islands of the western Indian Ocean. Almost all of these lands were part of the ancient supercontinent Gondwana, which began to fragment 150 million years ago. Because Africa is a very large continent, the area has many types of climates and habitats. However, most of the Afrotropics have a tropical climate. A wide strip of deserts (Sahara and Arabian Desert) separates the Afrotropics from the Palearctic zone.
4. **Australian bioregion.** It includes Australia, the island of New Guinea (including Papua New Guinea and the Indonesian province of Papua), the eastern part of the Indonesian archipelago (including

the island of Sulawesi), the Moluccas (the Indonesian provinces of Maluku and North Maluku), the islands of Lombok, Sumbawa, Sumba and Timor, as well as several groups of tiny islands in the Pacific. The rest of Indonesia is part of the Indomalayan bioregion. Australia, New Zealand and New Caledonia are fragments of the former supercontinent of Gondwana, whose fossil and geological traces are still visible in the Mariana Islands and other geographical entities in the Pacific Ocean.

5. **Indomalayan bioregion.** This area covers most of South and Southeast Asia, as well as other parts of East Asia. Indomalaysia stretches from Afghanistan to Pakistan through the Indian subcontinent and includes all of Southeast Asia to southern China, Indonesia, Java, Bali and Borneo. Indomalaysia borders the east of the Australian bioregion, from which they are separated by the so-called Wallace biogeographic line. Indomalaia includes the islands of the Philippines, Taiwan and Ryukyu (the latter is part of the Japanese islands). Lately this bioregion has also included the former oceanic bioregion, which is not part of any continental land. It included the Pacific Ocean, the Micronesian Islands, the Fiji Islands and most of Polynesia (except New Zealand). The Indomalayan bioregion is made up of volcanic and coral islands (which have recently emerged from the sea and were created either by volcanic activity or by the collision of tectonic plates that helped push the islands up).
6. **The Neotropical bioregion.** It consists of all of South and Central America (bottom of Mexico, Caribbean Islands and southern Florida). Its flora and fauna are unique and distinct from the Nearctic, due to the long separation of these two continents. South America was originally part of the supercontinent Gondwana. That is why in this bioregion the lineage of many plants and animals (including marsupial mammals) originate from that supercontinent. After the breakup of Gondwana 110 million years ago, South America was separated from Africa. Much later, about 2-3 million years ago, South America joined North America through the Isthmus of Panama. The formation of this isthmus 3 million years ago brought together the two American continents today, so that many species of the two bioregions mixed. The long-term effect of the descent and exchange of southern and northern species was the reason for the extinction of many species in South America, especially due to competition from species from North America that were better adapted to environment.

Other zones were made in the oceanic and freshwater aquatic environments (Figure 67 and 68) (Godeanu and Popa, 2022).

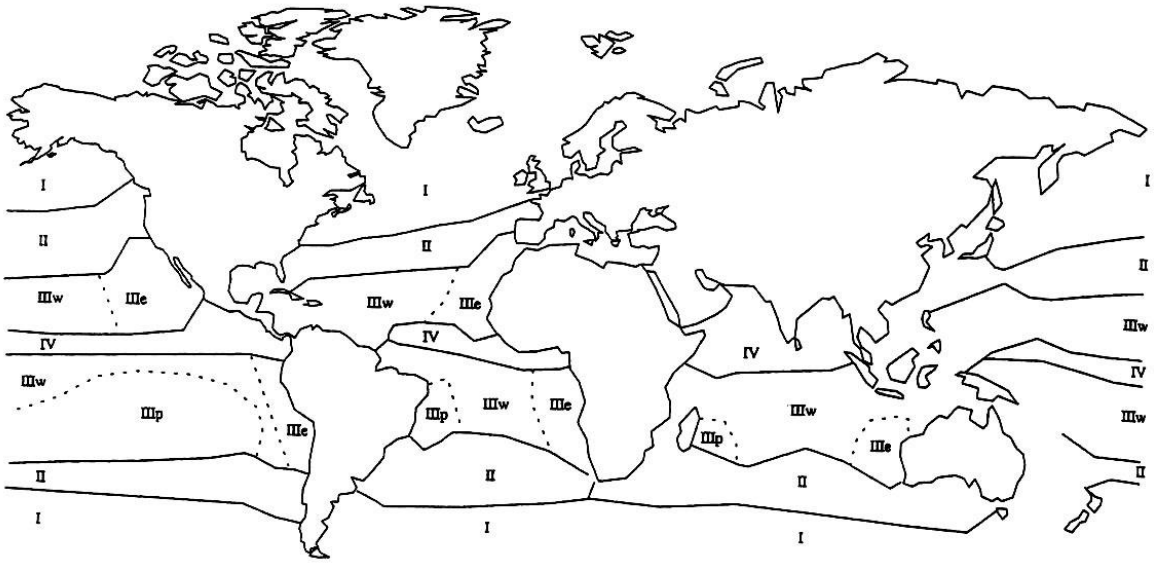


Figure 67. The great oceanic zoogeographic regions. Ocean domains: **I** -Variable currents of the eastern subdivision, **II**-Weak and variable currents, **III**-Currents driven by trade winds, **IIIe**-Strong currents of the equatorial subdivision, **IIIw**-Currents of the western subdivision, **IIIp** - Strong currents of the polar subdivision, **IV** - Strong Currents of the Western and Equatorial Subdivisions (after Hawksworth 1995, modified).

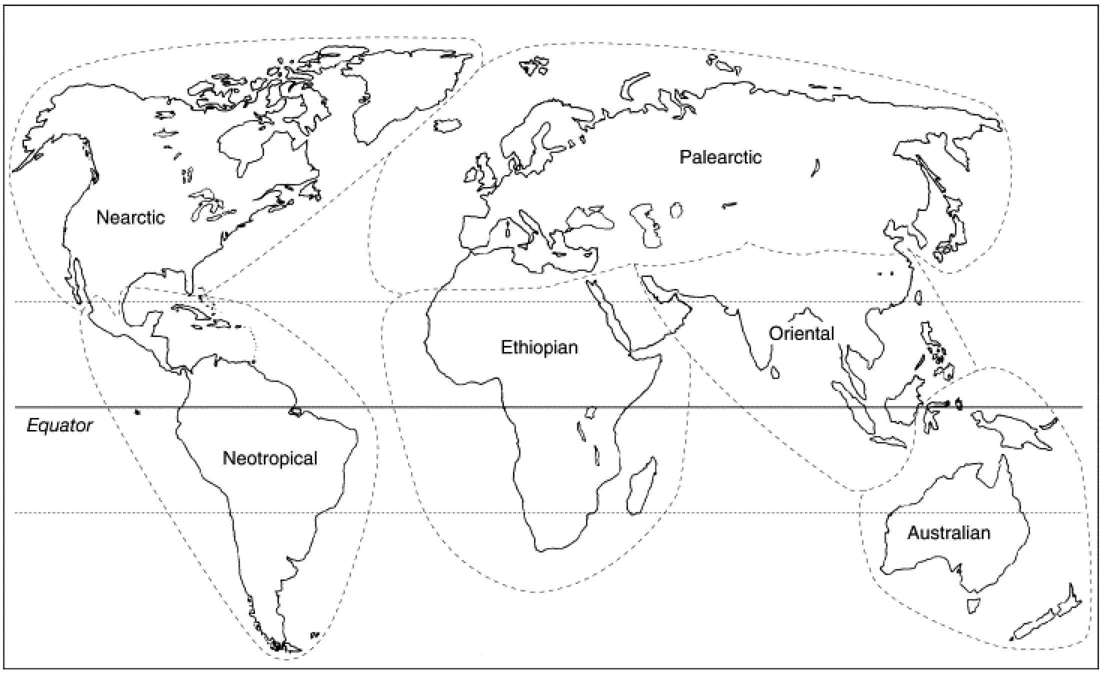


Figure 68. Zoogeographic regions for aquatic fauna **1** - Holarctic Region, **II** - Sino-Indian Region, **III** - Ethiopian Region, **IV** - Malagasy Region, **V** - Neotropical Region, **VI** - Australian Region, **VII** - New Zealand Region, **VIII** - Indo-West Region -pacific (after Bănărescu, 1970)

The biomes of the planet

Biomes are groups of interconnected natural ecosystems, possessing common climatic and pedological characteristics, occupying certain geographical areas, in which all living things, throughout the history of the earth, have adapted and now occupy the same niches in the toposphere. They contain a certain type of vegetation and are populated by consumers and decomposers specific to these plants. The biota of biomes is constituted by the totality of organisms that have formed over a long period of time and that populate a certain geographic region more or less permanently (Purves *et al.,* 1992).

The different natural areas on Earth can be most easily grouped into categories based on plant and animal life and how they are able to survive in a particular area of the globe. Although it seems simple, making biome categories based on living organisms can be very complicated. But by carefully grouping organisms with similar adaptations into specific biomes, we have a chance to better understand life on our planet.

A biome is a type of environment that is defined by the types of organisms that live in it. We can also think of these as life zones ("bio" means life). Dividing the land in this way allows us to talk about areas that are similar even though they are found on different continents. But depending on the specialty of the different researchers you talk to, the way we divide the world into different biomes differs a lot. A biome can comprise a variety of biogeographic subunits, superecosystems, and very different ecosystems that share certain physical-chemical features, climatic, pedological and floristic.

According to some researchers, all forest types belong to one group – the forest biome. Others, however, believe that temperate forests (which also have a cold season) or boreal forests are very different from tropical forests (with trees that grow close together, that have permanent foliage and that need a lot of rainfall). This difference means that the number of forest biomes alone can vary between 5 and 20 different types of forest biomes.

To be able to manage this huge variety of characters by which we can classify the various biomes, researchers sought to reduce their number to the minimum possible. In addition, different ways of grouping biomes have been tried for a long time. The best classification proved to be the one elaborated by Whittaker (1962, 1970, 1975) and which is based on the distribution of dominant types of vegetation in correlation with temperature and precipitation (Figure 69).

Whittaker based his approach on theoretical claims and empirical sampling. In order to understand Whittaker's scheme, it must be known that he relied on several key terms:

- Physiognomy: refers to the appearance of plants/or the more obvious characteristics of the biome, i.e. the external features or appearance of ecological communities or species - including dominant plants.
- Ecology: a grouping of ecosystems, which is similar in vegetation structure, physiognomy, environmental characteristics and their animal communities.
- Formation: a major type of plant community.
- Biome-type: grouping of convergent biomes or formations of different continents, defined by physiognomy.
- Formation-types: a grouping of converging formations.

Whittaker's distinction between biome and type-formation can be simplified: formation is used when applied to plant communities only, while biome is used when referring to both plants and animals. Whittaker's convention of biome type or formation type is a broader method of classifying similar communities.

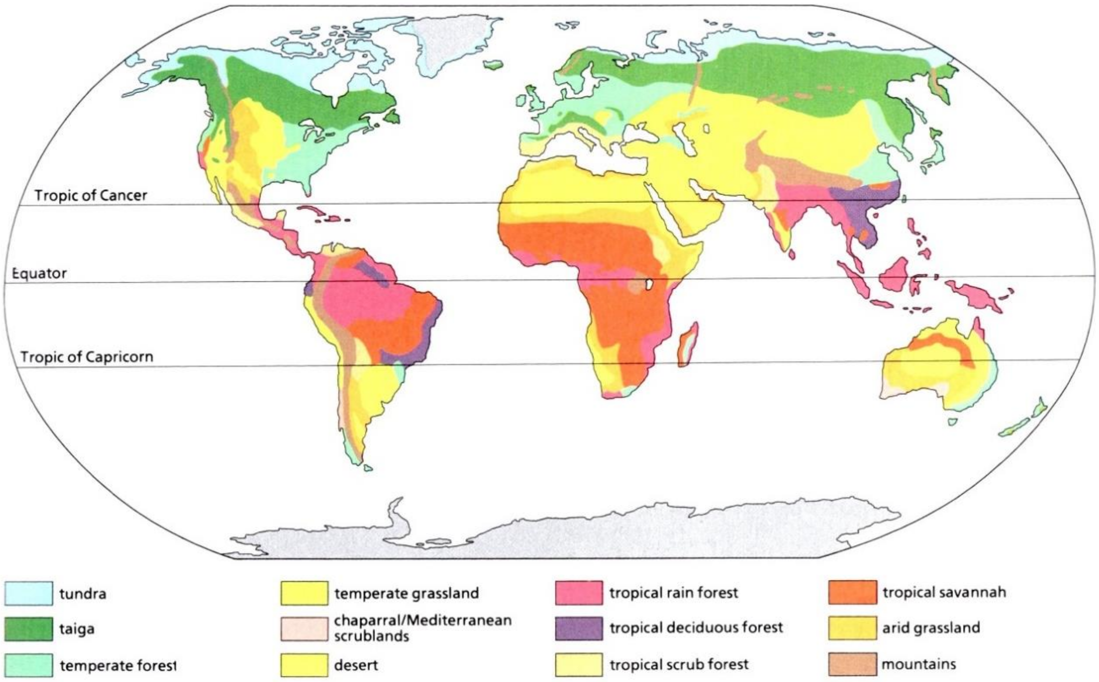


Figure 69. The distribution of terrestrial biomes on Earth (Levine et al., 1994)

To classify biome types, Whittaker used what he called "gradient analysis" of ecocline patterns to relate communities to climate on a global scale.

Whittaker considered that four main ecoclines are sufficient for the terrestrial environment.

1. Intertidal levels: the moisture gradient of areas that are exposed to alternating water and dryness with intensities that vary according to location, from high tide to low tide;
2. Climatic humidity gradient;
3. Temperature gradient according to altitude, and
4. Temperature gradient according to latitude;

Along these gradients, Whittaker noted several trends that allowed him to qualitatively establish different biome types:

- The gradient goes from favorable to extreme, with corresponding changes in productivity;
- Changes in physiognomic complexity vary with how favorable an environment exists (declining community structure and reducing stratal differentiation as the environment becomes less favorable);
- Trends in structure diversity follow trends in species diversity; alpha and beta species diversities decrease from favorable to extreme environments;
- Each growth form (ie grasses, shrubs, etc.) has its characteristic place of greatest importance along the ecoclines;
- The same growth forms may be dominant in similar environments in very different parts of the world.

Whittaker summed the effects of gradients (3) and (4) to obtain an overall temperature gradient and combined this with another gradient (2), the moisture gradient, to express the above conclusions in what is known as Whittaker classification scheme. The scheme plots mean annual precipitation (x-axis) against mean annual temperature (y-axis) to classify biome types (Figure 70).

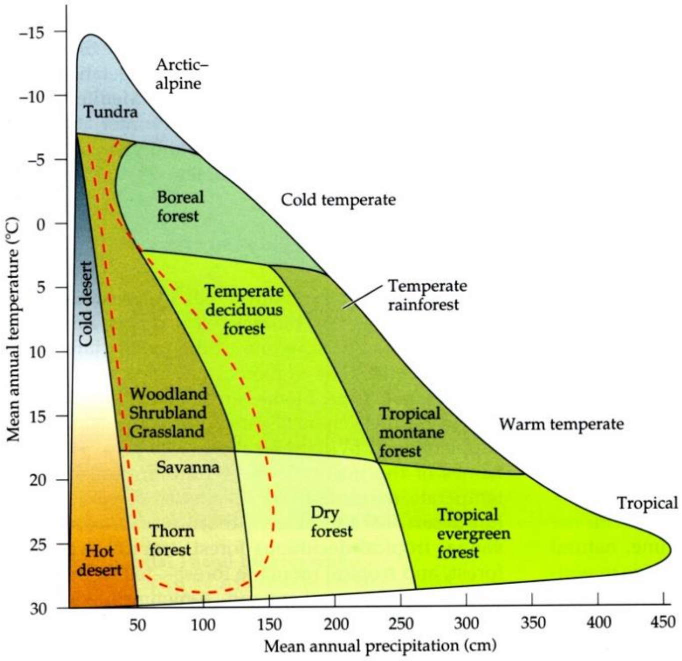


Figure 70. The biomes of the planet established by Whittaker according to the type of vegetation, temperature and average precipitation (Purvis *et al.,* 1992)

1.The humid/rainy tropical forest (Figure 71). The rainforest is like a jungle, very warm all year round. The climate in which they exist is equatorial, with constantly high temperatures (25-300C) and abundant precipitation (1500-2000 mm/year) which favored the development of a lush forest vegetation. The forests contain a wide variety of plants and animals (about half of all known species on earth). The equatorial forest has a layered character, the result of the struggle for light (Figure 72). Among the tree species we mention palm trees (coconut, banana, oil), cocoa tree, figs, mahogany, etc. The trees mostly have hardwood and keep their leaves throughout the year. Lianas and epiphytic plants are attached to the tree trunks. In these forests there is an extremely large variety of animals. The fauna is very varied and includes species adapted to arboreal living conditions (monkeys, birds), various reptiles, as well as many carnivorous animals that come from the savannah. The soils are deep, the result of intense pedogenetic processes. Heat and high humidity accelerate the alteration of organic matter and the washing of soluble substances from the soil; that is why the soils are lateritic, poor in humus and have relatively low fertility. Tropical forests are found near the equator in Central and South America (Amazon basin), parts of Africa (Congo basin, Gulf of Guinea), Australia (north and east), and Asia (Indonesia).

Figure 71. The humid tropical forest

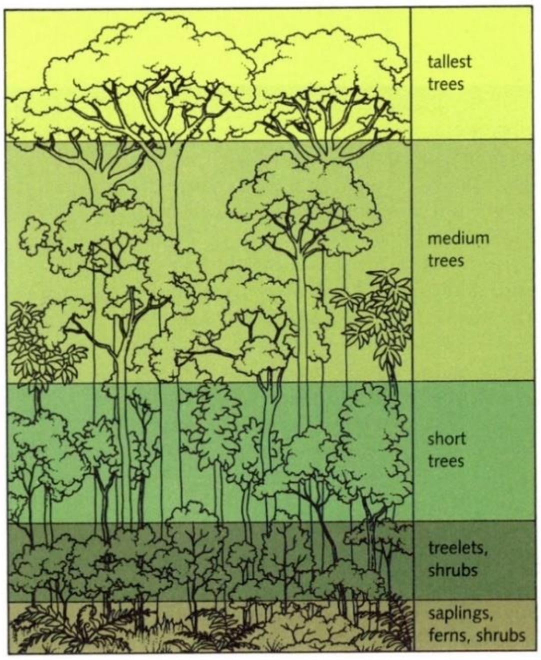


Figure 72. Vegetation stratification in the humid tropical forest (Purvis *et al.,* 1992)

Temperate forest (Figure 73). It is a type of forest with a four-season climate. It is characterised by high rainfall (500-1000 mm per year) and moderate temperatures; depending on the proximity of the ocean basins, the climate can be oceanic, transitional or continental, which is also reflected in the biogeographical components.

The weather in this biome is mild and humid (that's why the climate is called temperate). The specific vegetation is made up of deciduous tree species, dominated by beech and oak, but there can also be elms, ash trees, hornbeams, maples and even conifers. The vegetation in the temperate forest is also well stratified (Figure 74). The fauna is rich and varied. Among herbivores there are deer, wild boar, and among carnivores wolf, fox, weasel and bears (some hibernate in winter). Many birds live in the trees. The soils are forest brown, deep, rich in organic matter. The organic matter on the surface of the soil decomposes slowly, determining the existence of good fertility. The area of deciduous forests is characteristic especially of the northern hemisphere, occupying vast areas in Western and Central Europe, southern Siberia, eastern Asia (China, Korea, Japan). In the southern hemisphere, the areas occupied by temperate forests are reduced, they being present in the south of the state of Chile, the south-east of Africa, the south-east of Australia and New Zealand.

Figure 73. Temperate forest

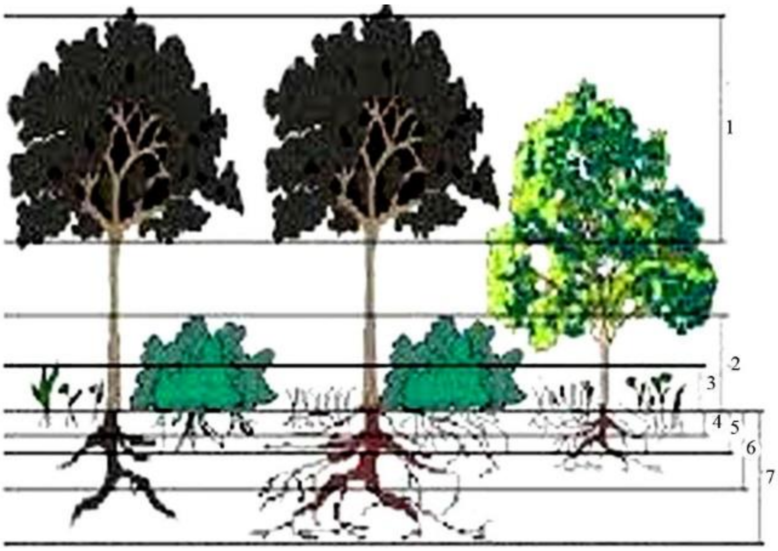


Figure 74. Stratification of vegetation in the temperate forest **1** -layer of trees, **2** - layer of shrubs, **3** - layer of grasses, **4** -layer of rhizomes and bulbs, **5** - layer of superficial roots of trees and stumps, **6** - layer of middle roots of trees, **7**- layer of deep roots of trees (https://www.researchgate.net/publication/310373910_Fitosociologie_si_vegetatia_Romaniei/figures?lo=1)

The desert (Figure 75). The zone of hot deserts and semi-deserts includes the land areas of the tropics (between 18-250 south and north latitude). The climatic conditions are characterized by low precipitation (below 250 mm annually), high temperatures, very large diurnal temperature variations (over 200C), intense evaporation. Deserts make up the hottest biome, but some can have very cold temperatures in winter, often below 00C. Such temperature changes make deserts an extreme environment, where many animals have to burrow underground to find - either in summer or winter - more stable temperatures to survive. The plants and animals here must be able to withstand long periods without water. The vegetation is discontinuous and has specific adaptations to the lack of humidity (they are xerophytic plants). Fauna shows specific adaptations to harsh conditions. There are reptiles (snakes, lizards), rodents (rabbits, mice), camel herbivores, but also some carnivores (even lions). The soils in these areas appear as a discontinuous layer. They have a short profile, are poor in organic material and rich in skeletal material (rock fragments, sand). Due to intense evaporation, the salts are deposited on the surface forming a glossy crust (desert patina). In the northern hemisphere, the most important deserts are in Africa (Sahara), in Asia (Arabian desert, Thar desert in India), in North America (Mexico). In the southern hemisphere, deserts occupy smaller areas: in Australia (Great Sandy Desert, Gibson), in Africa (Kalahari and Namib), in South America (Atacama).

Sahara Desert Hot deserts

Cold desert

Figure 75. Different kinds of deserts

Tundra (Figure 76). The tundra is relatively smooth/flat and cold. In the tundra can live a limited number of plants and animals that are able to survive the conditions here. The climate is harsh, with the predominance of the cold season. The average annual temperature is negative and precipitation is low (200-300 mm annually). The substrate is permanently frozen to depths exceeding 200 m, thawing only in summer to a thickness of a few centimeters. It is called permafrost. The vegetation consists of grasses, mosses, lichens and dwarf shrubs (willows, birches). The fauna includes rodents and herbivores (the rabbit, the lemming - a kind of hyena -, the fox, the reindeer, the musk ox). Many birds visit the tundra in summer to nest, but most migrate to warmer areas in winter. Mice and other small mammals stay active during the winter by living under the snow in tunnels dug by them. The tundra surrounds the two poles of the earth and is sandwiched between the permafrost at the two poles and the coniferous forests. The transition from the coniferous forests to the tundra proper is through a transition strip where isolated clumps of trees and shrubs appear against the background of the herbaceous silvotundra vegetation. It occupies large areas in Asia (northern Siberia), Northern Europe, America (northern Canada and Alaska), the southern tip of South America and the Antarctic Islands.

Figure 76. Tundra

Taiga (Boreal Forest) (Figure 77). The Taiga is the largest terrestrial biome on the globe. Coniferous forest area a larger extension in the Northern Hemisphere in the form of a continuous strip from North America, Asia and Northern Europe. The taiga climate is temperate-cold, with long winters (lasting 5-8 months) and relatively low rainfall (400-500 mm annually). The vegetation consists of coniferous species: Douglas fir, white pine and spruce in North America, spruce, fir, pine and larch in Northern Europe and Asia. The fauna includes animals with fur adapted to the cold winter (marten, sable, hemelina), deer, bear. Most mammals hibernate in winter. In winter the birds migrate or leave the area because in the taiga the winters are too cold for them to stay and feed. Birds and animals that do not migrate or hibernate, such as weasels, roosters or rabbits, grow dense feathers or their fur turns white (to camouflage themselves in the snow). The soils have low fertility and have a gray color (it is podzol). Organic matter decomposes slowly and has an acidic character. Bogs and bogs are common due to stagnant moisture. Coniferous forests are found in Scandinavia, Russia and Canada.

Figure 77. Taiga

Steppe (Grassland) (Figure 78). The steppe has a temperate continental climate with hot and dry summers and cold and frosty winters. Precipitation decreases with distance from the ocean, from 700-800 mm to 400 mm inland. The specific vegetation is the grassy one formed by grass species, with dense roots that favor the development of the soil. The fauna consists of herbivores (antelopes, horses), rodents (mouse, vole), carnivores (fox, wolf), reptiles, birds, etc.

The transition strip between the steppe and deciduous forests, in which grassy vegetation alternates with tree-like vegetation, is called silvosteppe. The steppes are almost entirely made up of short (up to tall) grasses; there are no trees in them. This type of land receives enough rainfall to help grasses, flowers, and grasses grow, but can later become dry enough that fires become frequent. The steppes are populated by large mammals that always travel and form huge herds. The steppe zone makes up a strip that stretches from Hungary, across Ukraine and Russia to Mongolia. In North America the equivalent vegetation formation called prairies occupies the great plains of Canada and the USA. In South America it occurs in eastern Argentina and southern Uruguay and is called depampas. In the southern hemisphere, it occurs insularly in South Africa and is called veld.

Figure 78. Steppe

Savannah (Figure 79). The area of savannas and subequatorial forests corresponds to the climatic transition zone between the Equator and the Tropics. Savannas have two distinct seasons - a dry season when much of the vegetation dies and a rainy season when it grows rapidly (because they receive enough seasonal rainfall).

The combination of fire (which ignites spontaneously) and grazing animals are important for the maintenance of savannas. Hot, dry tropical savannas or grasslands. The vegetation is mainly made up of tall grasses (up to 2-3 m) among which shrubby and arborescent species (baobab, acacia) appear in islands. The fauna is very varied and includes large herbivores (antelope, giraffe, zebra, buffalo) and carnivores (lion, cheetah).

Along the great rivers, populated by crocodiles, the equatorial forests penetrate in the form of gallery forests. Herbivores living in savannahs have long legs to escape predators by running and usually form mixed herds of hundreds or thousands of individuals.

The soils are well developed, favored by the presence of rich vegetation, have yellow or reddish colors (and are called laterites). Intense evaporation during the dry season causes the formation of crusts on the surface of the soil. This area includes territories located between 50 and 150 north and south latitude in Central Africa (Kenya, Zambia, Tanzania), northeastern Australia and central South America (Venezuela, Brazil) and central and Asia (India, Indochina).

Figure 79. Savannah

Fresh waters (Figure 80). This aquatic biome is characterized by the low concentration of salts dissolved in the water. This biome includes all stagnant and flowing continental waters (ponds, streams, lakes, permanent and temporary rivers, rivers).

Because salt is important to the functioning of any living organism, plants and animals in these waters do not find it and possess many adaptations that help them conserve salt. However, there are also pools with stagnant waters with excess salts (they are hypersaline waters), which have their own specific fauna.

Figure 80. Fresh waters

Sea and ocean waters (Figure 81). This is the largest biome in the world, as it includes the five oceans that cover 70% of the planet's surface. Their water has a high concentration of salt, so the animals and plants that live here have adaptations that help them remove excess salt.

Figure 81. Sea and ocean waters

3.3.4 Human - the last arrival into the biosphere and his oddities

The idea that, along with other forms of life, modern humans evolved from an ancient terrestrial ancestor was proposed by Robert Chambers as early as 1844. It was later taken up by Charles Darwin (in 1871) (Şerban, 1986).

There are many authors who attribute the civilization of Homo sapiens to extraterrestrial civilizing missions (Sitchin, 1999-2011). That is why we will not be surprised to find that many of these authors even attribute the appearance of man on Earth to these extraterrestrials. They are based on the inconsistencies of the evolutionary theory formulated by Ch. Darwin more than 150 years ago and on Sumerian manuscripts deciphered and interpreted in the last 50 years (Sitchin, 1999-2011; Tellinger, 2013).

The modern conception of all anthropologists is the anthropocentric hypothesis. According to it, "man is not descended from ape", but "man and anthropoid apes had a common ancestor from which the development of humanity began". This conception crystallized following the impossibility of finding the "connecting link" between the current anthropoid apes and man, and the fact that anthropology pushed, through modern research undertaken around the globe, the moment of their kinship much further back in time than it was believed until recently. The evolutionary theory demonstrated - with arguments that still remain unassailable today - that man has an animal origin specific to this planet and that he is closely related, especially from a genetic point of view, to the anthropoid monkeys that still populate Asia and Africa (Şerban, 1986, 1989) (Figure 82).

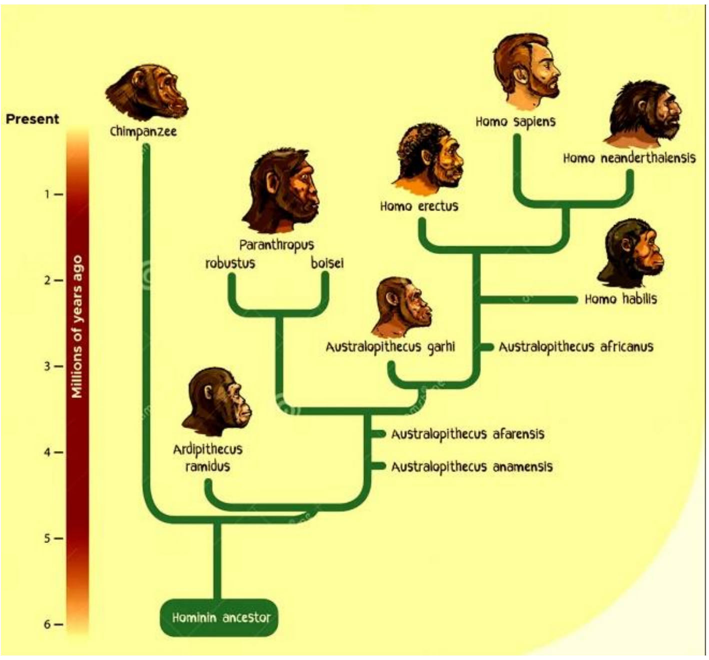


Figure 82. The evolution of hominids (https://www.shutterstock.com/)

There is much speculation as to the mode of transition from the simian stage to the human stage. According to the evolutionary theory, the process of humanization began when, due to the modification of some climatic factors, the tropical forest that constituted the habitat of our ancestor began to shrink. It's time to stand up. This factor is essential to becoming human, by freeing the organ of work (the hand) and gave birth to the interdependence between the hand (as an organ of work) and the brain (as an organ of thought), which led to the development of the functionality of both. The brain grew over 4 million years from 400 cm3 to 1200 cm3. The first hominids had a brain the size of a chimpanzee, but between then and now (in the last 3 million years) there was an increase in brain size of the hominid brain, but strangely enough, in the last 50,000 years - which are essential to the history of the human species -, nothing but insignificant progress has taken place. Man is now the master of a hypertrophied organ, with an immense capacity, of which he usually uses only a tenth part, and which is often a real burden to him.

Our hominid ancestor already stands permanently on its hind limbs, so it has a bipedal stance, which we are very proud of. But medical science unequivocally proves that the bipedal position is very unsuitable for humans, because (Şerban, 1989):

- causes an increased pressure on the internal organs (e.g. breathing causes us to use only 2/3 of the capacity of our lungs);
- leads to poor brain irrigation;
- causes an overload of the lower limbs and can cause varicose veins, phlebitis, thrombosis, calcanitis, etc.
- causes a generalized tension in the bone system (which leads to kyphosis, scoliosis, lordosis, arthritis, meniscus tears, saddle pain, etc.)

- The bipedal position modifies the pelvic girdle; as a result the birth of children is much more difficult and is accompanied by great pain.

It is true that the bipedal position freed the hands, but anthropologists believe that it preceded the bipedal position!

Another characteristic of primitive man is the paroxysmal exacerbation of the sexual instinct. In all animals the sexual instinct is strictly subordinated to the imperative of the perpetuation of the species and knows a precise periodicity. In man the sexual instinct has an evolution which seems to be inexplicable. The sexual instinct is for man first of all, an opportunity to obtain total pleasures, and he only rarely acts in accordance with the need for the perpetuation of the species, given its continuous and exacerbated character.

It must not be forgotten that science has shown that humans are strikingly similar to anthropoid monkeys, that the human embryo, during its evolution, resembles that of other vertebrates (don't forget Bayer's law, according to which "ontogeny repeats phylogeny").

If the question of human evolution is pursued exclusively by terrestrial means, one scenario is that in Africa man appeared in a region rich in uranium deposits, the emissions of which can cause genetic changes.

Another scenario that also uses radiation as a mutagenic factor states that it comes from outer space. Paleomagnetism studies have revealed a very interesting phenomenon, that over time there have been several sudden and total reversals of the Earth's magnetic field (in the last 4.5 million years there have been 12 such reversals, the last one happening now 20,000 years!). They cause the disaggregation of circumterrestrial radiation belts, a fact that would allow the access of waves of cosmic radiation that can determine the modification of the genetic code of living things (but only in humans?).

Hans Hòrbiger, hypothesized that Earth had four natural satellites (the current Moon is the last), which influenced the planet's astronomical and geological characteristics, including triggering a series of catastrophic ocean tides. They are the basis of the series of seven catastrophes that led to the periodic and at the same time drastic reduction of life forms on our planet (see ch. 3.1). Hòrbiger comes up with the assumption that human beings also lived during the time when dinosaurs lived on earth. In this way, humans appeared 150 million years ago, so they had time to progress more, until they reached their current stage. It's a theory, like many others.

Oskar Kiss Maerth issues a strange hypothesis, but based on scientific data. Namely, that cannibalism had a special aspect in the humanization process. He started from the observation that cannibalism was commonly practiced in all Paleolithic populations, that it also acquired ritual values over time. Maerth drew attention to the fact that most of the skulls found in all levels of remote archaeological sites were crushed (although skulls are the hardest bones of any mammal species).

Serotonin, a hormone secreted by the pituitary gland, has been found to have a definite role in the global regulation of the intensity of sexual life. Due to cannibalism, this process has become instinctual. Serotonin also led to the disappearance of fertility signs and fur. Primitive man then adopted the bipedal position, with all its inconveniences.

During this period, the increase in cranial capacity also occurred, as a result of the increase in brain volume. About 40,000 years ago, the first signs appeared that the human skull could no longer support the growth of the brain, and a series of specific human diseases appeared, such as epilepsy (which was called "madness" in the past). Trepanning skulls to extract cerebrospinal fluid was discovered by primitive man and became a long-practiced means of relieving the pressure of the brain on the cranium. As a result cannibalism decreased, then stopped and people moved to burying or burning the dead. In this way it is explained why the human brain has also grown only extremely little.

Maerth also states that only now has man lost one of the main characteristics of cerebral matter: the possibility of extrasensory perception and communication. Recent research has confirmed Maerth's intuition regarding the special, energetic and informational character of the own field of living systems, he highlights communication through this field at all levels of organization of living matter, including at the cellular level. It was believed that the hidden powers of our brain are the latest arrivals in the field of study of modern sciences: phenomena such as telepathy, telekinesis, telepresence, premonition, hypnosis are material phenomena accompanying certain aspects of higher brain activity. It is possible that they are not specific only to humans (Şerban, 1986).

Telepathy is the ability to communicate at a distance through the biofield. Laughter is a specifically human manifestation, which is associated with humor, satire and good mood.

The development of language increased the range of communication possibilities, but greatly reduced extrasensory communication in humans.

Maerth was the first to explain the role of sexuality in the existence of humanity, the emergence of modesty, which brings together a wide range of human manifestations, the emergence of the family as the basis of human society.

Freud highlighted a "classic" conflict between the two levels of psychological activities: the conscious and the subconscious. The sexual instinct is the most strongly repressed sector of our subconscious. The problem of human sexuality is in the most sensitive area of anthropologists concerns. It is about the feelings of modesty, restraint, etc.

Lovejoy shows that the human species has lost the signs of fecundity, which are well represented in the other primates. In compensation, this led to the emergence of the nuclear family, which is one of the first causes of the initiation of the humanization process.

Alister Hardy states that man is the descendant of an ape adapted to aquatic life, which about 5 million years ago preferred to live in the warm waters of tropical seas and lakes. It is based on the consideration that increased protection against predators is ensured in this aquatic environment. In the Pliocene and early Pleistocene the climate cooled and the aquatic environment became favorable for the ape that would give birth to the hominin line. This is how he explains the loss of fur, the growth of hair on the head, the change in the position of the nostrils, the noticeable slowing down of the heartbeat and the rate of breathing in conditions of immersion, the bipedal station, the much easier birth in water, the instinctive swimming movement of newborn babies in water etc.

From the anthropocentric hypotheses presented above, it follows that evolutionism was a reality, that man is originally from this planet, that he evolved from anthropoid monkeys, but that he had his own evolutionary path.

Based on research conducted by anthropologists, modern humans evolved from a line of four-legged anthropoid apes whose evolution began more than 6 million years ago.

There is still debate as to whether modern humans evolved around the globe simultaneously, from several hominid species, or are descended from a single small population (from Africa) that then migrated around the world (Figure 83).

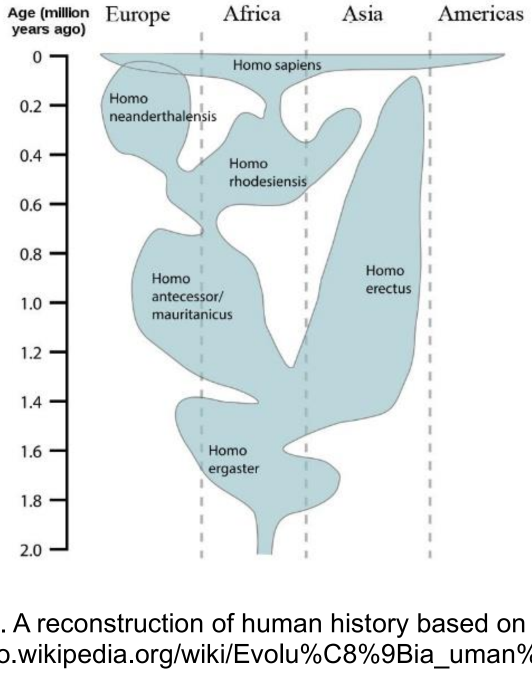


Figure 83. A reconstruction of human history based on fossil data (https://ro.wikipedia.org/wiki/Evolu%C8%9Bia_uman%C4%83)

Anthropologists R.Leakey and V.Tobias believe that 2-2.5 million years ago *Australopithecus africanus* is the common ancestor of the other Australopithecines and the genus Homo. Homo habilis, which appeared 2.5 million years ago, is the first to make tools in the history of its species. 1.5 million years ago Homo erectus already showed a skill in making tools from carved stones and used the spear as a hunting tool.

The descendant of Homo erectus was Homo neanderthalensis. He comes closest anatomically to contemporary man. It was well adapted to the ice age in which it arose and developed its social mechanisms of help and communication between human individuals. Unfortunately, the phonatory apparatus in the pharynx was not formed in him, so the verbal communication system could not develop in him (this appeared in a relative of his, Homo sapiens sapiens, the true ancestor of today's humans). For this reason, the path of evolution was closed to this species and it gradually disappeared.

The appearance of language led to the evolution of the modern man Homo sapiens sapiens, the one who lost the extrasensory perception capabilities. Human language has a much more conventional character, but primitive man could no longer communicate extrasensory with other living organisms, as before. This new language allowed the human brain to have two ways of representation: a concrete one (based on direct and immediate relationships with the environment) and an abstract one (achieved by the effect of accumulations of previous knowledge obtained through own experience), which could be transmitted verbally other human individuals.

45,000 years ago man entered the line of cultural evolution. This occurs at the beginning of the Neolithic. Now man begins to build houses, use rafts and boats, fish and the first manifestations of primitive art appear (paintings in caves are dated 15,000-20,000 years ago.

The Neolithic revolution of man began 12,000-10,000 years ago, when man started domesticating animals and cultivating the first plants used in his diet, so the first steps were taken in the artificial selection of animals and plants (later called "domestic"). This is surprising, because during that period there were no major changes in the planet's climate to justify this particularly important qualitative leap. However, from that period and probably as a result of the domestication of some plants and animals, man "came out" of Africa and then expanded the range of his species in all directions, gradually conquering the entire planet.

With the advent of cultivated plants and domesticated animals, man began to build homes and moved on to the exchange of products between human communities. The research of the human settlement at Catal Hùyùk in Central Anatolia (Turkey) proved that 9,000 years ago it was a kind of "city", with a highly developed economic, administrative and religious organization. Now it is considered that at Catal Hùyùk man came out of prehistory, to suddenly enter full civilization! As M. Şerban (1986, 1989) writes, here the man stepped right into history. Henceforth people settled in the welcoming meadows of the Tigris, Euphrates, Nile and Ganges. The great civilizations of antiquity flourished here: Sumerian, Egyptian, Indian, Far Eastern, and then Persian, Greek and Roman. Around the same time, the Olmec, Mayan, Toltec, Aztec and Inca civilizations flourished in Central and South America, whose emergence and development are still incompletely known to us.

The certainty that man originates from this planet consists of numerous data from all fields of biology: it is proven by paleontological data (through hominid fossils), cytological and histological data (specialists specified that human cells and tissues are identical to those known in the world of mammals), morpho-physiological (human anatomy and physiological processes are also identical to those of all vertebrates), embryological (the development of the human embryo is almost identical - up to a certain point - to that of the other anthropoid apes), ethological (human behavior instinctive and unconditioned reflexes are similar to those of apes), have social behavior like other mammals, have natural enemies, diseases and parasites from all groups of organisms, like all mammals, can be transplanted with organs or tissues from other animals to humans, tests for human drugs are first done on lab animals (proof that we are no different from them)…and the proof goes on.

Less than 100,000 years ago African populations of Australopithecus replaced earlier hominin species. Of these, later, through natural evolution, the representatives of the genus Homo appeared, and in the end, the species Homo sapiens was the one that prevailed, eradicated (it is not known how) the other species of humanoid anthropoid apes and expanded its range natural throughout the planet (Figure 84).

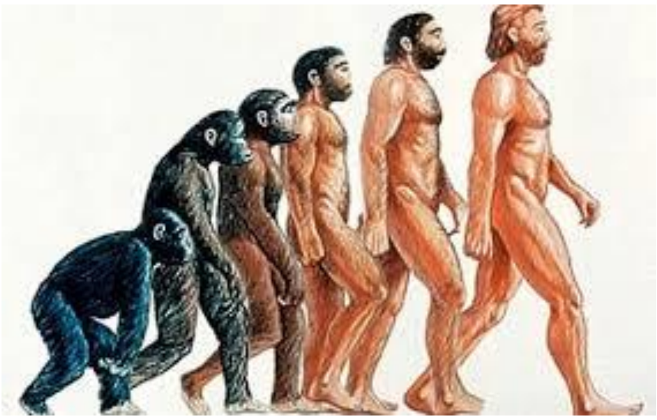


Figure 84. The evolution of man from ape to modern (https://www.google.com/search?client=firefox-b-d&sca_esv=583612193&q=Evolu%C8%9Bia+omului+de+la+maimu%C8%9B%C4%83+la+omul+modern&tbm)

What is certain is that about 40,000-10,000 years ago, primitive man made an inexplicably fast jump from the monkey stage (which had somewhat developed rudiments of intelligence), to today's humans, possessors of well-structured, relatively similar civilizations possessing high, highly complex intelligence. Modern humans (the species *Homo sapiens*) have something different from all other animals, including apes the way the brain works, language, the ability to make objects, anticipatory thinking, inventiveness, and many other aspects of brain activity. For all of these there is no rational, plausible, convincing explanation that can be linked to a natural evolution of the human species and that appeared in a particularly short evolutionary period (under 50,000 years, or even less). So where does this sudden jump come from, with extraordinary consequences only for humans?

Another hypothesis - which, although highly contested, seems now to be increasingly accepted - is that of the intervention of extraterrestrials who came to our planet, who took specimens from the most advanced hominids from a cognitive, ethological and social point of view (de Homo erectus), which they genetically manipulated, reduced their number of genes and then helped them to evolve faster (so in a way controlled by them) to become the people of today (Sitchin, 1985).

Michel Grangier (Şerban, 1986) claims that the beginning of the human species is due to a genetic engineering operation carried out by extraterrestrials. He is based on the fact that the number of chromosomes in apes is 48, and in humans 46, and after the deciphering of the human genome (by J.Craig Venter and Francis Collins) in 2000, the number of nucleotides in humans is - in absolutely surprisingly - extraordinarily simplified compared to all other species of mammals and apes for which such mappings have been carried out. Why... And who did this? Another researcher, Charles Font, appreciates that humanity is nothing more than a kind of guinea pig lot of superior extraterrestrial intelligences (Şerban, 1986).

The advances made in the last two centuries in many scientific fields, and primarily in genetics, allow us to evaluate evolutionary anthropogenesis as a rational system on a true premise: the animal origin of the human species. But it does not provide a fully satisfactory explanation of certain peculiarities of the evolution of our species from the simian to the human stage. Interestingly, modern humans had a sudden intellectual, cultural and technological "Great Leap Forward" less than 50,000 years ago, and if so, this was due to neurological changes not visible in fossils.

There is still a debate whether modern humans (Homo sapiens species) evolved all over the globe simultaneously, from several hominid species, or are descended from a single small population in Africa (it is even hypothesized that the billions of today they are derived from only about 2000 individuals who appeared in Africa, whose descendants migrated rather quickly - it is not known how - throughout the world). It is also interesting that in different geographical areas, depending on the climatic, geographical and food resources, different human populations have differentiated (color, height, hair, hairiness, eye color, other physiological and ethological characteristics, ethological differences, etc.), which, however, did not reach the subspecies level, as happened to the populations of other animal species that occupy large areas on the globe. For a long time they were called human races, because they were never clearly delimited into true subspecies (and as a result even now interbreeding between people from different geographical areas is perfectly possible) (Figure 85).

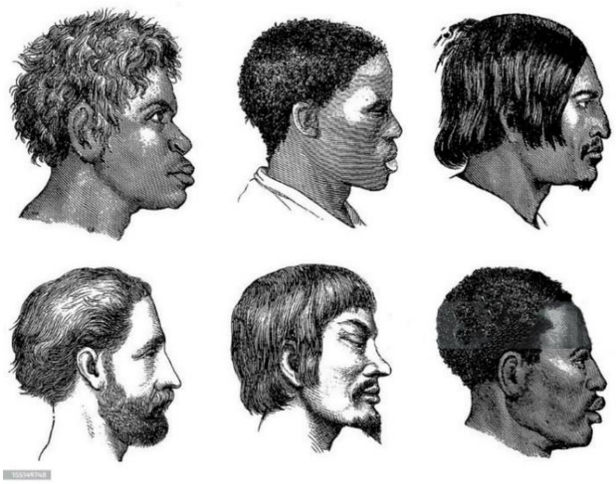


Figure 85. The diversity of human races (https://www.google.com/search?client=firefox-b-d&sca_esv=597772508&q=human+races&tbm=isch&source=lnms&sa=X&ved=2ahUKEwjEyNyT0deDAxVJ9QIHHWL3CpEQ0pQJegQIChAB&biw=1194&bih=534&dpr=1.13#imgrc=xZmYwTrS1qKwKM)

In the area of the Middle East (more precisely in Sumer), less than 10,000 years ago, a well-structured civilization suddenly appears, possessing scientific and technical knowledge that emerged from nothing. It is also here that the first writing and the first laws of social coexistence among these hominids appear. This information is based on the translation and interpretation of numerous Sumerian manuscripts over 4000 years old discovered by archaeologists, which describe the arrival of some cosmonauts on earth, what they did, how they created people and taught them everything, how they created crop plants and domestic animals (ie they provided food) and how they used them as workers. This is how the sudden appearance in the Near East area (more specifically in Sumer) over 4000-5000 years BC is explained. of a civilization - from the beginning well structured - which possessed scientific and technical knowledge peculiar and inexplicable at that stage of human evolution, which had a well structured religion (belief in gods who knew everything and to whom you had to obey and do everything unconditionally according to their will, gods who - attention! - resembled people, understood what they were saying and listened to them unconditionally!).

Here is what Sitchin (1995) writes about Sumer:

"*Sumer was not a mysterious, distant land, but the ancient name of Mesopotamia, as the book of Genesis clearly states: the royal cities of Babel, Akkad and Erech were in the "Land of Shinear". (Shinear being the biblical name of Sumer.).*

Once historians accepted this conclusion, the floodgates were opened. References in the Akkadian and Assyrian libraries to "older texts" made sense, and it was discovered that the long columns of words were actually dictionaries and vocabularies, made in Assyria and Babylon, for the study of the first written language, Sumerian. Without these dictionaries from long ago, we would not have been able to read the Sumerian inscriptions. But with their help, a whole literary and cultural treasure was discovered. It became clear that the Sumerian writing, at first pictographic, carved in stone, in vertical columns, was later passed horizontally, then stylized so that it could be written on clay tablets and thus transformed into the cuneiform writing that was adopted by the Assyrians, Akkadians and Babylonians, as well as by other tribes of the Near East (Figure 86). *Sumerian and writing, and the discovery that Sumer had been the source of the Akkadian-Babylonian and Assyrian civilizations encouraged archaeological research in southern Mesopotamia.All the evidence pointed to the beginnings here..*

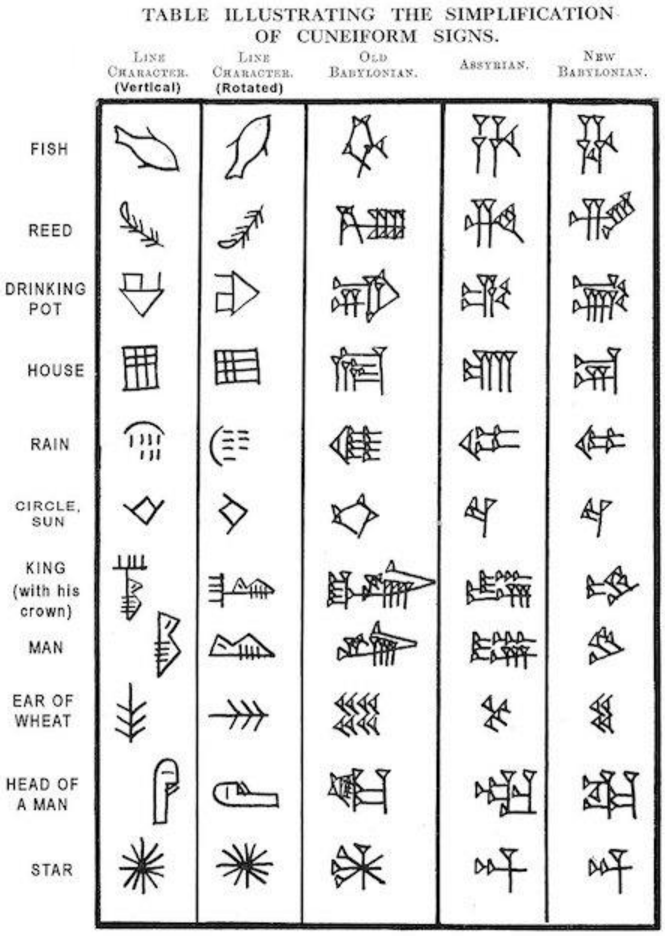


Figure 86. The Correlation of the Sumerian Language with the Cuneiform Language (Sitchin, 1990)

In 1956, Professor Samuel N. Kramer, one of the greatest specialists in the history of Sumer, reviewed the literary heritage discovered on the clay tablets beneath the Mesopotamian hills. His book "From the Tablets of Sumer" is itself a masterpiece. In the twenty-five chapters, one of the Sumerian "firsts" is presented, including here the first schools, the first bicameral parliament, the first historian, the first pharmacopoeia, the first "almanac", the first cosmogony and cosmology, the first astrolabe, the first "Job" , the first proverbs and sayings, the first "Noah", the first library and the first catalog of a library, the first "golden age of humanity", the first code of laws, the first social reforms, the first treatises on medicine, the first organized agricultural cultures... There is no exaggeration here.

Also here, in Sumer, the sexagesimal measurement system was created, petroleum products (oil, asphalt, bitumen, etc.) were used for the first time around 3,500 years BC, medicine appeared (so 5,000 years ago B.C.), textile clothing was "discovered" and used (around 3,800 B.C.), agriculture and culinary art developed and diversified, the first boats were built that traveled on rivers and canals (for the Sumerians 69 terms refers to navigation and ship building!!!). It seems that the wheel was also discovered here."

Also Z. Sitchin thus presents the "formation of man" by the gods:

" How was man created? The Sumerian text "When Gods Like Men" contains a passage that seems to explain why the "blood of the gods and the "dust" had to be mixed. The "divine element required did not simply consist of taking blood from one of the gods , but something far more essential and important. The god who had been chosen for this, we are told, had TE.E.M.A — a word which a number of authorities on the subject (W.G.Lambert and A.R.Millard of Oxford) translate as "personality". But the ancient term is much clearer, it means, literally, "that which houses that which is related to memory". Moreover, the same term appears in the Akkadian version as "etemu", a word that is usually translated as "spirit" or "spirit".

In both instances we are dealing with that "something" in the god's blood which defines his individuality. All these, we are sure of it, are but roundabout ways of saying that the god She was actually seeking, when he put the god's blood in a series of "purifying baths", the god's genes.

The purpose of the complete mixing of the divine element with the earthly element is also it explained in detail:

In the dust, god and man will be mixed,
For one to be.
And until the end of days
Flesh and soul
Who in the god was baked -
That soul, through the brotherhood of blood, let them be united.
At his sign, let life triumph.
So that this is not forgotten forever,
The "soul" forever through blood brotherhood be bound.

These words were not understood at all by scholars. The text clearly states that the god's blood was mixed with the dust to genetically bind gods and humans "until the end of days" so that both the flesh ("image") and soul ("likeness") of the gods would be imprinted on humans in a blood relationship that can never be separated.

The Epic of Gilgamesh tells that when the gods had to make a mate for Gilgamesh, who was partially of divine origin. The Mother Goddess mixed... "dust" with... the "essence" of the god Ninurta. Further in the text, Enkidu's incredible power is attributed to the fact that he had the "essence of Anu" in him, an element he had also obtained through Ninurta, Anu's grandson.

The Akkadian term "kishir" refers to an "essence", a "concentrate" that the gods possessed. E. Ebelling summarizes all his efforts to find out exactly what this kishir means by saying that "Essence, or some other shade of this term, it could very well be applied both to the gods and to the rockets in the sky." SHE. Speiser adds the idea that this term also implies "something that came from heaven". "It has a connotation," he continues, "as if he were using this term in a medical context".

Here we come to the simplest and most correct equivalent of this word: genes.

Clues from ancient texts, as well as those from the Bible, suggest that the process adopted to unite the two sets of genes - those of a god and those of a Homo erectus - involved the use of male genes as the divine element and female genes as the terrestrial element.

The result is shown on a figure on a Sumerian tablet (Figure 87).

Figure 87. The Making of Modern Man by the Alien Goddess Ninhursag (Sumerian Clay Tablet) (Sitchin, 1985)

In support of his hypothesis, based on Sumerian texts, Z. Sitchin developed a chronology of the events of the arrival and activities of extraterrestrials on Earth (Table 19).

Table 19. Alien activity on planet Earth based on Sumerian and Akkadian manuscripts (Sitchin, 1999, simplified)

x yrs B.C.	The event that took place
445.000	The Nephilim (the name of the aliens), led by Enki, arrive on Earth. Eridu (Earth Station I) is founded in southern Mesopotamia.
430.000	The great ice caps are beginning to melt. In the Middle East, the climate becomes hospitable.
415.000	Enki moves inland, establishing Larsa Station.
400.000	The interglacial period extends everywhere. Enlil arrives on Earth and establishes the space center at Nippur. Enlil travels to Africa and organizes there the mining operations of the gods (aliens).
360.000	The Nephilim establish Bad-Tibira, their metallurgical center, for smelting and processing metals. Sippar, the spaceport of the Nephilim, and other cities are built.
300.000	Revolt of the Anunanki (who demanded to have slaves/workers to work in the mine in their place). Enki and Ninhursag (his sister) "make" man (the primitive worker) (Figure 87)
250.000	Man manipulated by the Nephilim multiplies and spreads over the entire surface of the earth.
200.000	Life on Earth regresses during a new ice age.
100.000	The climate is warming up again. The sons of the gods marry the daughters of earthlings and have children with them. This is how demigods appear.
77.000	Lamech, a man born of a god and an earth woman (a half-breed), becomes the first earth king in Şuruppak, under the protection of the goddess Ninhursag.
75.000	A new ice age begins.
49.000	The reign of Ziusudra, "faithful servant" of Enki, begins.
35.000	The worsening climate is beginning to decimate humanity. Neanderthal man is disappearing from Europe.
13.000	The Nephilim, warned of the huge tide that their planet's approach to Earth would bring, decide to let humanity perish. The flood sweeps the entire Earth, ending the ice age at the same time.
11.000	The Nephilim, led by Enki, bring seeds and teach humans to practice agriculture. Enki domesticates the first animals.
7.400	The Neolithic period begins. The demigods rule in Sumer and Egypt.
cca. 6.500	The Nephilim manipulate the human genome a second time; consciousness arises in humans.
3.800	Urban civilization emerges in Sumer.
3.760	Monarchy is granted to mankind. The calendar also begins in Sumer, in the city of Nippur.
2.900	Civilization begins in the Indus Valley.
2.371	The Akkadian Empire comes into being.
2.123	Avraam is born in Nippur.

Over the last 50,000 years man, this product of our planet, despite the fact that he is apparently not the best adapted to the environment, but because of his social life, communication skills (language) and, above all, because of his intelligence , conquered, subjugated, and changed the entire planet to suit his interests in a way that no other living organism had done before him. In a very short time - viewed on a planetary scale - it entered and can live - because it uses external energy sources, material resources and all living habitats (terrestrial, aerial, aquatic and underground), even if it is in very diverse climatic conditions (from equatorial to polar climates, or from desert to alpine habitats) – anywhere, and now they are trying to conquer the cosmos. As a consequence of the development of technology, he has become one of the most disturbing beings on this planet.

3.4 Interactions between components of the biosphere

From what was presented before, it was possible to see how varied and somewhat complicated are the capacities of living things to diversify and adapt to the most different living conditions.

During the 3.8 billion years, life has always had two fundamental components, for which every living thing does absolutely everything to achieve them: 1. ensuring the exchange of information, energy and matter with its living and non-living environment and 2. the production to descendants capable of ensuring the continuity of the existence of the respective species.

Relationships between individuals of the same species

In all the kingdoms that life has created in the course of its evolution there are numerous examples of such relationships.

In the pre-individual phase, so when there were only organic masses exhibiting metabolic growth processes, living masses that appeared in the primordial ocean, there is no information related to relationships between these living organic masses with different physico-chemical and metabolic characteristics.

Since the emergence of living organisms belonging to the kingdom Bacteria, isolated individuals first appeared that metabolized and grew in size until they reached a certain size, then divided into two smaller individuals, which continued their metabolic processes and grew again. This process continued as long as there was sufficient food in their living environment and they found the energy necessary to carry out the processes of metabolism and reproduction, all operating on the basis of the informational program specific to the respective species.

At some point, in some species, the individuals no longer separated after the division, they remained united by creating a common protective shell. Later, several descendants of the original individuals joined other species as well. Thus, groups of individuals of the same species appeared, either constituting an amorphous ball, or because they formed filaments or plates (Figure 88). If at first the common shell was very fragile and unstable, over time, the individuals found the solution to stay together by secreting a common gelatinous shell, through which exchanges of matter could be carried out more easily). Currently, in many representatives of the kingdom Bacteria grown in laboratory conditions, single individuals in the form of cocci, rods, spirilla or vibrios, diplococci, filaments and larger or smaller amorphous or branched clusters can be found (Figure 88).

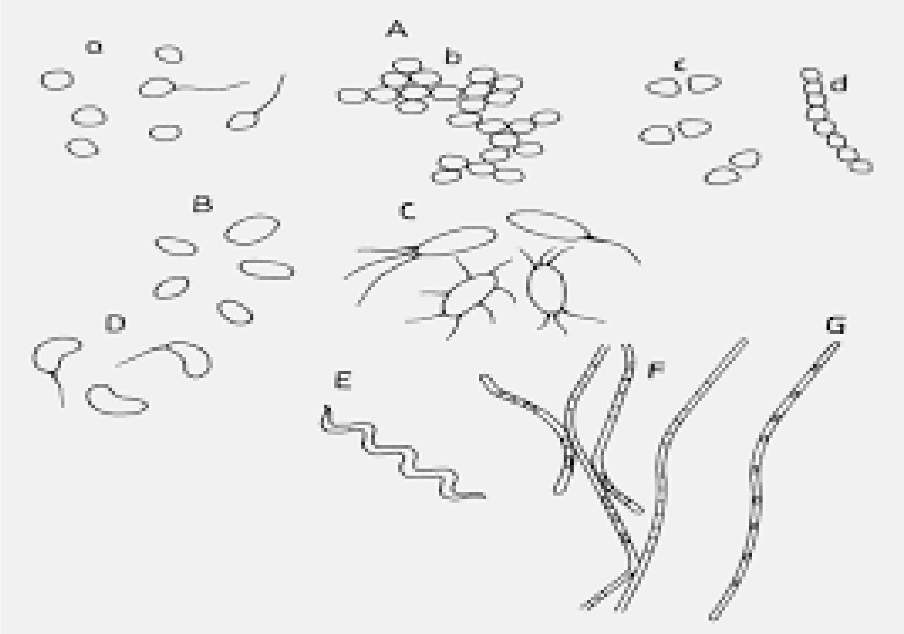
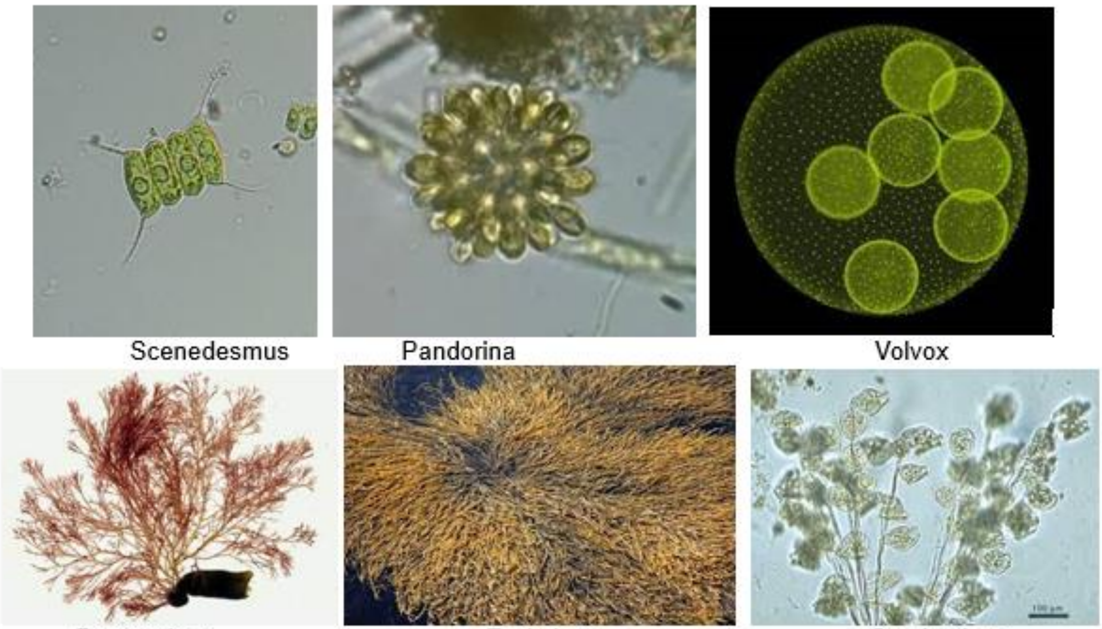


Figure 88. Types of uni - and multicellular bacteria

In the representatives of the kingdom Protista, with the appearance of the membrane, and then the differentiation of some internal structures within the protoplasm (structures that performed different metabolic functions, of producing or storing energy or some enzymes, storing certain metabolic products, etc.), the complexity of cellular structures increased. At the same time, in these single-celled species, some individuals that were initially single, after division remained stuck together, as happened in bacteria. But here the life of the adjacent individuals took on a very wide range of associations, because simultaneously with this process, symbiosis and commensalism appeared. Although protists are characterized by unicellularity, the grouping of individuals takes on particularly large ways: from those that form filaments or amorphous groups, to those organized in plates, those that form aborizations or spheres, etc. As a result of symbiosis with other species, the possibility of grouping individuals appeared to create very varied morphological formations, because in this way they could carry out the processes of metabolism and division in a much wider range of possibilities (Figure 89). This is how the range of protists with a colonial way of life appeared and diversified.



Scenedesmus Pandorina Volvox

Brown algae Red algae Carchesium

Figure 89. Different multicellular protists

Within the Fungi kingdom, all species are multicellular, but possess mostly similar individuals, but which can no longer live alone. Since all fungi are saprophagous and/or detritophagous organisms, they can coexist in order to decompose the necromass of other living organisms that have died, growing side by side, thus competing or associating to carry out the processes of metabolizing the necromass on which they live.

In the Plantae kingdom, the various species coexist, but the competition manifests itself especially in the uptake of light energy from the sun. For this purpose, plants have differentiated into luciferous and ombrophilous species, species that emit certain substances with the help of which they facilitate their ability to procure mineral salts from the soil (necessary for them in the photosynthesis process, or with the help of which they remove some phytophagous organisms) (e.g. aphids, other parasitic fungi, etc.).(Figure 90)

Ferns

Horse tail

Conifers

Dicotiledonates

Monocotiledonates

Figure 90. Plants

In the Animalia kingdom there is a wide variety of forms through which the relationships between different species are manifested (competition, association, symbiosis, colonialism, etc.).

Since the range of intraspecific relationships is very wide, we present only a few examples: migrations of birds between Europe and Africa and back, journeys of lemmings from north to south during the polar summers, migrations of sturgeon for reproduction in the Danube and Volga, and of Anguilla larvae in the Sea Sargassum in the flowing waters of Europe and back, the monospecific shoals of sardines or mackerel in the seas and oceans, the colonies of coelenterates that form the coral reefs or the Great Barrier Reef in eastern Australia, the flamingo colonies in South America, the nesting colonies of tailor birds from Africa, colonies of termites, ants or prairie dogs, clouds of migratory locusts or those of migratory ants, colonies of pelicans or cormorants for foraging in the Danube Delta, etc. (Figure 91)

Pelican colony

Termite colony

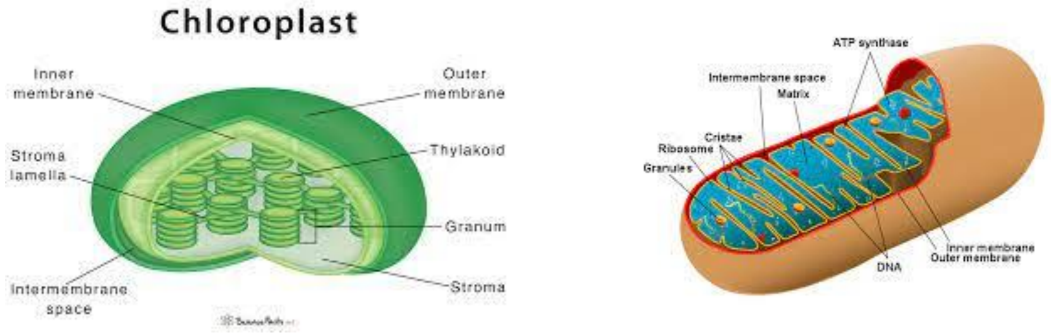
Figure 91. Life in animal colonies

Relationships between individuals of several species

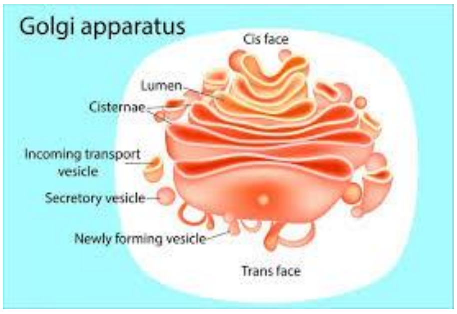
Three types of relationships can be included in this category: those of symbiosis, those of commensalism and those of aggregation.The phenomenon of symbiosis consists in the permanent coexistence between two different species. The best known is that of some species of fungi and algae. This association has created a special type of organism, lichens, which are found all over the globe on rocks, stones, trees or old roofs (Figure 40)

Researcher Lynn Margulis (1982, 1992, 2009) discovered that symbiosis is the most important process that accelerated the development and diversification of life forms on earth: a bacterium coexisted with a bacillus and thus created a bacterium that can move with with the help of a flagellum, a bacterium with chlorophyll pigments was included in the body of a protozoan and became a formation of its cell (they became the current chloroplasts present in all plants and algae in which chlorophyll pigments photosynthesize producing organic substances based on sunlight), mitochondria (in which the redox enzymes are secreted that ensure the realization of the intracellular respiration processes, as a result of which the energy necessary for the proper functioning of the processes in the cells is released), the Golgi apparatus (which processes protein and lipid macromolecules and where polysaccharides are stored) etc, (Figure 92).

Another symbiosis is the association of bacteria that break down cellulose into carbohydrates in termites guts, or bacteria in the digestive tract of vertebrates to break down/digest ingested organic substances more efficiently. And the examples can go on.



The structure of a chloroplast Mitochondria



Golgi apparatus
Figure 92. Cell formations created by symbiosis

Commensalism is a form of permanent or temporary coexistence between two organisms (different plants or animals) in which one consumes part of the other's food, or obtains a benefit from it. An example is the lark (Alauda arvensis), the partridge (Perdix perdix) or the polar hen (Lagopus lagopus) which consumes the faeces of ruminants, the epiphytic plants (ivy, lichens, mosses, etc.) (Figure 93) which receive shelter and water from on the plants they grow on. We know birds that sit on the backs of other ruminants and feed on the insects that live on them, Remora fish that move by sticking to the dorsal suction cup of sharks or whales and that feed on the remnants of their prey, etc. (Figure 94)

Orchid Tillandsia

Figure 93. Epiphytic plants

Birds commensal on buffaloes Remora fish on sharks

Figure 94. Commensal animals

The phenomenon of aggregation consists in the bringing together of individuals from different species to perform certain common activities. In this way the equatorial forests of many different species were formed, the mixed herds of antelopes, buffaloes and zebras in the African grasslands, the coral reefs made up of different species of coelenterates (Figure 95), etc.

Herbivorous animals in the Serengeti National Park Coral reefs

Figure 95. The phenomenon of aggregation in the terrestrial and aquatic environment

Energy and trophic relationships

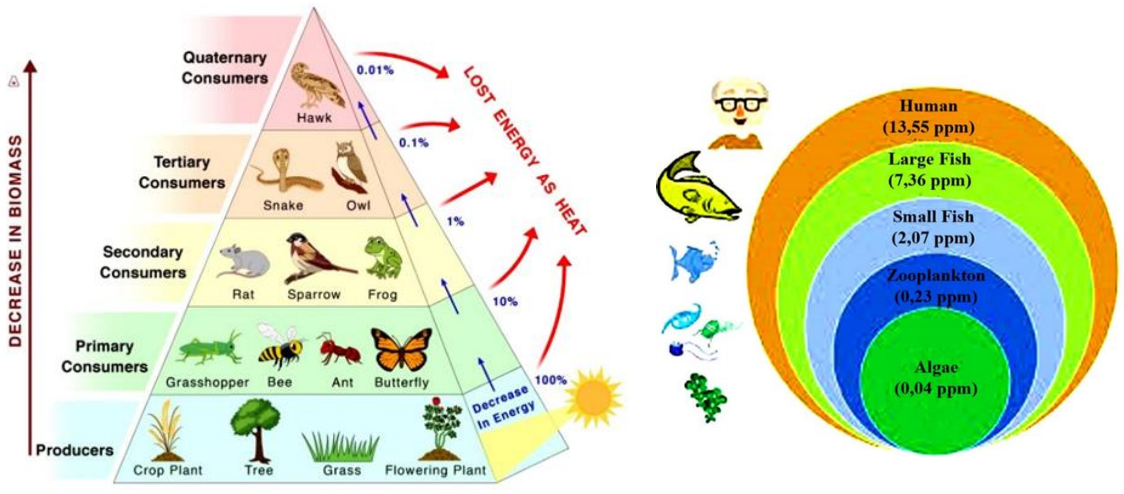
Food chains appear as a result of the relationships in which living things enter with different ways of feeding, and which aim to make the amounts of energy available in their food more efficient. They are based on the complex relationships of interdependence between the various plant, animal and decomposer organisms existing in an ecological system. Each organism in a given trophic system is a food source for other organisms, which in turn are a food source for others.

The following types of food chains are distinguished depending on the primary food source:

A. type plant-herbivore-carnivore: plant-animal phytophagous herbivore-secondary carnivorous animal-tertiary herbivorous animal-necrophagous organism 1 - necrophagous organism 2, etc.
B. parasitic type: host-parasite-hyperparasite.
C. detrital type: decomposing dead plant or animal material (detritus) - detritivorous organisms (for example, the remains of dead organisms from various causes are bacterially decomposed in the water mass) - detritus filters - predatory animals of the 1st degree - predatory animals orders 2, 3 etc.

At the end, from all the links of the trophic chains, they return to the water in the form of residues or droppings that are taken up again by the filters; and food chains resume.

These food chains are longer or shorter strings of living things through which the matter and energy accumulated in the living world circulate, at different speeds, to meet the metabolic needs of each participant in the food chains. That is why we speak of main and secondary trophic chains, or of trophic or energy pyramids (depending on the volume or quantity of existing biomass at each trophic level). (Figure 96)



A **B**

Figure 96. Diagram of a terrestrial (**A**) and an aquatic (**B**) food chain (Levine *et al.,* 1994)

A food chain refers to only one type of food and how it circulates (or to a virtual food chain consisting only of monophagous animal organisms).

Since consumers (most animals are polyphagous) make up food chains, they mix with each other, forming so-called food webs. Within food chains some predators are very voracious and active; they become a kind of trophic nodes, through which the bulk of the organic matter that constitutes the food of the respective trophic network circulates. (Figure 97).

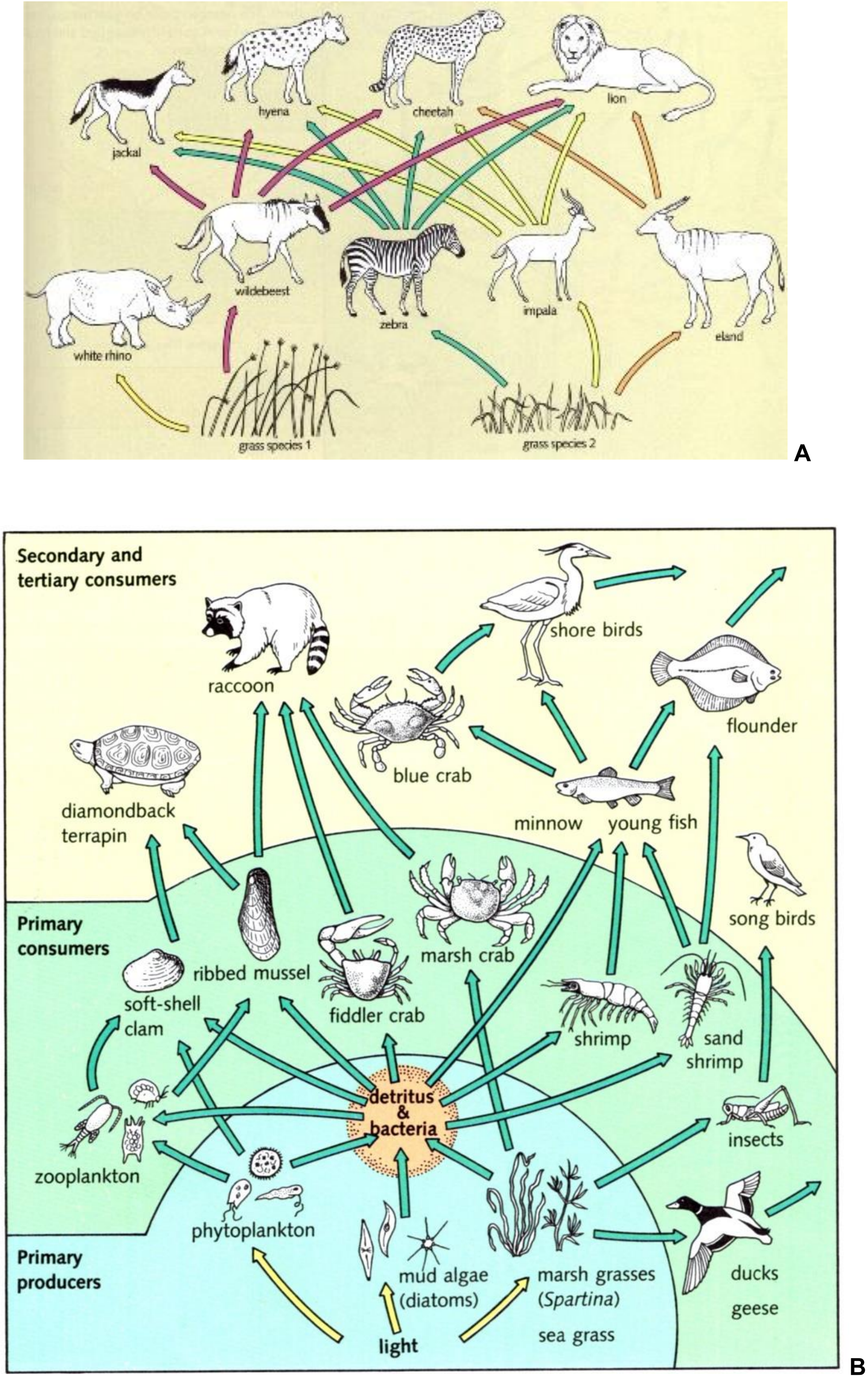


Figure 97. Diagram of A-terrestrial, B-aquatic food webs (Levine *et al.,* 1994)

Chains and trophic networks are the basis of the constitution of biogeochemical cycles (see examples of such cycles in chap. Ecosphere)

Biocenotic relationships

This type of relationship occurs only within associations of organisms that populate a certain type of ecosystem, where specific types of biocenoses are formed.

A biocenosis is the biological unit superior to the species in which lives a set of populations of living things belonging to the most different forms of life, occupying a certain space where there are relatively homogeneous living conditions (abiotic factors), to which the existing populations have adapted adapted over time and between which stable relations of cohabitation and efficient exploitation of abiotic materials have been created, through which a flow of energy and matter circulates, at the level of existing organisms, which is taken from nature and used with maximum effectiveness. (Figure 98) Biocenosis is a level of organization of life higher than individuals, species and their populations.

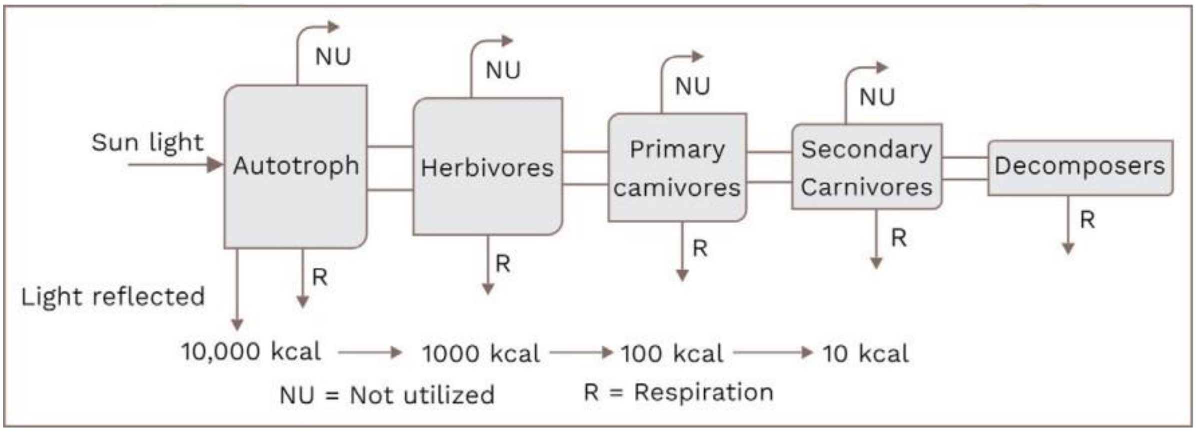


Figure 98. Energy flow through a food chain (producers, consumers, necrophages, detritivores)

Biocenoses (living component) together with their living environment (biotope) form an ecological unit called an ecosystem.

According to the systemic theory, ecosystems represent the basic unit of living-non-living complexes through which the functioning of the ecosphere of our planet is organized.

An ecosystem is a forest, a plain, a swamp, a lake, a river, a sea, etc. (Figure 99). In such an ecological unit there can be a single biocenosis (if this unit occupies a small space), or several biocenoses (depending on the size and variety of environmental conditions existing in these ecosystems). Thus, a swamp, a rocky shore, a ravine, have only one biocenosis, while a lake can have 2 or 3 (coastal area, water mass, bottom devoid of vegetation), a forest can have several biocenoses (the edge of the forest, the forest proper - if it is composed of a single species of trees -, or several (if there are forests in which there is a mixture of different plant species as well as glades, rocky areas, etc.).

To make the notions clearer, natural and anthropogenic, urban or rural, aquatic and/or terrestrial, saturated and unsaturated, pioneering, stable or aging biocenoses are distinguished. They are named according to the type of relief or living environment (coral reefs, marine/oceanic plateau, abyssal zone, lake, flowing water zone, rocky mountains, village, city or type of anthropized zone, etc). In the most common way, in the terrestrial environment the name is based on the main type of vegetation, in waters on the type of water-substrate interface, in the underground environment on the geological formation in which life is established (cave, aven, lake or underground river) etc.

The coastal area of the Black Sea

The beech forest in the Bucegi mountains

Lăptici swamp (from the Bucegi mountains)

Steppe in Neamt county

The Slatioara secular forest

Rocks in the Bucegi mountains

Figure 99. Types of aquatic and terrestrial ecosystems

3.5 Final assessments on the biosphere of planet Earth

Scientific research of the living world has gradually developed in multiple directions. The most different organisms were researched; their classification, their morphological description and the investigation of their physiology were made, the methods of reproduction, transmission of characters to offspring and adaptation were highlighted, the system of preserving the characters of different species of organisms was elucidated (genetics research) and recognized the fact that there are associations of organisms that relate to each other and that interact permanently with the abiotic environment they occupy.

Its living nature and continuously improving biological information are the main features of the manifestation of the biosphere, This clearly distinguishes it from the other shells of the earth. This force of the planet exists in the form of a huge variety of organisms with their own individual characteristics, which has different shapes and is extremely varied in size. Among living organisms, there are the smallest living things, but also large multicellular animals and plants. The sizes of living things vary from nano- and micrometers (bacteria, ciliates) to tens of meters (fewer now, most of which are known only in the form of fossils that we find in the present-day lithosphere).

Due to its great variability, diversity and uninterrupted activity, the biosphere is characterized by great stability and resilience.

The chemical composition of the living matter of our planet is characterized by the predominance of a few elements: hydrogen, carbon, oxygen, nitrogen, phosphorus, potassium. Their atoms create complex molecules in combination with water and a number of mineral salts. Chemical elements circulate permanently and at different speeds in the biosphere in ways that are characteristic of them, but which also circulate from the external environment to the body and subsequently return to the external environment. The processes of orderly movement of chemical elements that take place with the participation of living matter are called biogeochemical cycles. Currently, the cycles of water, carbon, nitrogen, phosphorus, sulfur, and other essential elements for the maintenance of life are well known (see also those presented in the Ecosphere chapter).

The main function of the biosphere is to ensure the circulation of chemical elements, which is expressed in the circulation of their existing compounds in the lithosphere, atmosphere, soil and hydrosphere. At the level of the biosphere, a biogenic migration of atoms takes place: atoms taken by plants from water and soil pass to herbivorous animals, then to their predators, and then to other higher-order predators (or parasites of the predecessors), etc. Dead plants and animals serve as food for a wide variety of microorganisms, and the minerals released by them are again taken up and consumed by plants. Only a small percentage of atoms emerge from this biological cycle; these atoms released from the life process usually end up in non-living nature. Biochemists have defined the following biochemical functions of the biosphere: (https://www.scrigroup.com/geografie/ecologie-mediu/Care-sunt-componentele-biosferei.php).

1. *The function of creating the organic matter that constitutes the biomass of living organisms* (taking from the non-living environment a wide range of inorganic compounds, from which they synthesize their own organic substances, necessary for the maintenance of life and ensuring its continuity indefinitely);
2. *The function of* chemosynthesis (chemoautotrophic bacteria participate in the oxidation of metal compounds that enrich their living environment, which allows them to live in extreme or special living environments);
3. *The function of metabolizing some chemical elements* (different salts of some chemical elements are produced as a result of metabolism and then eliminated in the environment by organisms);
4. *The function of decomposition of dead organic matter/necromase* (living organisms intervene directly and indirectly in the processing of dead organic matter, in mineralization, then in their humification¸ thus in the reintroduction of the thus decomposed components into the circuit of matter and energy);
5. *Oxygen and/or hydrogen generation function.* Atomic oxygen - the free one - results as a by-product of photosynthesis through the decomposition of water molecules. In the terrestrial environment, the highest amount of oxygen is produced by higher plants, and in the aquatic environment, it is produced by algae. There are also living organisms (cyanobacteria, green algae, some higher plants, but also termites) that release free hydrogen from water;
6. *The methane genesis function* (in anaerobic habitats - i.e. devoid of oxygen - under normal conditions methane is produced, which contributes to maintaining the amount of carbon in the atmosphere).

To these "biochemical" functions we would add the following "ecological" functions (*Godeanu et al.,* 2021; Godeanu, 1998):

1. The use of biological information in directing all processes in the living world and living-non-living interactions;
2. Finding several (and most often the most optimal) mechanisms to obtain the energy requirements for the functioning of life on a planetary level;
3. Specialization of different types of organisms to carry out certain major biotic processes (sensitivity, immunity, symbiosis, nutrition, etc.);
4. Creating a cybernetic system of control and supercontrol based on cybernetic self-organization and self-improvement;

5. The creation of new biological and ecological systems, which aim to increase the efficiency of survival mechanisms.

In the last three hundred years, relatively homogeneous terrestrial and aquatic territories of different sizes have been determined and the composition of their flora and fauna has been inventoried. A huge volume of scientific data was collected which seemed to lead rapidly to a good knowledge of the living world. The desire of biologists to put order in the multitude of knowledge related to living matter has always existed, but humanity is still far from truly achieving it.

A century and a half ago, the theory of the evolution of living organisms appeared (Darwin, 1859). Almost a century and a half ago, ecology emerged as the science of living-living interaction (Haeckel, 1886).

The diversity of the living world was and is particularly great. From the appearance of life on earth until now, living organisms have constantly evolved, adapting very quickly to the changes that occurred as a result of the action of cosmic factors and those that constitute the toposphere. Living organisms have successfully coped with the permanent changes that have taken place in their living environment, and even if there have been several times true catastrophes that have suddenly and greatly changed the environmental conditions that have arisen, they have coped with these changes, even of serious planetary accidents (collisions with other cosmic bodies, meteor showers, the action of deadly cosmic radiation, etc.). The components of the biosphere have constantly evolved, perfecting their mechanisms of exchange of matter and information with their surrounding environment and constantly perfecting their ways of obtaining the energy necessary for carrying out metabolic and reproductive processes.

As a result of this evolution, life on planet Earth is of extraordinary variety and presents itself in such great diversity that it is able to withstand the most diverse interventions that attempt to destroy it.

At the moment living things form that shell of our planet that not only protects life, but also the non-living components of the planet, contribute to the preservation and prolongation of the existence of this planet much better than do the non-living components on other planets.

During the last centuries, during which scientific knowledge about the living world developed, the main notions about the units on which this world is structured were established: organism, cell, species, population, biocenosis, biome, biosphere (Brewer, 1994; Botnariuc, 1967; Doniță, 2021).

As for systems based on living communities, the main problem concerns the relationship between the species and the biocenosis.

The species was defined as a genetic unit, involved in reproduction, heredity, multiplication, adaptation and evolution (Zawadsky, 1961; MacArthur *et.al.,* 1970; Ceapoiu, 1988; Mayr, 1982 1957; Ghiselin, 2002). Others stated that it is also an ecological unit (Van Valen, 1976; Doniță and Godeanu, 2019; Doniță *et al.,* 2020). Research in ecological genetics has revealed the important role that populations play in genetic processes (Ford, 1964; Stern and Roche, 1974). A detailed study was devoted to the adaptive processes related to the environment (ecological niche), not noticing that this was precisely the entry way to which the ecological character of the species was emphasized.

To clarify the connection between species and biocenoses, one can start from several statements (Doniță, Popa, Godeanu, 2020):

- species are not only genetic systems and taxonomic units, they are also ecological units, provided with adaptations to ensure their survival and evolution in the most diverse conditions of the non-living environment, globally (Van Valen, 1976; Doniță and Godeanu, 2019);
- species are functionally differentiated into three large ecological categories: producers, consumers and decomposers of biomass and necromass (Doniță and Godeanu, 2019);
- consequently, in nature, species cannot live separately, autonomously, but only in mixed associations (in biocenoses) integrated in their specific non-living environment (i.e. in ecosystems);
- within biocenoses, species are represented by populations (assemblages of individuals belonging to the same species) that become structural and functional parts of the biocenose they belong to;
- these populations can be found in several biocenoses of the same type, where the living environment (populations of other species) and the non-living environment (the particular biotope) are consistent with their ecological adaptations;

- within the biocenoses, the processes of production, consumption and degradation of biomass and necromass are carried out as a result of the relationships between the organisms that form the species, therefore as populations, integrated in chains and trophic networks. These processes ensure the energy and matter necessary for ontological development, the elimination of necromass and the recycling of the vital elements necessary for the functioning of the biocenosis (Botnariuc, 2003);
- within biocenoses, the genetic processes regarding the perpetuation and evolution of species (reproduction, multiplication, adaptation, emergence of new subspecies, then species) take place at the level of each population (Godeanu and Donița, 2016; Donița *et al.,* 2017; Doniță *et al.,* 2020).
- being integrated into biocenoses, species have more efficient access to their vital resources and are also able to ensure their perpetuation and evolution, without losing their genetic and taxonomic identity (Doniță *et al.,* 2019).

Biocenosis is at the same time the basic, elementary component of higher biological systems (bioscapes, biomes, biosphere). Changes in local abiotic factors triggered by biocenoses and their ecological activities can be greatly amplified on the scale of higher biological levels, which generates an environment that is more favorable to the existence and perpetuation of life.

In the middle of the last century, Bertalanffy formulated the theory of systems (Bertalanffy, 1940, 1952, 1968). Another promoter of this theory was in Romania N.Botnariuc (1967, 1976, 2003). Therefore it was now understood what is the existential paradigm of life: "all the forms through which it manifests are open systems, which in order to exist, as anti-entropic units, they need a continuous exchange of information, energy and matter, both with each other and with the abiotic environment in which they live. All forms of life are integrated into each other, from the smallest, the cell, to the largest (biosphere), making up a hierarchy of living systems" (Godeanu *et al.,* 2022; Doniță *et al.,* 2021).

It has been proven that the living world is structured on several levels of organization, integration, having the character of an open system and possessing the same existential functions, namely the exchange of energy and matter with the environment.

In several previous papers we presented our point of view regarding the levels of organization of living matter (Doniță *et.al,* 2017, 2018, 2019, 2020, 2021, 2022; Godeanu, 2013; Godeanu *et.al.,* 2010, 2016, 2020, 2021, 2022). In table 20 we present the main characteristics of biological and ecological systems. (from Donita and Godeanu, 2021)

Table 20. The characteristics of biological and ecological systems (Botnariuc, 2003, modified)

Characteristics	**Explanation of the concept**
Completeness	All systems have a structural and functional unity specific to them
Heterogeneity	Systems have several components that can have different functions
Self-regulation	The characteristic of living organisms is self-regulation, which leads to the existence of a dynamic equilibrium
They are open systems	Systems take energy and matter from the living and non-living environment, operate on the basis of the information stored in their components and exhibit an anti-entropic character
They have different (but specific) degrees of organization	Each level has its own structure and functions
They are hierarchically subordinate	Each system is structurally and functionally subordinate to the higher system
Historical character	Any system was created over time and evolves by constantly improving itself
They have an information system	Systems are a quintessence of specific information accumulated over time

Through the information they bring, living systems control and modify the environment, which can lead to strong changes in it, so that they create a more balanced living environment, more conducive to life locally, regionally and globally.

The paradigms of applying systemic theory in the living world are (Botnariuc, 2003):

1. On Earth, the living world is organized in systems, that is, in units formed by interacting living elements.
2. Living systems have wholeness, that is, a certain structure and function as a whole. They are heterogeneous, self-regulating (which gives them dynamic stability) and have the capacity of self-modeling and self-reproduction.
3. Living systems are open, anti-entropic systems, having an environment from which to extract the energy and matter necessary for the maintenance of life, their perpetuation and evolution.
4. Living systems are constituted on several levels of organization, having therefore different structures and functions at each level.
5. Living systems, located at any level of organization, integrate into the systems immediately above them, functioning as subsystems; thus a hierarchy of living systems arises.
6. By integrating into higher systems, the lower systems retain their vital structure and functions, but fall within the structure and functions of the higher systems.
7. In the hierarchy of living systems there are three categories of systems: individual, multiindividual (biocenotic) and multicenotic.
8. Individual living systems are organisms that are arranged at four levels of complexity: precellular, unicellular prokaryotic, unicellular eukaryotic, and multicellular eukaryotic.
9. Individual living systems have metabolism, ontological development and perpetuation as vital processes.
10. The multi-individual living systems are the species and the biocenosis, both at a single level of organization (the biocenotic) of the same species, They are formed by populations of organisms (which can be considered as subsystems).
11. Ecological processes common to multi-individual living systems are those of biomass production and consumption, as well as necromass consumption and decomposition processes; they provide the energy and matter of all living systems.
12. Multicenotic living systems exist through the ecological processes that take place at their level and can produce local changes in their living environment.

We are with those who believe that all processes in nature - of any kind, physical, chemical, geological, biological, etc. - are inextricably interconnected with each other, more or less visibly (it is the integrationist way of thinking of ecology - which, by its nature, is an interdisciplinary science).

These complex interrelationships do not unfold randomly, chaotically, but are subject to very precise laws and orders, created by biological information.

From the point of view of systemic theory, the biosphere is composed of the following **levels of organization of living matter**: biocenosis, biolandscape, biome and biogeographic zone (Doniță, 2022).

The biocenosis

As a rule, current hierarchies mention the community (sometimes the term "biocenosis" is used). In Botnariuc's opinion, biocenosis is a level of organization of the living world placed between the mixed level of species (by population) and biome. The biocenosis has all the features of a biological system, but it has a special character, being made up of genetically different species. Biocenosis is the first living system that has its own non-living environment. This environment is the non-living component of the ecosystem and is used by all the individual systems that are integrated, through populations, in the biocenosis.

Biocenoses are the living component of some ensembles of environmental factors (which make up a so-called biotope), with which they create a stable and sustainable functional unit - the ecosystem, in which the processes of evolution of the living world take place. The biocenosis must be placed (in the hierarchy of living systems) at the same level of integration as the species, which is actually included in the biocenosis.

The biolandscape

Biolandscapes are the living component of smaller portions of territory with relatively unitary climatic, geographical and pedological characteristics, in which they coexist and functionally interact, and which are part of a functionally different ecosystem group. The biolandscape is the living cover occupying an area of thousands to tens of thousands of km2 - on land or in water - consisting of a set of different types of biocenoses that alternate according to the variations of the non-living covers. Distinct local changes generate different habitats, in which different biocenoses occur. Examples of biolandscapes from Romania (in relation to its specific environmental conditions): Târnavelor Plateau, Ţara Bârsei, Moldavia Plateau, etc. A biolandscape does not contain a wide variety of biocenoses, considering that the number of species within each biolandscape is quite low. In terrestrial biolandscapes, the living element of recognition is the phytocenosis, while in aquatic ones this element is represented by the fixed phytocenosis assemblies and the permanent, mobile ones, stratified in relation to the light intensity.

The bioregion

The bioregion is the living shell that occupies a large area - thousands-millions of km^2. It consists of the sum of the living components of all the biolandscapes of which it is composed.

Bioregions are large regions of the globe characterized by groups of biomes with different characters, but which are viewed by geographers mainly from a climatic and spatial point of view - marine/oceanic waters, continents, or large portions of them with similar climatic conditions, etc. Bioregions appear as a result of changes in the characteristics of abiotic environmental factors that take place in zonal climates, from the shores of the oceans to the interior of the continents, since near the oceans the humidity is higher, a more temperate climate (in terms of temperatures) is formed, while on the continent, as we move away from the ocean, humidity decreases and thermal extremes increase, the climate acquires completely different features. Climate changes condition the appearance of flora and fauna made up of species adapted to the respective local climate - so depending on the structures of the regional biocenoses. Bioregions are integrated into biozones by groups of regions in the same zonal climate. Migrations of some animal populations can take place between bioregions; they temporarily influence the appearance and functions of biocenoses within the regional ensemble. For example, the temperate continental biozone that occupies the European subcontinent includes three distinct bioregions: the Atlantic, the Central-European and the steppe.

The biome

Biomes are ensembles of ecosystems characteristic of a geographical area in which all living things have adapted and are now considered specific to a certain area. Biomes are distinguished from cold and warm climatic zones, altitude or plains, fresh or marine waters, arid and humid zones, etc. The biome is the living shell occupying areas of tens of hundreds of millions of km^2 on land or in water, which develops on the surface of the Earth. On the continents it is arranged like some elongated strips. Biozones occur in zonal climates that differ in terms of thermal and water regimes, as a result of the annual movement of the planet that induces a seasonal variation in the incident solar radiation. The fauna and flora that occur in each of these different climates include very diverse species (both structurally and functionally) and biocenoses specific to that area.

In this immense biodiversity there is an order, an extraordinary organization, which ensures the stability and durability of life in forms that constantly adapt to the changes suffered by the environmental factors present on the surface of the earth (solar radiation, atmosphere, climate, water, rocks, forms relief, soil types) (Doniță *et al.,* 2020).

The biosphere is the only shell of the planet that carries out a permanent exchange of matter, energy and information with the living and non-living environment and influences it in a very varied range of ways. The uniqueness of our planet lies in the fact that it is the only one in the Solar System where life exists.

4 ECOSPHERE, PEDOSPHERE AND ANTROPOSPHERE

All processes in nature of any kind: physical, chemical, geological, biological, etc. are interconnected from each other indissolubly, more or less visibly (it is the integrationist way of thinking of ecology - which, by its nature, is an interdisciplinary science).

These complex interrelationships do not unfold haphazardly, chaotically, but obey very precise orders and laws.

In nature research, a fundamental paradigm is that the world has three basic components: matter, energy, and information.

This triad is always presented in this order.

We tried to analyze the information-energy-matter relationship in the living world and its connections with its environment, in order to correlate them in a more rational way, by uniting systemic theory with the theory of evolution and with the paradigms of evolution.

Information is considered to be a non-material category that reflects the state or movement of the forms of energy or matter of which the world is composed, and therefore also the living world. And based on information, these states are maintained or modified, according to the laws by which those states operate.

Physics puts energy first, because according to the "bing-bang" theory, in the beginning it was energy. It led, at some point, to the formation of matter (the first atoms), and this, on a cosmic scale, then returns back to energy (through black holes).

But for energy to organize, information must preexist. As a result, energy diversified and took different forms. One of these consisted in the appearance of matter. At first it was only in the form of electrons and protons, then as free atoms, which gradually acquired different shapes and complexities. The atoms combined, gave rise to a wide variety of substances, starting from simple compounds consisting of only two atoms. This was followed by the emergence of chemical compounds made up of atoms of the same kind, then chemical compounds made up of several types of atoms. And later, complexing, they evolved to create new and new kinds of substances, which culminated in the extraordinary complexity of carbon-based molecules that created organic macromolecules.

How the idea of the ecosphere came about

In the eighteenth century, as geology consolidated as a modern science, James Hutton argued that geological and biological processes are interconnected. Later, naturalist and explorer Alexander von Humboldt recognized the coevolution of living organisms with climate and phenomena occurring in the earth's crust. The first term for the ecosphere was biosphere and was proposed by Austrian geologist Eduard Suess in 1875.

In the twentieth century, biochemist Vladimir Vernadsky formulated a theory of the development of the Earth that is now one of the foundations of ecology (Vernadsky, 1945). Vernadsky also used the term biosphere in the same sense as Suess, a confusion that persisted for many decades and is still used by geographers. Vernadsky was one of the first scientists to recognize that oxygen, nitrogen, and carbon dioxide in Earth's atmosphere result from biological processes (Vernadsky, 1945). As early as the 1920s, he published papers arguing that living organisms could reshape the planet as safely as any physical force. He pioneered the scientific foundation of all environmental sciences. His visionary statements were not accepted at the time, just as happened decades later with Lovelock's Gaia hypothesis (Lovelock, 1972).

Since the emergence of the term biosphere at the end of the XIX century and ending with the creation of a non-holistic doctrine (by Vernadsky), the definition of this concept has undergone significant changes. It has moved from the category of a place or territory where living organisms live to the category of a system consisting of elements or components that function according to certain rules to achieve a specific goal. The way the biosphere is taken into account is judged which properties are inherent in it.

In the early twentieth century, Aldo Leopold, a pioneer in the development of modern environmental ethics and in the nature conservation movement, in his biocentric or holistic ethics relating to the earth, suggested that the Earth is alive.

The ecosphere_(known to geographers by its biosphere[5]) is the sum total of all types of ecological systems existing on Earth. The ecosphere is basically a relatively closed system with respect to matter, with inputs and outputs dependent on various cosmic factors. In terms of energy, it is an open system based on photosynthesis achieved by capturing solar energy. It can only work if it is based on a stable and versatile information system, which is the one given by the biosphere (Godeanu *et al.,* 2022).

The biosphere is thought to have evolved, starting with a process of biopoiesis (life created naturally from nonliving matter, such as simple organic compounds) or biogenesis (life created from living matter), about 3.8 billion years ago. It is obvious, then, that the term biosphere is misunderstood, a fact that has been perpetuated to this day.

There are many subsystems that make up Earth's natural environment ("planetary ecosystem" or "ecosphere"). Many of the subsystems are characterized as "spheres", which coincide with the shape of the planet. The four "spheres" recognized by geographers are the atmosphere, geosphere, hydrosphere and biosphere.

When Tansley coined the term ecosystem (in 1935), in Soviet Russia Sukatchev, Severtsov and Schmalhausen coined the term biogeocenosis. Levine has the merit of showing that biogeocenosis is more complex than the biosphere of the aforementioned authors and expressed the opinion that "the ecosphere is the sum of all biogeocenosis on our planet".

Geochemists were the first to consider the "biosphere" to be the sum of all living organisms (which equated to the "biota" of biologists and ecologists). Then came the holistic and interdisciplinary concept of biosphere, which was gradually associated with those of astronomy, geophysics, meteorology, biogeography, evolutionary biology, geology, geochemistry, ecology, thermodynamics, so with all the earth and living sciences on our planet.

Lovelock proposed the term symbiosphere to emphasize the interdependence between species and everything in them. It was only in the 1960s and 1970s the term ecosphere appeared, which is an ecological term and clearly separates the notions of biosphere from ecosphere.

Vladimir Vernadsky and his school were confronted with the great ambiguities existing in the Western scientific community regarding the concepts of biosphere and ecosphere, which were very often confused or interpreted in opposite ways. He and his school pointed out that the ecosphere arises as a collection of living organisms (eukaryotes) and their habitats, produced by the same organisms, within an already existing biosphere produced by microorganisms (prokaryotes). The biosphere and ecosphere would therefore be two interconnected "thermodynamic fields" which he himself called:

1. the "domain of the living" (or the small thermodynamic field of vital stability, the habitat of living matter), namely the biosphere, **2** the "house of the living" (or thermodynamic field of vital existence, habitat of living organisms), which would take here the mean name of ecosphere, term that did not exist in its time.

The distinction of these two thermodynamic fields during their formation would be, according to Lynn Margulis, the product of endosymbiosis. Following lectures held at the Sorbonne, Teillard de Chadin launched the concept of the noosphere, by which he understood the action of human phenomena on the biosphere. Beyond Teillard de Chardin's theosophy, the understanding of modern scientific ecology was popularized and the conception of the environment of the planet, which hosts the biosphere, developed.

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[5] According to geographers, the *biosphere is "the global ecological system that integrates all living beings and their relationships, including their interaction with the elements of the lithosphere, cryosphere, hydrosphere, and atmosphere" (Huggett, 1999).*

From the above, one can notice the multitude of confusions that ecology has gone through (and is still going through - in clarifying the terms and content of the notions of biosphere, ecosphere, noosphere and endosymbiosis, confusions that affect even today the research field of the ecosphere. Is it geographical, biological, ecological, geochemical? Or is it a combination of all of these?

According to the Ecological Society of America, *"Ecology is the study of relationships between living organisms, including humans and their physical environment, and seeks to understand links between plants and animals around them. Ecology also provides information about the benefits of ecosystems and how we can use earth's resources in ways that preserve the healthy natural environment for future generations"* (Schmitz, 2017). We agree with most aspects of this definition.

Ecology deals with the life of organisms, but only from a certain complexity upwards. It always takes into account a large number of aspects that make up the object of other sciences (Godeanu, 2013). We have made it clear that ecology is based on the functional component of living beings and on the interrelations between living and non-living matter. We believe that *"Ecology is the science of living matter in motion; It is dynamic, it highlights the complex mechanisms that unfold incessantly in nature, economy, society and human consciousness. Within ecology, the functioning of all processes is based on interactions between living and non-living elements."* (Godeanu, 1984, 2013, 2020).

Initially, ecology dealt only with relationships between individuals of the same species and the influence of different environmental agents on these organisms (a field of ecology called autecology).

Later, the study of relationships between different species living in a particular environment emerged a new field of ecology that was called synecology.

After some time, ecology approached living ensembles in their own right. This is how biocenology appeared.

The last phase is the biocenosis system that only works when they are integrated into their non-living environment. This is how the study of ecosystems appeared.

In the twentieth century, ecology and geography have shown that ecosystems can associate to form supersystems (which were called landscapes, then other, more complex ecological systems called biomes) (Vernadsky, 1986; Dediu, 2007).

When studying different natural ecological systems, researchers have noticed that there are two other types of ecological systems created by, and dependent on, humans in nature. They are half natural and half man-made; are the so-called anthropogenic ecological systems.

Nowadays the claim that man conditions (directly or not) everything that happens in the atmosphere, hydrosphere and lithosphere is increasingly accepted. Therefore, the notion of the noosphere (according to us the anthroposphere), designates the stage in which the development of all natural and artificial processes that take place on Earth and that are influenced by various human activities (sometimes positively, but usually negatively). UNESCO President Di Castri illustrated this situation perfectly in an article published in 1981 (the evolution of ecology from a biological science to an interdisciplinary one (Di Castri, 1981) (Figure 100).

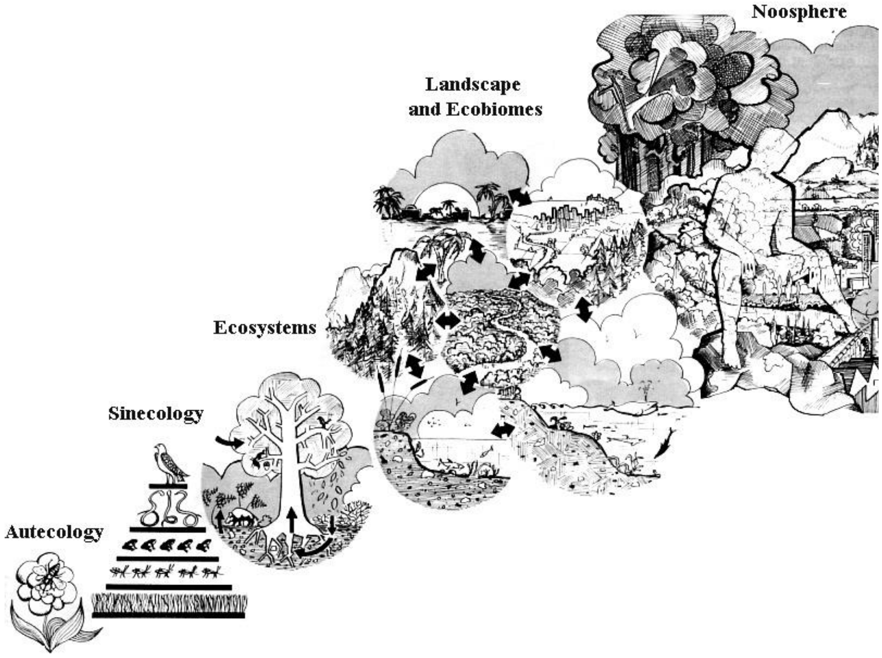

Figure 100. The stages of ecology, since its emergence to the end of thr XX-th century (Di Castri, 1981)

In 2017, Oswald Schmitz launched the concept of New Ecology (Schmitz, 2017). He describes how ecology evolved to provide a better understanding of how humans shape nature in ways never seen before. The new ecology underlines its importance in preserving species diversity. It offers a variety of options to make ecosystems more resilient to environmental change. Schmitz imagines that people assume the role of stewards who must take care to ensure that ecosystems have the capacity to provide environmental services in the future that ensure economic well-being and our very future existence. The New Ecology shows how today's ecology can offer future prospects

Nicolae Botnariuc dealt with the systems approach in biology and ecology in the second half of the twentieth century and in the first years of the XXI century (Botnariuc, 1976, 1984, 2005). Although he has always considered ecology to be a field of biology, he pointed out that there are similarities and differences in how systems theory applies to the two fields of biology and ecology. If we consider how the two sciences approach living matter, we find that in biology systemic levels begin with the individual, while in ecology they begin with the population (Godeanu, 1984; Botnariuc, 2005). Biology focuses exclusively on living beings, whereas in ecology living beings are always associated with the living and unliving environment in which they inhabit and from which they cannot be separated.

In ecology, different organisms live together and interact within a certain distinct life system. The ecological system can function only when it interacts continuously with non-living factors that can create the activity of the ecological system thus formed (that is, there is a permanent living-non-living interaction) (Botnariuc, 1976, 1984, 2005).

From an ecological point of view**, the ecosphere is** a complex of abiotic shells (those that in this work have been grouped under the name of toposphere), which are permanently interconnected with the living shell, that is, with the biosphere.

In the geographical literature, the ecosphere is *defined this way:* "*An ecosphere is a closed planetary ecological system. In this global ecosystem, the different forms of energy and matter that constitute a given planet interact continuously. The forces of the four fundamental interactions cause the different forms of matter to settle into layers identifying balls. These layers are referred to as component spheres; The type and extent of each component sphere varies significantly from one ecosphere to another. Component spheres that make up a significant part of an ecosphere are referred to as primary component spheres. Earth's ecosphere consists of four main component spheres which are the Geosphere, Hydrosphere, Biosphere and Atmosphere*." (https://en.wikipedia.org/wiki/Ecosphere (planetary).

From ecological positions we consider that the ecosphere is "the global ecological system that integrates all living beings and their relationships with the non-living environment, including their interaction with the elements of the lithosphere, geosphere, hydrosphere and atmosphere" (Godeanu, 2013).

4.1 Determinants of the emergence and evolution of the ecosphere

In the scientific world there is a paradigm: that everywhere there are three basic components: matter, energy and information.

Theoretical physics and astronomy proved that in the beginning, there was only energy in the cosmos. According to the Bing bang theory, initially it was a burst of energy that generated matter, which evolved from simple to complex.

The hydrosphere has a great significance both by proportions, by the complex role it has in the functioning of our planet, by the fact that life appeared in the planetary ocean, and by the fact that it is a great generator of atmospheric oxygen (only ocean phytoplankton emits annually into the atmosphere about 363 million tons of oxygen!).

We believe that the determining factors of the ecosphere are the interactions between the shells of the toposphere and the biosphere, the importance and role of information, energy relations, relationships related to matter and the laws that direct the processes that take place at the level of the ecosphere.

All processes in nature, of any kind, physical, chemical, geological and biologically are interconnected from each other, more or less visibly (it is the integrationist way of thinking of ecology - which, by its nature, is an interdisciplinary science).

We tried to analyze the information-energy-matter relationship in the living and non-living world, but also their connections with the environment, in order to correlate them in a more rational way, by uniting the systems theory with the theory of evolution and with the paradigms of evolution.

Information is an immaterial category that reflects the state or movement of the forms of energy or matter of which the world is composed, and therefore also the living world. Based on information, this state is preserved or modified, according to the laws according to which each form works.

If one traces how biological evolution took place, it can be seen that it took place in different ways, but which most often took place simultaneously.

At the level of the living world, several kinds of evolution can be distinguished: informational, energetic, physiological, morphological, populational, social, geographical and ecological (Godeanu *et al.,* 2022).

In an attempt to unite into a coherent whole the concepts of matter, energy and information, in explaining how living matter evolved and structured on different systemic levels, we appreciate that information appeared first and then energy. Information has always been the basis of all forms of manifestation of energy flows and how it appeared, and then the circulation of matter began. Knowledge about the evolution of the living started from strictly biological concerns, which became more complex with the ecological approach to living-nonliving relationships. The interrelationships that created ecological structures and conquered all environments to form a unitary whole were highlighted. They could only be achieved under the influence and being coordinated by information mechanisms, which, in turn, have continuously diversified. Information in the living world is much more varied and active than that in the non-living world. It has become dominant, being able to significantly influence the information processes in the abiotic environment: physical, chemical, pedological, hydrological and climatic processes.

Biological information is constantly improving, regardless of whether some characters (morphological, physiological) seem to barely change. The proof is given by the existence of a multitude of living organisms, which, although they are entities that appeared several eons ago, are still viable, live very well today. They have been maintained because they have remained indispensable for the development of processes that take place on all biological and ecological levels of matter organization (we refer to all types of prokaryotes, and among eukaryotes, to most protists and multicellular fungi).

Since the emergence of complex organic macromolecules, the processes of metabolism and growth and multiplication have started. They have correlated with physical and chemical characteristics in the primordial planetary ocean since the adaptive ecological stage of biological evolution began.

In the first stage of biological evolution (the individual one) took place the transition of biochemical mechanisms from linear processes (such as in the chemistry of organic molecules) to increasingly complex and diversified circular biochemical processes, all under the control of biological information that was constantly complex and diversifying (Soran and Borcea, 1985).

From the emergence of organic macromolecules with metabolic and reproductive capacities to the realization of the current biosphere, seven different forms of evolution can be distinguished: informational, energetic, physiological, ecological, morphological and geographical evolution (gradual occupation of the four main living environments: marine aquatic, freshwater aquatic, terrestrial and underground) (Godeanu *et al.,* 2022) (see also Ch. 4.2). Due to living organisms and the necromass produced incessantly by it, in association with materials from the superficial lithosphere that is permanently subject to climatic and hydrological factors, a new shell, the pedosphere, appeared at some point on the surface of the planet's lithosphere.

The change produced in the evolution of living systems from the individual biological stage to the ecological stage (the one in which the complex functional systems of living-non-living interrelations appeared) is emphasized.

Since life began to unfold autonomously at the individual level, we can discuss levels of organization of living matter.

Life, as probiotics organisms, then as prokaryotes and eukaryotes appeared about 3.8 billion years ago. She manifested from the beginning a special capacity for adaptation (physiological and ecological, and later morphological) under the influence of the environmental factors in which they lived and which, although so much time passed, were constantly improved. That's why they still exist today, as if they are more adaptable to environmental factors than ever. It is important to emphasize that this process was not unilateral (only at the level of living), but it takes place in correlation with the abiotic environment, in both directions (living-non-living and non-living), but always being determined predominantly by biological information.

4.1.1 Information

From our point of view, information is the priority of energy and matter, being the guiding factor of all activities that take place in nature, consciousness and technology.

In the following we will try to synthesize a small part of the ideas and opinions of those who deal with information.

Information is a category in its own right, having an abstract and subtle existence - that is, non-material - category that is https://ro.wikipedia.org/wiki/Categorie reflected by states, signals and constitutes an essential element in the process of knowledge.

This definition also needs to be complemented by two aspects:
1. In nature, information exists only in the living world (therefore implicitly in man);
2. Humanity has created artificial material information, which manifests itself in cybernetic systems.

Natural methods of knowledge are based on the biological properties of the subjects of the information process. Information exists at the time of dialectical interaction of objective data and subjective methods.

Currently, many scientists choose to define life solely on the basis of property their informational. How can we relate abstract information to the physics and chemistry of molecules?

"For life to generate order out of disorder and bypass the second law of thermodynamics, there must be a molecular entity that somehow encoded the instructions for building an organism, an entity complex enough to contain an amount of information and stable enough to withstand the effects of degradation postulated by thermodynamics. We now know that this entity is DNA" (Davies, 2021).

"The message is the materialized form of information. He has an origin, a sender and a destination. However, not everything in a message is information, only the portion that has the same meaning for both the sender and recipient. Only this can be considered information. Simply put, information is a message received and understood" (Biro, 2011).

Advances in cybernetics and nanotechnology have allowed us to make incredibly fine experiments to test fundamental problems at the intersection of physics, chemistry, biology and computer science (Davies, 2021).

What is information?

All theories, including modern genetics, focus primarily on material carriers of information. In reality, "Information is information, neither matter nor energy."

The concept of information comes from the field of human knowledge and until recently was considered to be a property specific only to man. Information now plays an extremely important physical role in the world of technology and biology. Information is invisible, but it influences the world. The power of information as a cause can have a real and huge impact (Davies, 2021).

Real information is completely independent of the material medium. It serves only to "wear" it. The material carrier cannot and is not the cause of the information (Marks, 2013).

Thanks to the study and development of cybernetics, the development of computer science, computers, robotics, and now artificial intelligence, information can only now be studied and understood. Davies proposes to adopt a view of biology according to which the foundations of life are akin to cybernetic systems, in the sense that life as we know it should be considered a phenomenon similar to the storage and management of information.

Nature discovered how to process digital information billions of years before humans invented the computer. Mankind has known about it for less than a century.

Information is a specific property of living matter.

Using accessible language, in his book "*Information Networks and the Mystery of Life"* Davies (2021) lays out different interdisciplinary theories to be able to make us understand the place she and man have in the universe.

The view of information as a message became prominent with the publications of Ralph Hartley in 1928 and Claude Sahnnon in 1948.These works laid the foundations of information theory and endowed the word "information" not only with a technical meaning, but also with a unit of measurement.

Shannon's information entropy (H) is often confused with physical entropy (S) because both concepts have very similar mathematical formulation. However, they have very different meanings. Thermodynamic entropy characterizes a statistical set of molecular states, while the entropy seen by Shannon characterizes a statistical set of messages. In thermodynamic terms, entropy refers to all the ways molecules or particles could be arranged, and increased entropy means that less physical labor can be extracted from the system. In Shannon's view, entropy refers to the fact that all message paths could be transmitted through an information source, and higher entropy means that messages are more likely (Laszlo, 2008).

Is there a precise definition of information?

Unlike mass and energy in physics, there is NO single model or definition of information. Information has its definition outside of the matter and energy on which it resides and, in addition, constrains matter and energy to operate in a thermodynamic environment away from equilibrium. McIntosh (Marks II *et al.,* 2013) It outlined the principles of informational interaction with energy and matter in biological systems. In different fields of knowledge, information is viewed and understood in different senses. which are usually related to the interests of the respective field. Each chooses exactly the formula the area which most accurately describes the application of information in its field of knowledge. None of the existing definitions for information is universally accepted, which causes confusion and ambiguity. Present day More than 400 definitions are known that works on different fields of knowledge.

For engineers, biologists, geneticists, and psychologists, the concept of "information" is identifiable with those signals, pulses, codes that are observed in technical and biological systems. The information must always be related to some system specific to the respective field, such as DNA the latter, Spoken language, Computers etc. Norbert Wiener, the father of cybernetics, said that "Information is information, neither matter nor energy" (Davies 2021). Gitt, Compton and Fernandez (Marks II et al., 2013) define universal information as; "A symbolically coded message, abstractly represented, that conveys the expected action and the intended purpose."

In 1990, the biologist and physicist Tom Stonier, supported the idea that information is "an expression of the organization of energy and matter in the evolution of the universe. There is an exponential growth of the information spiral. A few years later, he claimed that: "described any physical system encompasses not only parameters defining the amount of matter and energy, but also the amount of information, and any change in a system must take into account not only changes in energy or mass, but also changes in the information contained in the system", "So, if information is an intrinsic component of all physical systems, then all laws of physics must be reevaluated" (Stonier, 1997).

Some believe that anything that can reduce the degree of uncertainty, whether facts, assessments, predictions, connections or generalized rumors must be considered information.

Others believe that:

- information is a reflection of the real world that is expressed in the form of signals, signs;
- information is any set of signals, information (data), which any system perceives from the environment (input information), problems originating from the environment (output information) or which are stored inside a particular system (internal information);
- information exists in the form of sound signals and light, energy and nerve impulses;
- information is data about objects and phenomena of the surrounding world, which are perceived by any kind of living organisms - but conscious only of man - and which aim to rise that level of awareness;
- information is a generic term related to any signals, sounds, signs, etc., which can be transmitted, accepted, recorded and/or stored;
- information can also be considered that part of space that reflects a certain part of the real world and gives us a set of knowledge about real and abstract objects and concepts, their connections and signs);
- information is subjective, it exists only to the extent that it is understood by a person.

What for one person may be information, for another may mean just a certain amount of data without any meaning. Also, the same amount of data can acquire different meanings depending on the receiver (Marks II, 2013; Gleick, 2011).

The information can be divided according to the method of perception according to the type of sensory receptors that exist: visual, tactile, olfactory, vibrating, thermal, etc.

Information has its own properties. These are suitability, objectivity, availability, accuracy, reliability and relevance.

Shannon said that when we get information, we learn something we didn't know before (therefore we have less uncertainty). Shannon proposed that the "bit" become the unit of measurement of information. He also noted that his mathematical formula for quantizing information in bits is, except for the minus sign, similar to the formula physicists use for entropy, suggesting that information is, to some extent, the opposite of entropy. This connections is not surprising if we equate entropy with ignorance.

SO "information refers to what we know, and entropy to what we don't know. Information means reducing ignorance or uncertainty about the system being measured" (Davies, 2021).

Both information theory and thermodynamics share the concept of entropy referring to disorder and maximum uncertainty. Recognizing that life does not conform to the demand of thermodynamics for ever-increasing disorder, Erwin Schrödinger invented null terms of negentropy (negative entropy) to apply to life.

Landauer was interested in the fundamental physical limits of information used in the computer industry. Discovering the connection between logical operations and heat generation by computers, he discovered a deep connection between physics and information. Starting from Landauer, information was no longer a vague, mystical quantity, but became strongly anchored in the material world, because he appreciated that the volume of information could be correlated with the volume of entropy. So, information has properties in common with energy: it can be measured. Also, energy, like information, can pass from one system to another; so it can be preserved (Davies, 2021). Energy and matter serve only as transcription media for information. Information can also control the structure of matter and energy phenomena.

Relative to matter or energy, the information has the following characteristics (Stonier, 1990):

- It does not know the idea of the original, it can be copied whenever desired and is independent of the place;
- The information does not become obsolete and can be combined almost unlimitedly;
- The information is highly condensable;

- Information is perceived as a certain measure of order because it annihilates uncertainty and indeterminacy. One measure of ordering is negative entropy, a term that arose by analogy with entropy, which is, in thermodynamics, a mathematically expressible measure of disorder;
- -The quality of information consists of the degree of probability with which it creates the user's certainty of a statement;
- -Information is transmitted using messages.

Information and knowledge are of great importance for the evolution and development of all processes in the living world – currently for the development of all activities at the level of living organisms – (and implicitly for humans, both for the development of human personality and society). Neither society nor its individuals can progress satisfactorily if they do not use a wealth of information. Through information, the transfer of knowledge from one generation to another is ensured, access to the most advanced achievements of mankind is ensured.

Knowledge often occurs spontaneously when available information reaches a critical mass. A very important and distinctive feature of information is that it comprises data that makes sense to the sender and recipient. The information is the data, especially organized ones that have meaning, have value for their producer and are necessary salt for the receiving factor. The value attributed by data provides means and forms of knowledge and experience, shortening uncertainty and accidents and ignorance.

Information is not a static object – it changes dynamically and exists only as data and methods interact. The information exists only at the time of its information process.

Nature also discovered digital information processing billions of years before humans invented the computer. But mankind has known about it for less than a century.

What is biological information

Biological information has been written and is always being written. We present below, in the form of quotes, some of these opinions.

"We all know that Earth, unlike the other planets in our solar system, has been shaped in large part by life that has existed on it for over 3.8 billion years. Life diversifies and adapts, ceaselessly occupying new niches, and inventing ingenious survival mechanisms, the most important of which is information management" (Davies, 2021).

The expansion of our knowledge must be done by including in the sphere of study as many forms of manifestation of living matter as possible, forms that until now were either neglected or treated superficially, but most often were quasi-unknown. Regarding the reception, processing and capitalization of the more important information that the environment offered to organisms, it consisted in gathering as many details as possible of the informational connections of living systems with the abiotic mineral environment, while the informational links existing within living systems were very limited and most often superficial (Șerban, 1986).

In a way, all biology is quantum. Quantum effects are a subtle and delicate form of atomic and molecular order. The enemy of all quantum effects is disorder. Or, life is full of disorder. Life differs from any other phenomenon by its ability to store and process information in an organized and anti-entropic manner. Life involves both rich information and complex chemistry.

"The thing that separates life from non-life is information. Organisms reproduce. Through this process they transmit to their descendants primarily information about themselves as form and activity, that is, about information about previous generations and how they passed on to the next. The essence of biological reproduction is the replication of information that can be inherited. Schrödinger's great merit was that he placed the storage, processing and transmission of information at the molecular level, at the nanoscale, inside living cells. Quantum mechanics helped explain the stability of information storage. Today the information base of life has permeated every field of science" (Davies, 2021).

"The life story is made up of two intertwining narrative threads. One is complex chemistry, a rich and elaborate network of reactions, and the other is information, not only that passively stored in genes, but also that which flows through organisms and travels through biological matter to maintain a certain order. Thus, life is a mixture of two dynamic patterns: chemical and informational. These patterns are not independent, but coupled, forming a single system of cooperation and coordination. Information controls and organizes chemical activity in the same way that a program controls a computer's processes. Therefore, buried deep in the field of complex chemistry, there is a network of logical operations. Biological information is the software of life" *(*Davies, 2021).

"Biologists still disagree on the most appropriate terms to define biological information. Unfortunately, multiple definitions of the same terms and other disagreements have long inhibited the development of a general framework for integrating different categories of biological information" (Danchin and Wagner, 2010).

Mihai Șerban (1986) states: "It should be emphasized that, above all, each organism represents a complex information unit**.** The study of organisms from an informational point of view is, from a historical perspective, the latest addition to the arsenal of problems of biology. Any living system can be viewed under three distinct aspects: material, energetic and informational. In every organism there is an immanent information, even from its first moments of existence.

"The term 'biological information' is currently defined rather ambiguously, because there seem to be several levels of communication systems to investigate: from information encoded in the DNA of the genome (which is best studied) to intracellular information (based on communication networks involving RNA and proteins). to intercellular signaling (through entities such as hormones and going all the way to the nervous system and brain). If we can identify and study more deeply all these communication systems and define more precisely all the forms of information that are transferred, we will have much to gain. It is clear that there are many categories of biological information, and they will certainly still be discovered" (Marks, 2013).

The science of biological information is very young. DNA was discovered in 1953 (Wilkins, Crick and Watson), the genetic code in 1961 (Nirenberg and Matthaei), protein sequencing in 1951 (Sanger), nucleic acid in 1977 (Sanger); the first sequence database was published in 1965 (Dayhoff); and sequencing of the human genome was completed in 2003 (led by Collins and Venter). Bioinformatics (a new interdisciplinary scientific field) emerged in 1981 when Smith & Waterman described their fundamental equation for sequence similarity searches. This field has only become fruitful in the last 50 years.

It is appreciated that in the twenty-first century, biological information has become the general problem that unifies the life sciences. Recall that in the nineteenth century, in the time of Darwin and his colleagues, there was no notion of biological information (Sanford, 2013).

The conventional or "old" on biological information is determined by the fact that biological information manifests itself through purely chemical processes. The origin, structure, and dynamics of biological information boiled down to a combination of stochastic chemistry and undirected evolutionary forces.

In 2011 Marks II initiated and organized at Cornell University in the U.S. a conference entitled "Biological Information. New perspectives", which gathered the best specialists in the field of biological information. The list of participants included experts in information theory, computer science, numerical simulation, thermodynamics, theory of evolution, whole organism biology, developmental biology, molecular biology, genetics, physics, biophysics, mathematics and linguistics. Two years later, the papers and a summary of the papers by sections were published (Marks II et al., 2013). The volume represents a turning point in bioinformation research. All participants in this congress questioned the conventional view of the origin and evolution of biological information. Many theoretical biologists now believe that new theoretical approaches are needed to understand the hierarchically integrated information networks underlying morphogenesis.

If we define information more broadly as "all that is communication", the amount of information in a living cell is much greater than that accumulated in its DNA sequences.

Davies states that "living organisms behave like real computers!"

"Living organisms have strange powers, such as the ability to move autonomously, manage their environment and reproduce. And everything is controlled by the information that exists in their body. Although it is contained in matter, biological information is not inherent in it. Living organisms possess multiple tiny mechanisms that manipulate information in intelligent and highly efficient ways, producing order out of chaos and thus avoiding the limitations of the second law of thermodynamics. The extraordinary thermodynamic efficiency of life must be emphasized. Evolution has refined the mechanisms of life to the point where they operate extremely efficiently, otherwise they would have died in their own waste heat (entropy caused by the process of copying information from DNA molecules)".(Davies, 2021).

In the functioning of cells there are several complex networks. They are metabolic networks, which control cell energy, signal transduction networks, which involve protein-protein interactions, and neural networks (in animals). They are not independent of each other, but couple together to create a set of networks in which information flows intertwine. The existence of such a large number of chemical regulatory pathways allows cells to respond to external changes with a very high degree of fidelity. (Davies, 2021).

Regardless of the form of multiplication of living organisms, we can speak of a continuous accumulation of information. From this point of view, throughout the living world there is a remarkable unity – the concentration of information, its transmission and use take place in the space of infinitesimal quantities of substance and energy (Șerban, 1986).

All components of the cell, including all RNA molecules and proteins communicate continuously with each other. It is now recognized that there are hundreds of thousands of different types of interactions, and most of them involve communication in one way or another. In this sense, the amazing communication network inside a cell can be compared to the Internet.

Biological information is usually seen as being transmitted by genes, in which information is stored. Non-genetic information can also be inherited across generations (Champagne, 2008; Danchin and Wagner, 2010) and can be transferred through a diversity of vehicles Jablonka *et al.,* 1998, Danchin *et al.,* 2004; Wood & Oakey 2006; Jaffee & Price, 2007; Miller & Sweatt, 2007; Wilkinson *et al.,* 2007; Champa *et al.,* 2007, 2008; Hager *et al.,* 2008; Mesoudi, 2008 all in Wagner and Danchin, 2010).

A fact becomes information only after an organism detects it, and they are valuable only insofar as it predicts the future state of the environment. It is this predictive power that allows organisms to make adaptive decisions. These processes can generate complex dynamics which, in turn, can affect the evolution of information use (Wagner and Danchin, 2010).

Schrödinger argued that a defining quality of life is that it manages to overcome the tendency of the second law of thermodynamics (that it is anti-entropic). According to Schrödinger, living organisms manage to defy entropy by accumulating information and orienting it towards certain goals (Davies, 2021).

The explosion in the amount of biological information we now recognize makes us concludes that biological information is profoundly multidimensional and moves in all directions through elaborate communication networks. The many types of information are not only dynamic, they are integrated globally.

Types of biological information

Two general categories are currently recognized: genetic information, which is encoded in DNA, and non-genetic information (Danchin and Wagner2010).

Many authors have applied different meanings to different types of non-genetic information, precisely because of the confusion produced by the use of terms that are not explicitly related to the meanings of the terms used.

Danchin and Wagner carried out a systematization of various types of biological information. They are represented hierarchically, from general to specific, and follow from each other:

Biological information: they can be of two kinds: potential and expressed. Both can affect the phenotype. Biological information can be acquired passively from genes or through epigenetic processes (as influences given by parents during the growth of offspring), or as a result of one's own experiences accumulated throughout their lives (Danchin and Wagner 2010):

Biological information may also be:

1. Genetic information: information encoded in DNA sequences as a synthesis and also a consequence of information collected and stored by individuals of that species during the thousands of generations preceding it.
2. Non-genetic information: information is not encoded in DNA sequences. In turn, they can be acquired passively or actively. In turn, these can be:
   A. Passively acquired non-genetic information: information acquired through different processes such as epigenetics, parental effects and habitat inheritance;

B. Non-social information: information that is not extracted from interactions with, or observation of, other organisms. All this is information extracted from the abiotic environment;
C. Social information: information extracted from interactions or observations related to the other components of the bocenosis of which they are part. The following kinds of social information are distinguished:
   - Genetically determined social information- extracted from genetically determined phenotypic traits of other organisms.
   - Unwanted social information - facts that are unintentionally produced by organisms and detected by other organisms.
   - Involuntary social information - can be extracted from facts that reveal the quality of resources either directly or indirectly.

The information can also be divided into:

1. Information consciously retrieved: they are synonymous with a signal (which is a trait or behavior produced by selection to intentionally transmit information, whose adaptive function is to modify the behavior of the receivers for the benefit of the sender).
2. Personal Information (or "Personal Knowledge"): the sum of information unintentionally obtained by one's own individual.

Properties specific to biological information

Here are the properties of biological information **(**Biro, 2011):

1. Signals used in communication technology are always analogue or digital modifications (normally they are electromagnetic waves in space or electrons/photons in cables). Biological signals are always 3D molecules transferred in a wet medium (biological communication is "wet communication", as opposed to technical communication, which is usually referred to as "dry communication").
2. There are two very important categories of biological signals. The first is the sequences. Nucleic acids first category. They are composed of 4 variables (bases), and the second category is proteins, which are built from 20 variables (amino acids). These sequences are represented by binary units to estimate their signal density and compress these binary signals (Shannon). Biological sequences fold and often have more than one 3D configuration. These allosteric configurations have the same primary sequence and the same calculated signal density (or information content).
3. The receiver (receiver of signals) is an essential component for information processing. The receptor is always a protein structure that forms a kind of mirror image of the molecule involved in communicating a biological signal (being a ligand). The receptor and ligand interact with each other in a unique and very specific way (e.g. insulin binds only to insulin receptors, not to other molecules).
4. The receptor has a high affinity for its specific ligand. The concentration of the ligand increases around its specific receptor.
5. Another peculiar biological phenomenon is the plasticity of the receptor (recipient). Sign them are often able to alter their specific receptors. Repetition of biological signals improves signal reception. This is one of the biological foundations of learning (any kind of learning, at any stage of biological evolution). Biological learning does not require awareness or knowledge. A special type of biological learning is the maturation of the immune system. Newborns have an insufficient immune response. However, they are exposed to a biological environment from which their immune system must quickly "learn" how to react to millions of biological signals coming from the environment. The immune response is carried out within a few weeks after receiving the biological signal (in this case -called antigen) for the first time. The second time an antigen is encountered, the immune response will appear within a few hours because the body has developed specific receptors (antibodies) to that antigen. So, the induction of antibodies by antigens suggests that a biological signal is capable of creating its own receptor to which it transfers its message in the form of information.
6. In biology there is always signal redundancy (because all the genetic information of the species is present in every cell of that organism).
7. The concepts of 'signal' and 'noise' differ widely in terms of information in biological and physical systems. A signal for one species can only be a noise for another.
8. The security of information transfer is a vital issue in living systems. Redundancy is one way to achieve this on the "feedback" system. The signals continue to flow from the sender to the

receiver until they are recognized by the target cells, which sends back a recognition signal to confirm signal reception. It's a wonderful regulatory mechanism, mostly endocrinologically based.

The place of information in systems theory

If we extend further the analogy between biological and computer information, we can consider the genome - as stored information (the "hard disk" of the cell), while RNA, proteins and other structures can be considered "active information" (the cell's RAM). While many of the papers presented at the 2011 Cornell symposium deal with information within the genome, it is important to remember that most biological information in the cell exceeds that existing in the genome (Marks II, 2013). Information does not only take place within a cell, but also between cells and between different organisms. At a higher level, there is human biological information (still poorly understood, which consists of our own intelligence and human consciousness). They are all biologists' information that! There are an unknown number of symbolic languages (genetic code being just one of many biological codes) underlying this amazing labyrinth communication that integrates all levels of biological information. (Marks II, 2013)

Ax and Gauger (Behe, 2013 and Marks II, 2013) consider that life consists of many layers of information, from molecular to cellular, then to organism and ecosystem. If so, this means that von Bertalanffy's systems theory also finds application in how biological information applies to the different levels of organization of living matter (see chap. Biosphere).

The information accumulated in any cell, both in prokaryotes and eukaryotes, is subordinate to the higher level (in the case of eukaryotes there is a specialization of information according to the degree of specialization of each organ or tissue in that individual).

At the level of the individual, the information forms a unitary whole, which allows the optimal functioning of all his subunits throughout his life. At death, integrative information at the individual level disappears. As a result, the whole organism, being deprived of this integrative information, enters a chaotic process of disaggregation (called "death") when the cells - now lacking the information of the higher level of organization - act the microorganisms with which it was throughout its life in various forms of symbiosis, or collaboration/cooperation (e.g., gut-bacteria interaction breaking down the intestinal chyle). It can be said - figuratively - that the disappearance of individual information can be equated with the departure of the "soul" from that individual.

The higher levels to which the information is subordinated are, in ascending order, the cell, organ (or tissue), the individual, the population, the species, the biocenosis and the biosphere.

We need to better understand the full scope of what "biological information" really is. It is a serious error to think of biological information as simply located in the genome, because we can now best understand the genome as a kind of hard disk of the cell, as it largely reflects only the information stored for the purpose of maintaining the information that it respects to be useful to future generations. In this light, we should see that RAM or the active memory of the cell is that galaxy of RNA and proteins that comprises the communal network which active from inside the cell (Sanford, 2013).

Characteristics of biological information

The organization of life needs a "rule and control" system. If information is a non-material and non-energetic property of living matter, in order to manifest, it needs a material support. It is represented by a series of proteins from the mass of the body of living organisms. If there are several kinds of information, it is normal to have more types of proteins capable of retrieving different types of information.

Life involves a pact between two different classes of protein molecules: nucleic acids and proteins. Their duties are: nucleic acids store details about the "plan of life", and proteins make it possible for the body to function. Both elements are constantly needed. For this, not only organized and complex chemistry creates all patterns must be taken into account, but also informed chemistry, i.e., chemistry plus information (Davies, 2021).

Regardless of the form of multiplication, one can speak of a continuous accumulation of information. From this point of view, throughout the living world there is a remarkable unity – the concentration of information, its transmission and use take place in the different forms that substance and energy take (Șerban, 1986).

Cells normally respond to very short molecular messages in very specific ways. This specificity and discrimination between signals develop during cellular difference. Each cell in an organism contains the entire genetic set of information with the characteristics of that species from the beginning of its life, and has the potential to perform a wide range of functions (it is therefore pluripotent).

Genetic information means information encoded in the genetic material with which any living organism is endowed https://ro.wikipedia.org/wiki/Organism . The totality of genetic information in an organism is called a *genotype*. Genetic information is stored in the complex macromolecular structure of deoxyribonucleic acid (DNA) (https://ro.wikipedia.org/wiki/ADN Figure 101), which is present both in the nucleus of each cell (nuclear DNA) and outside it (extranuclear DNA). The entire amount of genetic material in an organism is called a *genome*. There is a nuclear genome and a cellular genome. The nuclear genome is represented by one (in prokaryotes) or more (in eukaryotes) bi-stranded DNA macromolecules (*chromosomes).* Their number is a characteristic of the species, being the same for all individuals of that species. But it is also for all somatic cells of each organism of that species.

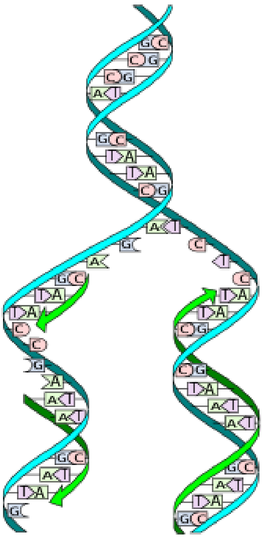

Figure 101. DNA spiral. Up, double helix, Down the two unfolded spirals (https://www.slideserve.com/imelda/acizi-nucleici)

The information needed to build and function an organism lies largely in the system's ability to turn genes on or off and modify proteins by translating genetic instructions. Life has created incredibly intelligent and effective ways to read the resulting DNA and correct deviations.

The cell as a whole is a vast and complex network of information management. On its own, the information in the gene is static. But once read, it triggers a wide variety of activities. The information in DNA is combined with other information flows that follow different complex pathways within the cell and cooperate with lots of other information flows to produce a coherent collective order. As a result, the cell integrates all this information and moves forward as a single unit through a cycle with different identifiable steps culminating in cell division. (Davies, 2021).

DNA and RNA are carriers of information that is stored and passed hereditarily from generation to generation, i.e., genetic information. The carriers of adaptive information and cosmic information are unknown - and, unfortunately, there have not yet been attempts to track down the material carriers of this information.

Between our intracellular DNA/RNA systems and our ability to express thought. There are many highly integrated levels, organized into systems that themselves necessarily operate under the control of certain types of biological information. At each of these levels there are many structural components and biological machines that perform the required actions. Essentially, all of these structures and machines are composed of proteins synthesized by the DNA/RNA protein synthesis system.

The genetic code is universal, being the same for all living organisms. The latter ask which countries have highlighted some exceptions to the universality of the genetic code. The absence of a mechanism that can reverse the direction of this process from proteins to DNA underlies the fact that the experience an organism gains during its own life cannot be inherited.

For decades it was believed that there was only one genetic code and that only the sequences that code for proteins in the genome are functional (and that make up less than 2% of the human genome). This concept has been reversed in the last ten years. It is now clear that most non-protein-coding genomes are functional. This means, first, that there is much more information in the genome that needs to be explained, and second, it means that there are many codes other than the amino acid code (Sanford, 2013).

In addition to the base protein code, there are other codes associated with the conventional gene concept. They include Trifanov's 12 codes, transcription codes, alternative splicing codes, and RNA folding/code processing. At a completely different level, there are genome-wide codes that transcend the concept of a gene. These include isocore codes, nucleosome positioning codes, 3-D topological codes, and epigenetic codes. Even the tiny but super-abundant Alu elements in the human genome, the most famous class of "junk DNA," are now known to contain several codes as well (these include transcription regulation code, protein binding code, and also a special "pyknon" code - small RNA). It is obvious that other codes are waiting to be discovered. Seaman revealed very interesting new evidence for repeat-based codes in the genome (cit. Marks II, 2013).

During an organism's life, its genes are turned on and off as needed. Changes made to proteins after their production are important regulatory elements within the system by which the cell manages information.

When genes are replicated, the information is first copied and then checked for errors; if necessary, errors are corrected. Even cells gather information about their environment, and beyond individual organisms, lie social structures and ecosystems. Science has shown that the relationship between information and energy has been used by living organisms for billions of years. It turns out that living cells contain a lot of highly efficient and well-calibrated nano mechanisms, mostly made of proteins (Davies, 2021).

However, sometimes mistakes occur in the process of copying DNA. Cells do have a mechanism that checks and corrects these mistakes, but sometimes a mistake goes uncorrected, resulting in a genetic mutation – and these subsequently influence natural selection itself (Biro, 2011).

The endocrine system is now thought to be a well-understood signaling network in organisms with developed circulation, hormonal messages are carried by the circulatory system. There is a local communication network between cells located very close to each other and which performs so-called autocrine and paracrine regulation, respectively.

Information evolution

Information has worked relentlessly, from the appearance of the first macromolecules that could exchange substances and energy to the way life exists today.

If at first the information made an order in which the other modalities of evolution unfolded, gradually it functioned in such a way that it formed some patterns that were constantly perfected.

Information evolution had decisive roles in key moments in the development of the living world – the emergence of prokaryotes, photosynthesis, the emergence of nucleus and cell division, the transition from prokaryotes to eukaryotes, the emergence of multicellular organisms, the emergence of specialized organs and organ systems to eukaryotes, the transition from the ocean environment to freshwater, terrestrial and underground environments, and culminated in taking control over non-living matter.

The most important fact was the introduction into the living world of the ability to transmit the main processes that became laws of life: a) its perpetuation/continuity, b) perfecting of basic functions, c) adaptation to the environment and d) management of all processes at planetary level.

Information has played an important role since it began to be transmitted condensate at the species level, by genetics. It is therefore interesting how in living organisms' information has found its own ways of organizing, which biology has brought together into a separate science, genetics.

Depending on current knowledge, information is of several kinds:
- adaptive (functional at the level of life of a single individual),
- stabilizing (non-hereditary and hereditary), and
- those of a social character (manifesting themselves in species that have reached a way of social life).

It seems that there are other forms of information in the living world, but they are still too little taken into account (or even denied by the scientific world, although they have been known for a long time). In this last category (which was discovered in humans, but which was later found to manifest itself in all types of living things) falls into the so-called Subtle information, in which the aura of bodies, the Kirlian effect, premonition or extrasensory communication may be included.

Living organisms can only exist under conditions of information much more complex than linear ones, as they are known in physics, chemistry and other natural sciences (and therefore biological information over time has subordinated them).

With the incessant interactions caused by relationships with other living organisms and with the relentless fluctuation of environmental factors, living things had to cope, through their own active learning systems (so Adaptive information) and information stored in the memory of the species (i.e. Hereditary information). This is best evidenced by the very high mortality of young individuals of eukaryotes (who are deprived of experience of survival details specific to each individual and then to each population) and subsequently by the decrease in this mortality with age, precisely as a result of acquiring greater individual experience.

Hereditary information is that information that has passed, as a result of its very frequent repetition at the individual and then population level to its storage in the memory of the species, therefore in genetic memory, in cellular DNA and RNA (especially in reproductive cells).

Along with this information appearing on our planet, living things receive from the cosmos, various other forms of information, which are grouped under the generic name of Cosmic/Akashic information (Laszlo, 2008). It exists permanently, changes continuously, acts on the physical body, on chemical reactions (but also under the action of various life forms that can exist in other solar systems in our galaxy or in other galaxies and that we can currently consider to exist only from a theoretical point of view).

As individuals grouped into populations, whose interrelationships took different forms in different types of organisms, information diversified and began to evolve in different ways. This is most evident with the advent of social relations.

Over time, gradually, so-called "subtle information" (mentioned earlier) appeared and manifests itself through a wide variety of forms. About it we do not have conclusive data, although we are forced to believe that it exists.

In Figure 102 we present the forms of manifestation of information - from when life appeared on our planet to the present day.

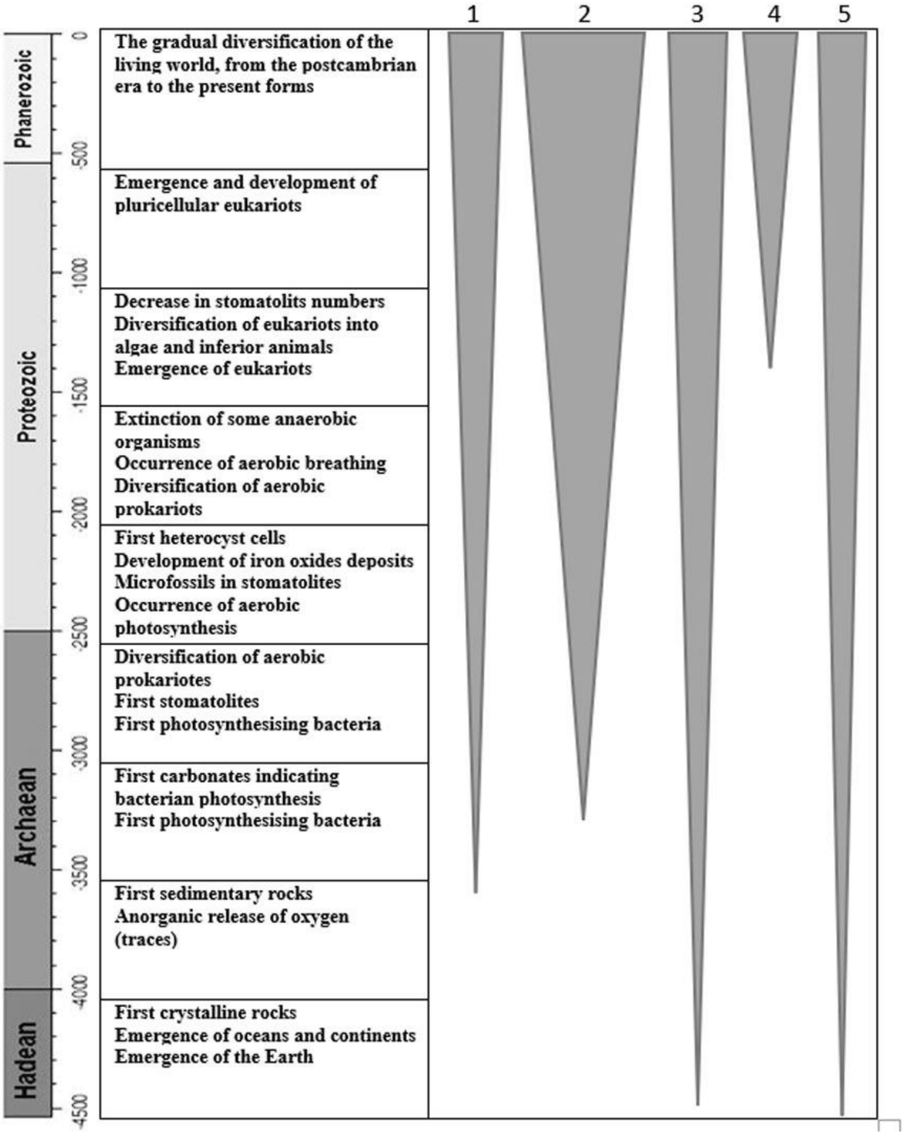

Figure 102.The evolution of different forms of information during the development and diversification of living on our planet. 1- individual adaptive information, 2- information stored at species level (genetics), 3- cosmic information, 4- social information, 5 - other forms of information (subtle information) (Godeanu and Popa, 2022)

How information became complex in humans

How many genes are in the human genome? The textbooks further suggest that there are over 20,000 genes in humans. We now know that what we used to call a gene was an excessive simplification, because it is actually a complex of many functional elements that encode more proteins and more RNA. If we define each of these functional elements as a gene, there must be hundreds of thousands of genes.

Our awareness of biological information, right inside the genome, is really exploding (Sanford, 2013).

The transition from living matter to man-made machines

"Nature discovered digital information processing billions of years before humans invented the computer" (Davies, 2021).

When DNA was discovered, it finally became clear that genetic information closely resembles written human information, resembling a wide range of codified text strings in a particular language.

Returning to biological information, it was clearly implemented during the last genetic manipulation, about 8500 years ago, by the Nephilim. If we follow human knowledge, from the second genetic manipulation, the evolution of philosophy, culture, social life, their interpersonal relationships and the emergence of language, it can be seen that from then until the last two centuries there were no significant changes (except for the period of the Middle Ages, when there was an obvious regress of human interrelations in all fields). If you analyze the literature of antiquity carefully, even in terms of consciousness, we still haven't evolved significantly compared to the people of ancient Greece!

In the last 300 years, extraordinary changes have occurred in one field: that of science, with its applicative corollary - of technology. In these areas, there is a permanent, upward trend. It was as if a ferment worked that caused an almost explosive, amazing evolution, which even now shows no sign of decreasing in intensity. What is very important for mankind is that in the field of natural sciences the accumulation of new, more and more precise sciences occurred especially in physics, chemistry and biology (the applications of these fields determining a technological leap, which culminated in the activity of conquering the cosmos).

We want to point out that, although this is not recognized, the conquests in the sciences mentioned only recognize the fact that science is "discovering America", in the sense that the extraordinary evil conquests of science only put us in front of the fact that what we are discovering now, has been realized and applied by nature for thousands and millions of years. Unfortunately, we turn out to be like the "sorcerer's apprentice" who, as he took his first steps, quickly jumps stages and risks making mistakes that can have huge negative implications. We will talk about these in chapter 4.3. Anthroposphere.

In the last hundred years, humanity has made several leaps that are of particular interest to us now: it is the case of research that has led to the emergence of new directions in science, such as cybernetics, informatics and artificial intelligence (with their technical corollary: computers, genetic manipulations, widespread use of nanomaterials).

If we carefully analyze the acquired knowledge and compare it with what nature has long done, we find that it is far ahead of us (for example, the biologic information that it works formidably, on multiple levels, almost without loss of energy, so it has anti-entropic properties, a situation that science has not yet managed to achieve). That is why we believe that by observing nature with our minds now, we can find ready-made solutions faster and more efficiently (or better optimized) than if we "discovered" them ourselves through long and repeated attempts, and which we can more quickly and efficiently translate into scientific and technical knowledge.

The Relationship of Biological Information to Cosmic (Universal) Information

Scientific discoveries, especially in the last six decades, have left no doubt that "information" plays a central role in biology (Gitt *et al.,* 2013).

Computer scientists have concluded that there is information superior to all kinds of information discovered by man. It is the so-called Universal Information (others call it Universal Consciousness).

If we examine the systems in which proteins entering DNA and RNA are synthesized, and taking into account the existence and proper functioning of Universal Information (UI), we can conclude that Universal Information is indeed present and that it is essential for all biological processes (Gitt *et al.,* 2013).

Gitt *et al.,* (2013) distinguish the following: Universal Information transmitters, transmitters and receivers:

1. An original sender is an intelligent agent that creates the original UI message;
2. Intermediate streamers receive a UI message and simply copy, transmit, display, or broadcast the message;
3. Receivers obtain and process messages and perform the ordered action;
4. Smart receivers have the ability to determine the meaning of the message.

Biro sums up the data about universal information this way: "It is not just an interesting theoretical concept; it really exists. Universal information is not only a basic component of nature and human languages and communication; it is a system of vital function and control found in all biological life on earth" (Biro, 2011).

4.1.2 Energy

Energy is a concept used to understand and describe physical and chemical processes. It is currently considered that Universe that surrounds us exists in two forms: substance (substance) and force field. Matter is characterized by two fundamental sizes: Your: *massage* and *Energy*. The most general definition, it presents energy as *measure of the motion of matter*. This formulation, although correct, presents the drawback of a less explicit expression, given the great diversity of forms of motion of matter.

Classical energy defines the quality of changes and processes that take place in the universe, starting with space travel and ending with thinking. The unity and connection of the forms of motion of matter, their capacity for mutual transformation allowed to measure different forms of matter by a common measure: energy. Energy is one of the most important physical concepts discovered by man. A correct understanding of energy is a prerequisite for analyzing energy systems and processes. Formally, energy defined in classical physics, mechanics, and thermodynamics, is the state of any physical system performing work between two different positions of that physical system in space.

Energy is a *status function*. When a physical system undergoes a transformation from its state to its reference state, changes remain in nature regarding its relative position and the properties of physical systems outside it, that is, it can have: change Position, Speed, change of status Thermal, or change of status Electric, Magnetic both his own and those of the systems outside him. The effects on external systems are called shale actions in the course of transformation.
The sum of the mechanical work equivalents of all the external actions that occur when a physical system undergoes a transformation from a given state to a reference state is called the total energy of the physical system in the given state relative to the reference state and reflects the capacity of the system to produce mechanical work.

The two laws of thermodynamics are:

1. Energy conservation exists when heat is included as a form of energy. It is part of matter, with its two forms of existence, substance and force field. The first law, conservation (conservation of mass), was formulated by Antoine Lavoisier.
2. There is a universal tendency towards degeneration and disorder (entropy). The second law of thermodynamics holds true in all physical systems, even in the entire cosmos. Entropy is the unit of measurement of disorder in a multicomponent system (Eddington wrote that "the law according to which entropy always increases, occupies the supreme position among the laws of nature."). When heat is generated, entropy increases (because entropy always wins).

Like the rest of the physical world, living things are subject to the second law of thermodynamics: entropy—disorder—can either remain constant or increase, but it can never decrease. In relation to this fundamental principle, life itself constitutes an apparent paradox: a process of *negentropy* manifests itself in them. How, then, can living beings build, grow, and maintain their organization—thus create and maintain order—without a decrease in entropy? This question has been studied since 1944 by physicist and Nobel Prize winner Erwin Schrödinger, who introduced the concept of negentropy.

According to this principle, living beings function as open dissipative systems. So:
1. they are permanently dependent on a flow of energy coming from outside the system;
2. this energy is used to construct ordered structures, which effectively corresponds to a decrease in internal entropy
3. They release heat into their environment, which induces an increase in external entropy.

In the balance of global entropy, if we consider both living beings and their environment, entropy always increases, and the laws of thermodynamics are obeyed. Since life depends on permanent exchanges of energy, any ecological system needs an energy source and organisms capable of capturing this energy and integrating it through autotrophic organisms into the food web. The terrestrial biosphere depends primarily on solar energy, thanks to organisms capable of photosynthesis (plants, phytoplankton, algae, etc.).

To a lesser extent, other forms of energy can be integrated as a complement, e.g., geothermal energy for thermophilic bacteria. Once integrated into the food chain, energy is stored in the form of chemical energy, and circulates within food webs, moving from one trophic level to another: from autotrophs to heterotrophs, from prey to predators, without forgetting the essential role of decomposers. The great importance of solar energy for today's biosphere is illustrated by the extinction mass events, in which a catastrophic event prevents solar radiation from reaching the ground (volcanic winter impact winter, etc.).

As a result, subject to cold and deprived of light, plants become rare, then herbivores die of hunger, and then it is the turn of predators (it is believed that such an event caused the extinction of dinosaurs at the end of the Cretaceous). In cells, energy may be present in a directly usable form (as adenosine triphos fetus), or, conversely, it may be stored for later in the form of simple or more complex sugars, such as fat (in animals), or oils (in plants).

Depending on different criteria, there is talk of *various forms of energy transfer*.

The evolution of different forms of energy

Energy evolution is the expression of how living things obtain and manage energy at planetary level (Botnariuc, 2006; Godeanu and Popa, 2022).

In the beginning, when only organic macromolecules existed, ocean water was warm because the Earth's crust had barely formed and was still hot, and the circulation of water in the vapor-liquid ratio was very active. The first macromolecules of organic substances worked based on heat energy coming and accumulated in water from the young earth's crust. They were able to diversify vertically, depending on the fluctuation of temperature gradients.

After the temperature of the primitive planetary ocean dropped and reached below a certain limit, therefore insufficient to satisfy the primary metabolic processes, the need arose to obtain energy from other sources. In the beginning, all thermal energy was used, which was also taken from other natural sources (such as by fixing it to the benthic substrate formed by warm rocks, heated by magma inside the earth, or in surface waters that were heated by thermal radiation coming directly from the sun).

The first alternative was anaerobic chemical reactions by reducing sulfates or nitrates. This way of procuring energy still exists today in many types of prokaryotes and eukaryotes that function in all living environments without free oxygen, but also in fossils on the ocean floor. A proof of maintaining anaerobic chemical processes is also the speed of wound healing in all eukaryotic terrestrial organisms, so that at the intracellular level anaerobic processes are not disturbed by the direct action of molecular oxygen.

The energetic evolution continued, living things subsequently finding another, more efficient solution. At some point, living things were able to synthesize substances based on energy taken from light radiation from the cosmos. For this, special formations appeared – chlorophyll molecules. Initially, they were diffusely spread in the bodies of primitive prokaryotes (cyanobacteria), but later they concentrated in specialized organelles – chloroplasts. Photosynthesizing organisms currently exist in prokaryotes (cyanobacteria), some single-celled eukaryotic protists (photosynthesizing flagellates and algae), and some multicellular eukaryotes (plants).

After representatives of the Plantae kingdom appeared, photosynthesizing organisms, became the main producers of energy on the basis of which organic substances were synthesized. All types of photosynthesizing organisms have become the basic link in food chains and are referred to as primary producers. Currently, the terrestrial, freshwater and partly marine environments (where light radiation reaches) are dependent on photosynthetic organisms. The exception is the soil, underground environment, decomposing organic sediments, necro mass deposits - in which anoxic processes prevail.

In figure 103 we show the types and extent of forms of manifestation of energies at the level of living organisms on our planet.

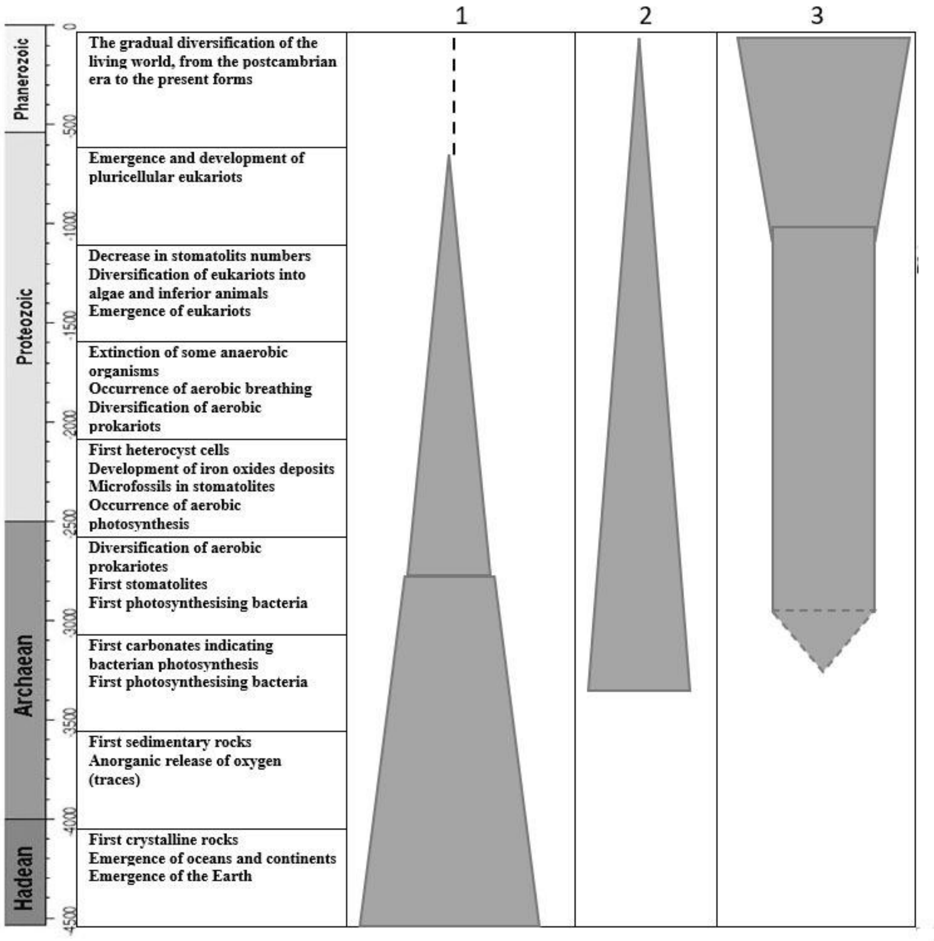

Figure 103. The occurrence of different types of energy and the intensity of batch use by living organisms. 1-geothermal energy, 2-chemical energy (chemosynthesis), 3-biochemical energy (photosynthesis) (Godeanu and Popa, 2022).

4.1.3 Matter

Matter is a general term for all the elements that surround us and make up all living organisms, including us humans (https://ro.wikipedia.org).

From the point of view of physics, matter is what brings all bodies together (i.e. whatever real object, which meets in the form of a substance or field and exists in space. The characteristic features that define matter are: mass, space, internal structure and internal thermal energy of matter.

Matter is composed of particles divisible as atoms – which group together to form molecules. Atoms in turn are made up of protons, neutrons and electrons – also called elementary particles. One million years after the initial explosion, today's era begins, the era of matter, made up of hydrogen clouds https://ro.wikipedia.org/wiki/Hidrogen, which form galaxies, stars, and later, by merging hydro atoms, helium is born, and then the other chemical elements up to carbon and iron.

It is assumed that by colliding neutron stars, as in supernovae, heavy elements were formed. Matter is in solid, liquid, gaseous form, but also in plasma form (i.e. ionized gas with specific magnetic hydrodynamics) and a condensate of Fermi ions (matter in a superfluid state at a temperature close to absolute zero 0^{o} Kelvin). Any material substance is characterized by: mass, volume, structure, quantity and a certain amount of caloric energy.

Matter, at the fundamental level, is made up of quarks and leptons[6]. Quarks combine to form hadrons (mainly baryons and mesons by means of powerful forces, and it is assumed that they are always limited in this way). Baryons include the proton (whose electric charge is positive) and the neutron (whose electric charge is zero), which combine to form the atomic nuclei of all chemical elements of the periodic table.

Although the fundamental laws of physics do not indicate a preference for matter over antimatter, cosmological observations indicate that the universe is composed almost exclusively of matter. It is very interesting to note that most (99.99% of the volume of an atom) is made up of empty space. This is called a lacunar structure. The nuclei (hence the strict matter) of two atoms constituting "matter" are also separated by a great distance from the vacuum (https://fr.wiktionary.org/). Normally, these nuclei are surrounded by a cloud of electrons (of negative electric charge and exactly opposite to that of the proton). The set of a nucleus and a cloud that includes as many negative electrons as positive protons present in the nucleus is an atom. It is electrically neutral, otherwise it would be an ion. Atoms can fit together to form larger, more complex structures, such as molecules. Chemistry is the science that studies how nuclei and electrons combine to form different elements and molecules The French scientist Teilhard de Chardin invented the principle of the noosphere, a kind of medium of psychic energies that would envelop the earth, and thus affirmed that, according to the nature of good or bad thoughts, the latter penetrating into the environment, would be, among other things, capable of generating living organisms. In this case, matter is nothing more than a kind of dough for the spirit, therefore for the human being, and we have creation in our charge. According to him, matter, literally and figuratively, is our weight that we have to bear. No comment!

The notion of **environmental or ecological factor** is a material element capable of producing a direct or indirect action on other material elements, causing appropriate reactions (https://ro.wikipedia.org). Environmental factors vary widely; they may be necessary (useful) or, on the contrary, they may be harmful to living beings, and may also favor or hinder the survival and reproduction of organisms. Several categories of environmental factors are distinguished https://ro.wikipedia.org/wiki/Factor :

- *ecological factors*: capable of influencing the life of organisms. Each organism permanently feels on itself the direct or indirect action of other beings, enters into direct relations with representatives of other species, depends on them, and itself exerts an action on them. The organic world that surrounds every living being is part of their environment.
- *Abiotic factors* (*physical, climatic* and *hydric*): air, water, light, heat, humidity, wind.
- *Geomorphological factors*: relief altitude , inclination, exposure.
- *edaphic factors*: soil with its physical, chemical and biological properties.
- *biotic factors*: living organisms with their biocenotic interrelations (phytocenotic, zoocenotic).
- *Anthropogenic factors:* are forms of activity of human society that alter nature in terms of environmental quality for other species, or directly affect their lives.

The evolution of factors of the abiotic environment

Before proceeding to present the second and **the last form of evolution of living matter – the stage of interconnection of the living with the non-living through the formation of stable and specific ecological units** - **creating the ecosphere**, we need to address some of the issues relating to the broad field of another natural science, geography. This is necessary because the existence of organisms is closely related to the state of the environment in which they live, and therefore to the environment.

As I wrote at the beginning of this paper, before the advent of life, Earth was similar to the other planets in our solar system, so it had a harder crust and a hot core (it consisted of solid materials, liquid/fluid materials - both very hot - and gaseous materials). But Earth had something else, namely water, which came in two forms: liquid and vapor.

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[6] In modern theoretical physics, matter has a much more complicated structure, but we are not interested in complex physical characteristics.

In order to efficiently use substances and energy from the environment, living things have constantly adapted. They gradually "conquered" all living environments, which they then used for their own benefit.

First environment, the one in whom life appeared, was the aquatic environment, represented by a single substance - relatively chemically simple-, **water** (which is a combination of just two elements – hydrogen and oxygen). But liquid water can dissolve a large number of inorganic and organic substances and from which organisms could take whatever they needed. Water has a low viscosity, can carry anything and anywhere, is a good selector of solar radiation, and is also protective against harmful cosmic radiation (especially for the first living organic compounds, which were more sensitive). And, most importantly, water is a compound that is always found in great quantity. We can speak of liquid water as one of the three main environments of life on our planet.

Currently, water is found on Earth under all three physical states: solid, liquid and gaseous. Over time it changed the morphology of the Earth's crust, both at the surface and inside the superficial layers of the lithosphere (thus in the underground environment); Water has transformed the earth's crust through erosion, dissolution and as a result of precipitation. It transforms mountains into hills and then into plains, erodes rocks, determines the transport of sediments and their accumulation in flat areas, clogs river valleys and depressions of the earth's crust, but also the coastline of seas and oceans, always shaping the relief of the planet.

Underground, liquid water, through infiltration and dissolution of rocks, created a hydrological system different from that on the surface of the earth. It consists of inland seas and lakes of varying size (do not forget that under the Sahara there is an inland sea containing 150,000 Km3 of water, and in North America there is the largest underground reservoir of the planet, the Ogallala basin - with a volume of 450,000 Km3 of water) and a huge network of flowing waters, but also from wet or dry underground cavities. Between the surface water of the planet and that of the underground is a permanent connection, created by gravitational processes.

We have presented water in more detail, in order to understand the particularly important role it plays not only for all forms of life, but also for the current structure of the earth's crust.

Over time, living things have conquered all geographical environments: oceanic, fresh waters (flowing and stagnant), swampy areas (fresh and salty, acidic or alkaline), terrestrial environments (mountains, plateaus, plains, deserts of sand or ice), underground environment (cavities, slits, reservoirs of stagnant or smoothly flowing waters), but also the air environment (in which they have adapted to spend at least part of their lives a series of bacteria, protists, some animals, spores of many fungi, but also forms of resistance or reproduction of many plants).

It can therefore be considered that on Earth, life has always depended on the presence of liquid water.

In comparison with liquid water, **terrestrial environment** It is not conducive to the emergence and maintenance of primordial organic macromolecules. In the absence of liquid water, the terrestrial environment is incapable of direct metabolic exchanges. It became suitable for life only after the first aquatic organisms colonized wet environments and especially after the creation of soil, which is like a huge sponge permanently containing water (see chapter 4.2. Natural ecosphere). Currently, life in the terrestrial environment depends 100% on this new shell, of living and non-living matter, which is the pedosphere.

On our planet there is an environment that is less approached: **underground environment**, into which life has penetrated almost from its beginning, taking on different modalities and constituting a more special type of ecosystem. Although it is located in the upper layers of the lithosphere, it depends mostly on the water seeping into it (through which it circulates or stays and which brings here and ensures the survival of a wide variety of living forms).

Air, the environment composed of gaseous atoms and molecules, powders and vapors, or fine particles of water, was, compared to the terrestrial environment, all the more unsuitable for the emergence of life. Air, which constitutes the atmosphere, is the interface between the cosmic environment and the three terrestrial environments on Earth and has special properties that we have presented in a separate chapter.

Life could not exist without a spatial component, or if organisms did not occupy a certain territory.

Gradually, depending on the nature of the living and dead plant material, but also on the hydrological and climatic conditions, local climate changes occurred, which, in turn, influenced and modified the relief of the planet.

All these changes in the structure of the geosphere, hydrosphere, climate, albedo, etc., are direct or indirect effects of ecosystem functioning, and then, over time, led to the emergence of supra-ecosystem units, called by land geographers biolandscapes, ecobiomes, biogeographical areas, and finally the ecosphere was established (Table 21).

Table 21. Ecology's levels of organisation; its living and non-living components (Godeanu and Doniță, 2021)

Biotic environment	**Abiotic environment**	**Ecological system**
Biocenosis	Habitat / Biotope	Ecosystem
Biolandscape	Topolandscape	Landscape
Biogeographical zone	Topozone	Ecozones
Biomes	Topobiome:	Ecobiome
Biosphere	Toposphere	Ecosphere

Many aspects of our planet's past are explained by geographers, geologists and paleontologists resorting to this ecological approach. Currently, there is an important branch of geography, Biogeography, which delineates biogeographical areas in the main terrestrial and aquatic environments (see Chapter 2.3.2), makes proposals for biogeographical spatial planning and, more recently, deals with humanity's influence on the planet (studying the anthroposphere and looking critically towards its future).

4.1.4 Biosphere – Toposphere interactions

How the spheres of the planet interact

In other papers we have addressed the issue of paradigms and the influence of biotic factors at the level of ecological systems Doniță and Godeanu, 2017, 2019, 2020, 2021; Godeanu 2016, 2019, 2020; Godeanu and Doniță, 2016, 2021; Godeanu and Popa, 2022). From them it emerged that they all have a common denominator: that of how the non-living interaction manifests itself specifically at each systemic level of organization in the ↔ field of ecology.

We emphasize from the beginning that from an ecological point of view, it can be seen that from a material, energetic and informational point of view, our planet is under the control of biota! Information relationships are the guiding ones, because information directs everything. It is predominantly biological in nature and subordinates the functionality of all processes from atomic to planetary level.

Earth's four spheres interact in all six possible combinations: lithosphere and hydrosphere, lithosphere and biosphere, lithosphere and atmosphere, hydrosphere and biosphere, hydrosphere and atmosphere, biosphere and atmosphere - and always in both directions. Furthermore, we believe that, in line with the idea put forward by Barry Commoner as early as 1972, the essence of the interactions between the spheres of the planet lies in his concept that "everything connects to everything".

When interpreting the results of these interactions, "everyone is good." Each specialist gives his opinion, comes up with pros and cons from his field of activity, so it is hard to find two people to have exactly the same opinions. We are convinced that this material will be appreciated as well.

An event is a change in one of the shells (sphere) or the effect of a change in a contiguous sphere. Interaction occurs when an event in one sphere ends up affecting another. A classic example of interaction between spheres is when a plant (part of the biosphere) takes carbon dioxide from the atmosphere (from the atmosphere) and water (from the hydrosphere), and mineral salts through its roots from underground (from the lithosphere) to carry out photosynthesis, creating its own food and releasing oxygen into the atmosphere. Another example is when volcanoes (lithosphere) erupt; Dust and ash particles (i.e. components of the lithosphere) mostly spread throughout the atmosphere and block sunlight. Less sun can cause a colder, drier climate in certain parts of the world. The colder climate affects the biosphere by shortening the growing season.

Of the planet's spheres, the biosphere has the largest in area and diversity, and as a determining factor of its presence on the planet, it is the hydrosphere - because without it there would be no life. It is to them that we will mainly give our attention.

The biosphere is, quantitatively, a very thin shell; yet it is of astonishing diversity, possesses the greatest capacity for action, and performs the most diverse and versatile actions on the other components of the toposphere. The biosphere cannot exist without a permanent exchange of information, energy and matter with the surrounding environment (i.e. with the components of the toposphere), but these exchanges can also take place between its millions of components under which it presents itself on earth. Because life is so complicated, that's why it rarely appears and develops on other planets or in other solar systems (hopefully we will come into contact with other life forms in other solar systems in the future).

Biosphere–hydrosphere–lithosphere–atmosphere interactions play a crucial role in the structure of weather and climate. Surface waters and energy exchange flows drive the diurnal and seasonal dynamics of the lower layer of the atmosphere, both on a local and regional scale. Gas exchange flows between the lithosphere and atmosphere affect the chemical composition of the solid surface layer, acting as both a source and reservoir of gases coming into the atmosphere. They include both greenhouse gases and other more reactive gases that can alter the chemistry of the atmosphere, such as isoprene. Together, these supra-atmo-sphere interactions dominate the environmental conditions of life on earth. As man-made emissions alter the earth's energy balance, surface-atmosphere interactions also change. Increased or reduced hydrological cycles and slow change in the biosphere and soil surface conditions due to land-use change or the increasing frequency of extreme weather and climate events will not only alter local energy and water flows at regional level, but will also affect gas exchange rates. Both are expected to create feedbacks with atmospheric conditions.

The four layers of the Earth interact uninterruptedly. Thanks to these interactions, in nature there is an amazing capacity for self-cleaning, self-regulation. If I have a disturbing component in any natural complex, self-regulating reactions immediately occur in all other shells, thus the system seeks to regain its balance.

Water, although it is also everywhere, in its three physical forms (vapor, water and ice), is "used" by the components of the biosphere especially in its liquid and vapor forms. In the atmosphere, it is mixed with other gases, but also in the form of water vapor that makes up clouds.

The exchange of energy, water, carbon dioxide and other trace gases between the biosphere and atmosphere has a profound impact on processes related to the soil surface, the thermodynamic structure of the atmosphere and the climate of the Earth system. Changes in water availability, temperature, or vegetation activity can alter these interactions. Seasonal variability and periods of drought provide important information on feedback mechanisms that are related to photosynthesis, sweating, and energy use.

The atmosphere protects all living beings on Earth from the harmful effects of ultraviolet radiation from the sun and cosmic rays – high-energy particles in motion that have a speed close to that of light.

The lithosphere, although it is based on the solid matter from which the planet was formed at the beginning, also contains materials attracted from space, but also material produced by the biosphere, material that now forms specific rocks. The components of the lithosphere, with the input of the biosphere, created a special shell, the pedosphere.

It was in the biosphere that man was created. This is one of the factors of the biosphere that for less than 1000 years has been acting on all the layers of the planet and the ecosphere, creating a new sphere, the anthroposphere, the youngest - and most destructive form of damage to the interactions between the shells of our planet.

In the following we will try to briefly review how the living has changed the nonliving component of the planet at the level of the ecosphere.

Effects of the biosphere and its components on the planet

Multiple interactions on a planetary level

The biosphere has changed the way biogenic elements circulate within their biogeochemical circuits. The biosphere has changed the structure of the planet light spectrum. Seen from the troposphere, the planet has several predominant colors: blue (from the color of oceans, seas and large lakes), yellow and brown (from the color of deserts and arid areas devoid of vegetation) and green (from the color of terrestrial vegetation covering the pedosphere).

The biosphere has determined a new way of circulating matter in the universe, transforming the circulation of matter (from simple chemical circuits to biochemical evolutionary spirals). The biosphere, through its anti-entropic characteristics, has changed the speed of energy leakage, which currently proceeds much slower, but has a much higher efficacy. The biosphere, through its complex and uninterrupted operation, extracted certain mineral compounds from the environment, thereby creating new types of rocks (chlorides, carbonates, predo sedimentary rocks organic mines (coal, graphite, oil deposits, etc.), which now naturally enter the structure of the lithosphere. Erosional processes occur not only strictly abio mechanismstics, as they worked before the emergence of the biosphere, but have new features that pose problemsme not only to geologists, but also to those who exploit or act in different ways on the lithosphere (urban construction, terrestrial communication routes, mountain penetrations (tunnels), land leveling, mining, exploitation of the most different components of the lithosphere, etc.).

The thermal regime of the atmospheric envelope is influenced by the distribution of oceans and land (continents) on the planet. In the seas and oceans appear vertical currents and on the horizontal, some warm, others cold, moving over distances of thousands of kilometers. Along the way, these currents allow either the mixing of very large amounts of water, with different temperatures, or the homogenization of the temperatures of the waters they cross. An example is the warm currents, which carry water from the equator to the poles, as well as the cold ones, which move it backwards, from the poles to temperate regions (e.g. the warm Gulf Stream – "Gulf Stream", which bathes the northwestern shores of Europe, or Kuro-Shivo for the eastern shores of Asia, or the cold ones of Greenland, Labrador, Oia-Shivo). The equalization of surface water temperatures is more evident in the equatorial zone.

Water and land behave quite differently from sunstroke. Water retains and/or releases stored heat more slowly, whereas in the terrestrial environment this process happens much faster.

By creating the anthroposphere, man has changed the structure of the plant envelope, destroyed part of the pedosphere and weakened the functioning of all the earth's envelopes. A first and most visible effect is the effect of global warming triggered by mankind over the last century and a half (it has created a climate different from that achieved by the natural ecosphere at global level over the last millennia).

Effects of the biosphere on the Earth's crust

The interaction between the biosphere and lithosphere is most active in the upper part of the lithosphere, that is, at the very surface of the earth's crust.

The first organisms to emerge from the aquatic environment are those that determined the creation and development of the youngest sphere of the planet, the pedosphere.

The biosphere has reduced the intensity of erosional processes. Because the biosphere created the vegetal carpet, it produced special changes in the protective action against erosional actions caused by climatic and hydrological factors on the earth's crust. In this way, erosional processes that are carried out predominantly by physicochemical pathways are greatly slowed down, or even stopped. The effect is to reduce the processes of clogging of marine, brackish or freshwater basins with stagnant water.

Plants, through their roots, penetrate cracks in the lithosphere, destroy hard stones and fragment them, forming mineral sediments. In the accumulated crust, plant and animal debris depositing on the bottom of reservoirs, causes the formation of layers of sediment (limestone or chalk from the skeletons of various animals - especially sponges and celenterates - organic sediment deposits and others). From dead plant remains, peat and coal, etc., are formed by abiotic enchanting paths.

Effects of the hydrosphere on the biosphere

About 70% of the Earth's surface is covered by water. This is the space where life emerged, where a large proportion of living things that have passed into the terrestrial environment continue to reproduce and live part of their life cycle. A significant amount of biotic activity is carried out in oceans, rivers, streams, lakes and other aquatic environments. Without water, life in the terrestrial environment cannot take place. If we look at plants in the terrestrial environment, we see that they cover most of the continents. They need water to survive. Water plays an essential role in the process of achieving photosynthesis (so we can consider water as a food source), and plants as producers of oxygen (the second requirement for life) that both they and all land animals breathe. It is the interaction between the biosphere and hydrosphere that provides water to oxygen-producing plants and plant life for animals to eat.

Effects of the biosphere on the marine and oceanic aquatic environment

The interaction between the biosphere and hydrosphere is essential, because without it, organisms cannot exist. In turn, biota affects the chemical composition of water. It is estimated that over the last 200 million years, the salinity of ocean water has not changed. Salts in seawater are used by organisms for their vital functions. For example, calcium underlies the constitution of the skeletons and shells of snails and clams, but it is also the basis of the support constitution of the coelenterates that created coral reefs. Currently, the chemical composition of marine and ocean waters is constant precisely due to the processes taking place in the component of our planet's biosphere.

The biosphere has also changed the composition of dissolved inorganic substances existing in the mass of these waters (as a result of the reduction of chemosynthesis processes and the appearance of photosynthesis). The biosphere led to the emergence of oxidative processes caused by the presence of oxygen produced by living organisms.

The biosphere caused the emergence of a very wide range of non-living organic compounds that are now found in waters in dissolved, colloidal and particulate form. Their presence has complex effects on physicochemical processes in these waters and causes chemical reactions with non-living chemical compounds that previously existed in these waters. Moreover, organic compounds produced by living organisms contribute to the acceleration of sedimentation processes of suspensions brought by flowing waters (and which originate from erosion of lithosphere rocks in the terrestrial environment and are subject to the action of destructive climatic and hydrological factors).

The biosphere has led to changes in the physical parameters of waters: most often organisms in waters change transparency, temperature, sometimes even the speed of movement of water masses. Photosynthesizing organisms in the water mass (algae) produced dissolved oxygen, which in turn changed most chemical processes (which thus became predominantly oxidative) and biochemical processes in these types of water. The biosphere has led to the creation of several major types of biocenoses (plankton and nekton in the water mass, biocenoses on solid or sandy sediments in coastal areas and on the talweg of the coastal zone, biocenosis on organic sludge sediments in benthal areas, etc.).

The biosphere also determined the appearance of sedimentary rocks of biogenic origin, which later, through the movement of lithosphere plates, reached the terrestrial environment, where they often created new reliefs, represented by mountains, valleys or plateaus formed especially by rocks of biogenic origin (e.g. limestone mountains).

Effects of the biosphere on the freshwater aquatic environment

The aquatic biosphere has altered the chemistry of waters, just as it has done in the ocean and marine environments.

The biosphere has altered the physical parameters of flowing waters – runoff rate, transparency and intensity of erosional processes.

Living organisms determined and altered the chemistry of water and sediment (organic compounds appeared); Living things develop on hard, stony substrates, thus ensuring their protection against erosional processes of physicochemical origin in waters, cleaning waters of pollutants and various biodegradable organic compounds).

In many cases, living organisms have reduced the lifespan of stagnant water basins by intensifying their clogging processes with dead organic substances. In other cases, they led to wetlands, and then dry lands formed by organic sediments brought by water. These sediments have caused – or still provide – increased farmland fertility on land in the major riverbeds of many rivers on all continents.

Effects of the biosphere on the underground environment

Research undertaken in the underground environment has revealed that life is present not only in soils, at the lithosphere-pedosphere interface, but also in the slits that exist in the rocks of which the lithosphere is composed. Underground, liquid water, through infiltration and dissolution of rocks, created a hydrological system different from that on the surface of the earth. It consists of inland seas and lakes of varying size (do not forget that under the Sahara there is an inland sea containing 150,000 Km3 of water, and in North America there is the largest underground reservoir of the planet, the Ogallala basin - with a volume of 450,000 Km3 of water) and a huge network of flowing waters, but also from wet or dry underground cavities. Between the surface water of the planet and that of the underground is a permanent connection, created by the gravitational processes of our planet. Living organisms can descend to great depths, hundreds or even thousands of meters (where temperatures can often be quite high), but they can also meet in underground cavities, probably brought here by infiltration waters coming from the surface of the lithosphere. Life is present in various forms throughout the planet's underground hydrographic network: in wet layers, in the form of flowing or stagnant waters (where it forms lakes or even true underground seas). The organisms existing here contribute, through their metabolic activity, to cleaning these waters from infiltrations that bring pollutants, consume dissolved organic compounds, or those in the form of particles of dead organic matter. Unfortunately, very little is known about these deep-sea organisms.

Effects of the biosphere on the atmosphere

The biosphere, by its action, caused fundamental physical and chemical changes on the Earth's atmosphere, especially its lower layer, the troposphere.

The living shell of the planet is responsible for the emergence and progressive increase of the amounts of dissolved oxygen currently existing in the Earth's atmosphere (it is in a percentage of over 21% of the total composition of gases in the Earth's atmosphere), but also of the ozone layer in the stratosphere.

The biosphere caused carbon dioxide (CO_2), sulfur dioxide (SO_2), and hydrogen sulfide (H_2S) to drop drastically from the primitive atmosphere.

The biosphere is the determining factor of the significant reduction in the intensity of acid rain that corroded the earth's crust. It is still actively working to reduce the negative effects of gaseous pollutants emitted by various anthropogenic activities into the atmosphere.

These three shells: the biosphere, hydrosphere, and atmosphere are interdependent. In more subtle ways, atmosphere-biosphere interactions influence the health of the air we breathe: vegetation removes aerosols, oxygen, and other reactive gases from the air. Earth's biosphere captures nearly 30% of carbon dioxide emissions from fossil fuels. Air pollutants also affect the biosphere. Acids in the air can suppress plant growth. In turn, dust in the air, aerosols and water vapor have direct and indirect effects on cloud formation, a process that leads to a decrease in light radiation, or leads to an increase in the fraction of diffuse radiation.

Plants emit a great diversity of volatile organic compounds that have different physiological and ecological functions. These compounds affect the chemistry of the atmosphere and have ripple effects on communities of organisms, ecosystems, air quality and climate. Current estimates predict a substantial increase in emissions of biochemically active substances in response to global changes. Temperature is the first to be expected to be affected, which means that the intensity of photosynthesis and then release of their volatile substances into the atmosphere will also increase.

The terrestrial biosphere influences the atmosphere through many processes. Some of the most important include CO_2 exchange and energy distribution in the form of latent heat streams. The sensitivity of the terrestrial biosphere to climate and atmospheric chemistry causes the biosphere and atmosphere sphere to behave as a coupled system, with increased potentialities for stronger positive and negative feedbacks. Anthropogenic disruption of natural ecosystems, climate and atmospheric chemistry is currently changing this coupled system across much of Earth's land surface. Understanding their coupled behavior is a priority for research, not least because of the major role of the terrestrial ecosystem in the global carbon cycle, but also because of the significance of surface characteristics for local and regional climate through its biogeophysical effects.

Human life depends on interactions between Earth's atmosphere and the biosphere. Plants provide the oxygen we breathe, remove the carbon dioxide we exhale, and through sweat – the biologically controlled evaporation of water from plant leaves – veneers harvest much of the water that falls from the atmosphere onto our crops and fills our reservoirs with drinking water.

The biosphere has determined various macro and microclimatic changes, as a result of the development of the vegetal carpet, but also separately, on the other climatic factors.

Effects of the biosphere on energy processes at planetary level

The biosphere has led to the diversification of forms of obtaining and storing energy on a planetary level. If until its appearance, energy was obtained from thermonuclear reactions taking place in the center of the planet, now the biosphere, as a result of the process of photosynthesis, allowed the production, and then storage of this energy in the form of biomass, which, after the death of plants, led to the formation of fossil deposits of oil, coal and natural gas.

Biogeochemical circuits

A biogeochemical circuit can be considered the path by which an element – present under a series of various chemical compounds – circulates between the different components of the biosphere and those of the toposphere. The main biogeochemical cycles are the water cycle, the carbon cycle and the nitrogen cycle. In each cycle, the element or chemical molecule under which the element appears at a given time is transformed and travels at different speeds through living organisms and through different forms existing in the atmosphere, hydrosphere, pedosphere or lithosphere (some may sometimes be stored for different periods of time).

Biogeochemical cycles involve the interaction of biological, geological and chemical processes. Biological processes include the influence of organisms, which are critical factors of the biogeochemical cycle. They have the ability to carry out a wide range of metabolic processes essential for the cycle of nutrients and chemicals in all ecosystems. Without the action of living organisms, many of these processes would not occur. This can have a significant impact on the functioning of all types of ecosystems, but also on all biogeochemical cycles on a planetary level, as cycles are interconnected and play important roles even in climate regulation. We emphasize from the beginning that all human activities can peat biogeochemical cycles, with consequences difficult to estimate, so implicitly all ecological balances at planetary level.

The concept of biogeochemical cycles was introduced by the biogeochemist Vernadsky in 1945.

Currently, the following biogeochemical cycles are quite well known:

- Water cycle in nature
- Carbon cycle
- Hydrogen cycle
- Oxygen cycle
- Nitrogen cycle
- Sulfur cycle
- Phosphorus cycle
- The cycle of some metals.

The existence of such cycles gives the ecosphere considerable power to self-regulator, which ensures their perennially. Research has led to the finding that there is a relatively constant rate of circulation of each element. In any biogeochemical cycle, there are certain stages in which circulation proceeds rapidly (for example, Nitrogen from soil) and stages in which circulation proceeds more slowly (e.g. atmospheric nitrogen).

In relation to the ability of the substance to return to the general circuit of that element, we distinguish two categories of global biogeochemical cycles:

- *Relatively perfect* or *gaseous cycles.* They exist in water, oxygen, carbon and nitrogen. The main reservoir of these elements is the atmosphere.
- *Relatively imperfect* or *sedimentary cycles.* They exist in phosphorus, calcium, iron, sulfur, selenium, mercury, etc. The main reservoir of these elements is the lithosphere. Along with these elements, there are other less important cycles, such as mercury and many metals.
- *The perfect cycle is that of water.* Water is not an element, but a chemical compound essential to the biosphere and necessary for most processes within the components of the toposphere.
- *Cycles of compounds synthesized by humans.* Such cycles have appeared since the XIX century; they are increasingly frequent. Such are the cycles of detergents, pesticides, or synthetic specialties, about which we have too little information, but which in the future may raise big problems related to their rate of circulation, or to their remanence in the various components of natural biogeochemical cycles.

Within biogeochemical cycles, substances that occur, possess different periods of remanence. Some have lifespans of the order of hours, others of the order of years, or even millennia.

Figure 104, schematically shows the circulation of energy and matter in the global ecological system (ecosphere). The main form of energy currently used on our planet, that coming from the sun, determines the functioning of living systems based on its transformation through the process of photosynthesis of plants.

Energy and nutrients flow from primary producers (plants) through primary consumers (herbivores), then energy passes through a succession of higher order consumers (carnivores and parasites). On the death of producers and consumers, scavengers and degraders return mineral elements to the soil, which can thus resume their biogeochemical cycles. In the course of these processes, energy is also returned to nature, but in the form of heat and movement.

This alternating passage between the toposphere and the biosphere (i.e. between the non-living and living environment) constitutes a biogeochemical cycle. That remarkable constancy of exchanges between the different elements of the non-living and living components of biogeochemical cycles reveals a high capacity for self-regulation, which ensures that the biosphere has permanent ecological systems but also of the ecosphere as a whole.

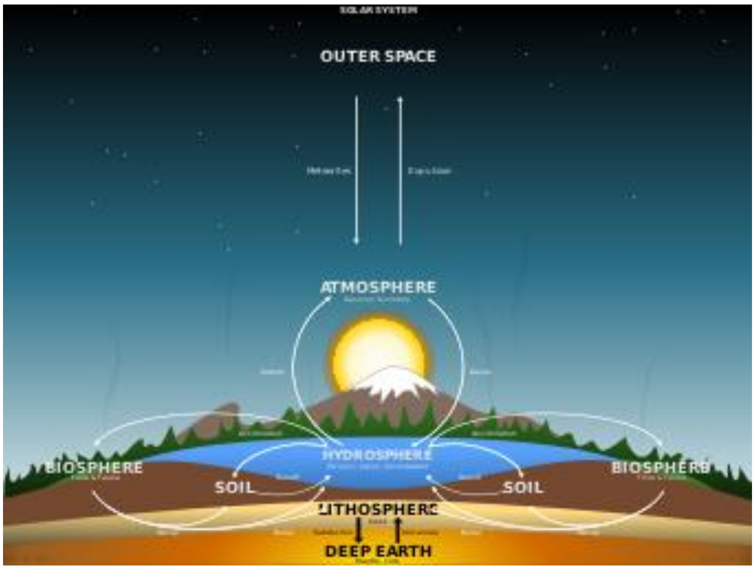


Figure 104. General diagram of energy and matter circulation in biogeochemical cycles (https://en.wikipedia.org/wiki/Biogeochemical_cycle#/media/File:BIOGEOCHEMICAL_CYCLING_OF_ELEMENTS.svg)

Main biogeochemical circuits

1. Carbon cycle

The carbon cycle in nature consists of a series of successive exchanges of substances containing this element. Figure 105 shows the carbon fluxes that exist between the atmosphere and the biosphere, hydrosphere, or lithosphere. Most of the carbon from which the biogeochemical carbon cycle starts is in gaseous form, especially carbon dioxide branded.

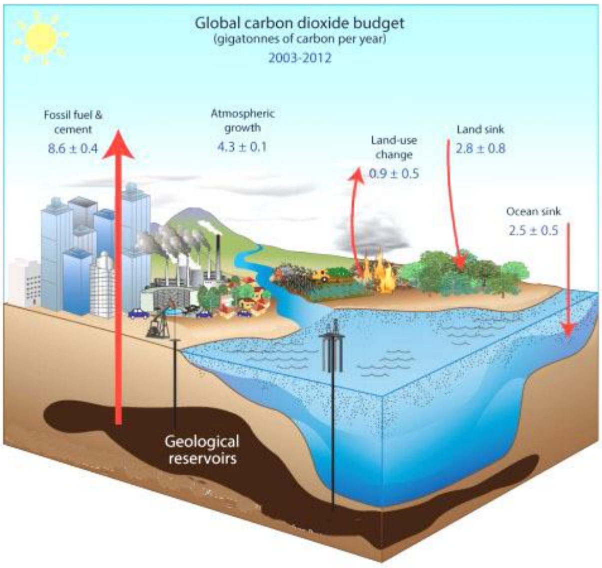


Figure 105. Biogeochemical carbon circulation (https://en.wikipedia.org/wiki/Carbon_cycle)

Within the biosphere, all living organisms excrete carbon dioxide through respiration. During the day, plants assimilate carbon from CO_2 and, with the help https://ro.wikipedia.org/wiki/Lumin%C4%83 of sunlight, through the process of photosynthesis, convert it into organic combinations, releasing oxygen. The biosphere's capacity to assimilate carbon is, however, limited.

Between the atmosphere and hydrosphere: CO_2 is a relatively water-soluble gas and there is an equilibrium of its concentration here. The oceans contain dissolved huge amounts of CO_2, which, if the balance were disturbed, could be ejected into the atmosphere, leading to extreme climate disturbance. The solubility of gases in water decreases as the water temperature increases. As a result of a warming of ocean water, the release of CO_2 into the atmosphere becomes a real danger.

The main mechanisms of carbon use in the biosphere are photosynthesis, respiration and oxidation.

Currently, between the atmosphere and lithosphere, carbon is released in the form of CO_2 and through anthropogenic activities (especially by burning fossil fuels). It is believed that in the last half century very large amounts of CO_2 and methane have been emitted into the atmosphere, which, through the greenhouse effect, led to the beginning of a global warming phenomenon.

The carbon cycle occurs at a relatively high speed. Carbon circulates in various non-living environments and within biocenosis via food webs. Carbon is present in nature in the form of calcareous rocks of biogenic origin, https://ro.wikipedia.org/wiki/Carbonat mineral carbonates and in gaseous form (as carbon dioxide). The atmosphere contains 320 ppm of carbon dioxide. The CO2 reservoir in the atmosphere amounts to 700 x 109 tones and the hydrosphere reservoir to 50,000 x 109 t. The biomass achieved by annual synthesis by plants is estimated to be between 30 x 109 t and 150 x 109 t.

With all the high consumption of carbon taken from the atmosphere and assimilated by organisms, its amount in the atmosphere remains constant over time, because in nature there is another important reservoir of CO2, the one found in the planetary ocean.

The global carbon cycle arises from the following major carbon reserves that are interconnected: Earth's atmosphere, biosphere, ocean (through dissolved organic and inorganic compounds and that present in living and dead marine biota), organic sediments, fossil fuels and deposits inside the lithosphere. Carbon exchanges between reservoirs occur as a result of various chemical, physical, geological and biological processes. The ocean contains the largest active carbon pool near the earth's surface. Natural carbon flows between the atmosphere, oceans, terrestrial ecosystems and sediments are fairly balanced; so carbon levels would be roughly stable without human influence.

Natural carbon flows between the atmosphere, oceans, terrestrial ecosystems and sediments are fairly balanced; so carbon levels would be roughly stable in the absence of human influences.

2. Hydrogen circuit

Hydrogen is an element that actively participates in the biogeochemical cycles of water, carbon, oxygen, nitrogen and sulfur. The role of hydrogen lies in the exchange of their hydrogen atoms occurring between biotic and abiotic sources of that element (Figure 106).

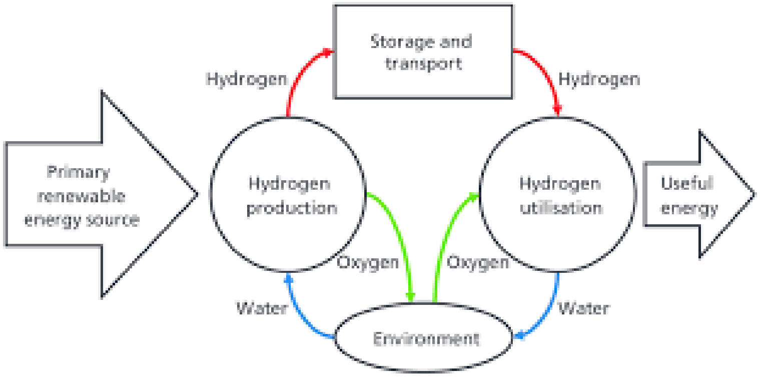


Figure 106. Biogeochemical circuit of hydrogen (https://www.google.com/search?client=firefox-b-d&sca_esv=583632294&q=biogeochemical+cycle+of+hydrogen&tbm=isch&source)

Anaerobic microorganisms play an important role in the anaerobic fermentation of many organic substances, reacting with carbon dioxide and methane, because they act as a kind of symbiont between some methanogenic archaea and non-methanogenic anaerobic bacteria (which in the course of their metabolic processes break down some organic substances, producing, among others, molecular hydrogen (H_2), which methanogens bacteria then use to synthesize methane (CH_4), even when the hydrogen concentration in the environment is particularly low and favors the production of hydrogen-rich compounds).

The hydrogen cycle consists of exchanges of this element between biotic and abiotic sources and reservoirs of hydrogen-containing compounds. As a consequence of microbial metabolism or natural rock-water interactions, hydrogen gas can be created. Other bacteria can then consume free hydrogen, which can be photochemically oxidized in the atmosphere (or lost to space). It is also believed that hydrogen was an important reactant in prebiotic chemistry and the early evolution of life on Earth and – potentially – in other parts of Solar System. In this way, hydrogen gas is released, which is taken up by some bacteria and photochemically oxidized.

Hydrogen gas is involved in water-rock reactions in the lithosphere (such as those that occur in the ocean subsoil near hydrothermal vents that erupt magma and gases) and in many photochemical reactions (oxidation of minerals such as siderite). Hydrogen is produced by hydrogenase and nitrogenase enzymes in many microorganisms, some of which are being studied for their biofuel production potential, as well as cold fermentation as part of the anaerobic microbial food chain occurs by dependent pathways either from light or in the absence thereof.

Anaerobic oxidation of hydrogen often occurs during its interspecies transfer, in which this gas is produced and transferred to another organism, which uses it to reduce carbon dioxide to methane, acetate, hydrogen sulfide, trivalent iron pass into bivalent iron. This hydrogen transfer maintains optimal concentrations of hydrogen molecules because fermentation becomes less thermodynamically favorable as the partial pressure of this gas increases.

3. Oxygen circuit

The oxygen circuit highlights how this element passes from the atmosphere, into the biosphere, then into the hydrosphere, lithosphere, and pedosphere, to return to the biosphere (Figure 107)

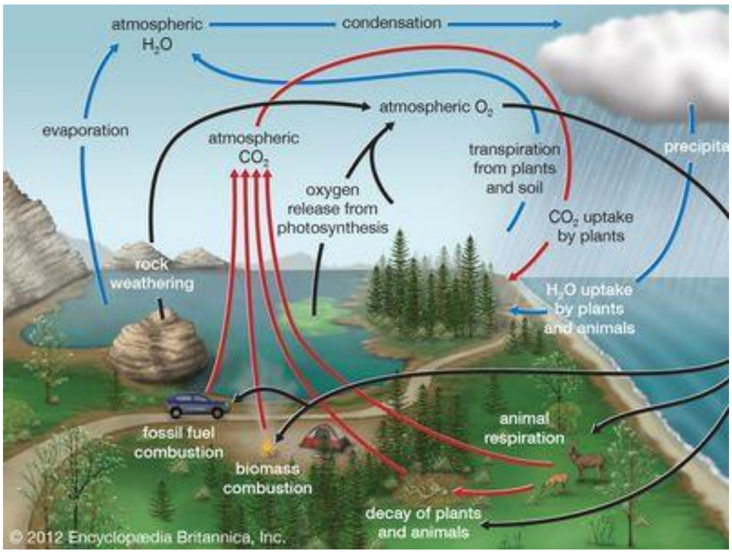


Figure 107. Biogeochemical oxygen circuit (https://www.britannica.com/science/oxygen-cycle)

Quantitatively, after carbon, oxygen is the main component of living organic substances. The oxygen cycle is complicated because it enters the composition of a large number of compounds, which have different forms and functions in both living and non-living environment, thus creating numerous sub cycles within the same global oxygen cycle.

Oxygen was only traces in Earth's primitive atmosphere. He was procured by autotrophic organisms. Oxygen, having a biogenic origin, is now present both in the Earth's atmosphere and in the form of various oxides in calcareous sediments, ferruginous deposits in the lithosphere, and water in the hydrosphere.

The release of oxygen from water during photosynthesis probably began immediately after the appearance of photoautotrophic bacteria in the primitive ocean and intensified with the transition of living things from aquatic to terrestrial environments.

We recall the fundamental role in creating the ozone layer that protects the terrestrial biota from the negative influence of the planets' radiation and their control over the current oxygen concentration in the planet's atmosphere. The molecular oxygen released by autotrophic organisms through the dissociation of water molecules can therefore be considered to be of strictly biogenic origin. The oxygen cycle takes place mainly between the atmosphere and the biosphere and is reversed compared to the production of carbon dioxide.

There is currently a balance between atmospheric oxygen production and the speed at which its renewal by primary producers is taking place. This process is proceeding at a fairly rapid pace, which has been taking place since 2000 years ago. In contrast, carbon dioxide in the atmosphere has a renewal time of only 300 years!
Under natural conditions, excluding modern human action of pollution and destruction of oxygen by various technical means, photosynthesis and respiration are very balanced, so the percentage of oxygen in the atmosphere remains constant. Details of man's action on the atmosphere will also be given in the head. 3.6. (Man and the Anthroposphere).

4. Nitrogen cycle

The nitrogen cycle in nature is the process of continuous circulation of nitrogen between the atmosphere, the earth's crust, animal and plant organisms. During this circuit, this chemical element goes through various chemical forms and combinations (Figure 108). The global reactive nitrogen cycle currently includes industrial fertilizer production, nitrogen fixed by natural eco-systems, nitrogen fixed by oceans, nitrogen fixed by agricultural crops, nitrogen oxides emitted by burning biomass or emitted from soil, nitrogen fixed by lightning, nitrogen oxides emitted by terrestrial ecosystems, nitrogen deposits in the terrestrial environment and oceans, emitted from the oceans, or from the atmosphere, and denitrification that occurs in the oceans. The biogeochemical cycle of nitrogen is very balanced, because as this element is consumed, active feed-back mechanisms bring nitrogen back into the circuit.

Nitrogen conversion can be carried out by both biological and physical processes. Important processes in the nitrogen cycle include fixation, ammonification, nitrification and denitrification. Most of Earth's atmosphere (78%) is atmospheric nitrogen, making it the largest source of nitrogen. However, atmospheric nitrogen has limited availability for biological use, which can lead to a shortage of usable nitrogen in many types of ecosystems.

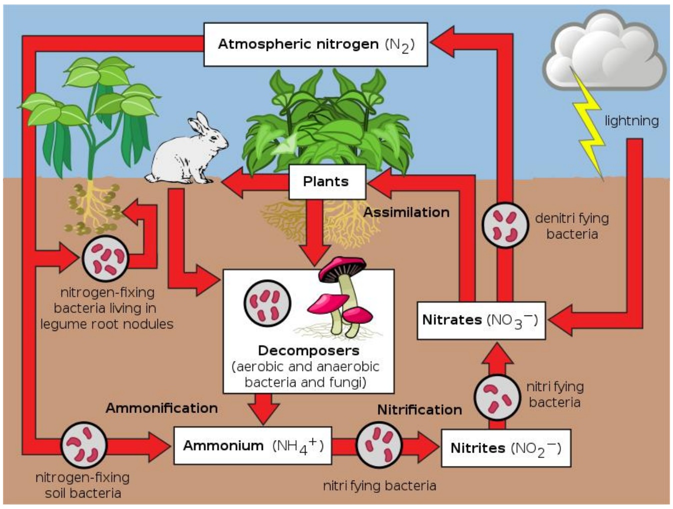


Figure 108. Nitrogen cycle in nature
(https://www.google.com/search?q=circuitul%20azotului%20in%20natura%20schema&tbm)

The nitrogen cycle is of particular interest because nitrogen availability can affect the rate of key ecosystem processes, including primary production and necro mass decomposition. Human activities such as burning fossil fuels, using artificial nitrogen fertilizers, and releasing nitrogen into wastewater have dramatically altered the global nitrogen cycle. Anthropogenic changes in the global nitrogen cycle can negatively affect the natural environment, but also human health.

Nitrogen is present in the environment in a wide variety of chemical forms, including organic nitrogen, ammonium (NH^{+4}), nitrites (NO^{-2}), nitrates (NO^{-3}), nitrous oxide (N_2O), nitric oxide (NO) or inorganic nitrogen gas (N_2). Organic nitrogen can be in the form of living organisms, humus or is in intermediate products of decomposition of dead organic matter.

The processes in the nitrogen cycle are the transformation of nitrogen from one form to another. Many of these are performed by microbes, either in their effort to obtain energy or to accumulate nitrogen in a form necessary for their growth. For example, nitrogenous waste from animal urine is broken down by nitrifying bacteria in the soil for use by plants. The diagram in figure 108 shows how these processes couple to form the nitrogen cycle.

In the ecosphere there are virtually unlimited reserves of nitrogen (mainly in molecular form in the atmosphere and in the form of nitrogen compounds in the soil). The forms of nitrogen accessible to plants are nitrates. A source of obtaining nitrates for plants are atmospheric nitrogen-fixing organisms (for example, Bacteria *Radicicola* fix up to 280 kg nitrogen/ha/year).

Some transition metals also participate in the process of nitrogen fixation, among which iron and molybdenum are more common. After being embedded in the protoplasm of plants, nitrates are taken up by animals and included in their protoplasm.

From here some pass into urea, and another, after the death of organisms, under the action of bacteria turns into ammonia (https://ro.wikipedia.org/wiki/Circuitul_azotului_în_natură).

One source of ammonia is electrical discharges in the atmosphere and volcanic emanations; part of this gas reaches the body of plants, and another part, under the influence of bacteria, turns into nitrites and nitrates. Partially, nitrites, under the action of boiling nitrite microorganisms, can again reach the atmosphere in the form of molecular nitrogen.

Currently, the biogeochemical cycle of nitrogen is modified due to anthropic factors, among which the most important are agriculture and pollution. Industrial processes of fixing atmospheric nitrogen to produce chemical fertilizers are also another cause of disruption of the biogeochemical nitrogen cycle.

5. Sulfur circuit

Most of the sulfur cycle is sedimentary in nature and occurs in waters and soils. The sulfur cycle is considered to be balanced in the absence of human action, since stocks and flows are substantially constant within and between different compartments of the biosphere (Figure 109).

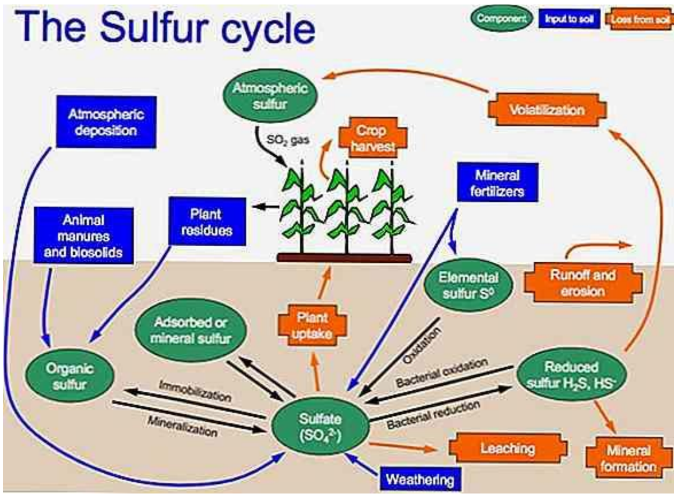


Figure 109. Sulfur circuit in nature
https://www.google.com/search?q=circuitul%20azotului%20in%20natura%20schema&tbm=isch&client=firefox-b-d&hl=en&sa=X&ved=0CKkBEKzcAigAahcKEwiAtKTjqf

The main source of sulfur available to living beings is sulfate. The water solubility of many sulfates makes them the only elemental, inorganic form of sulfur available to ecosystems. Sulfates are absorbed by plants which reduce them and produce sulfide amino acids. Sulphur normally reaches the atmosphere through volcanism, as a fermentation product in wetlands, as fermentation sludge accumulated in marine sediments (both coastal and especially abyssal slits). It is estimated that although volcanism releases an average of 28 million tonnes of sulphur/year (mainly in the form of sulphur dioxide) into the atmosphere, this production is still lower than that produced by sulphate-reducing microorganisms.

6. Phosphorus circuit

The phosphorus cycle is quite similar to that of nitrogen. He is an indispensable constituent of living organisms to constitute their own to organic matter, even if its weight and weight is relatively small compared to nitrogen or potassium. Its role is related to energy storage and transfer (for the production of nucleic acids) and the formation of many structural compounds (nucleotides, phospholipids, coenzymes etc.). That is why it is especially important for all living organisms. Phosphate is a limiting element in many terrestrial ecosystems because its availability is directly related to rock surface alteration (Figure 110).

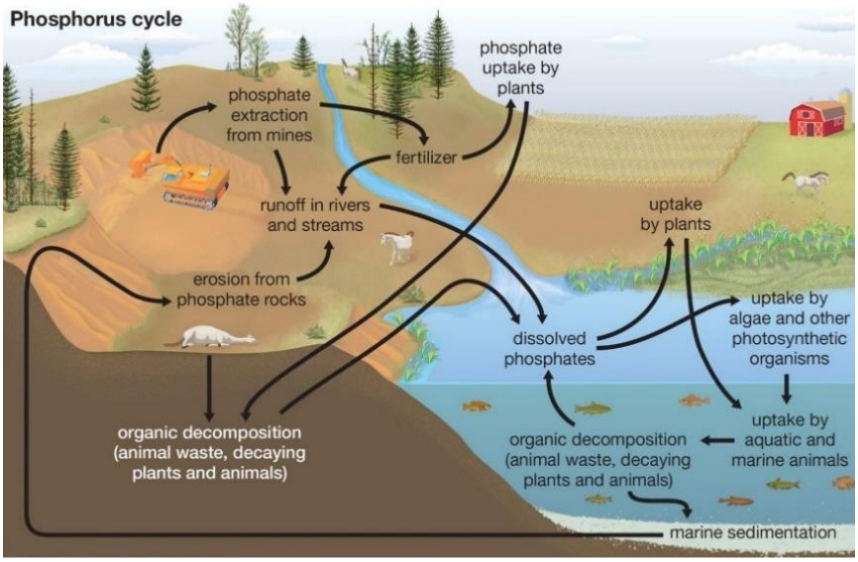


Figure 110. Phosphorus circuit in nature (https://www.britannica.com/science/phosphorus-cycle)

Lacking the gas phase in significant amounts, phosphorus does not affect the atmosphere. He is more in the lithosphere, pedosphere and hydrosphere. With human activity, the polluting effect of some phosphorus-containing compounds manifests itself significantly (in particular wastewater run-off and waste that collects in the various aquatic systems, contributing to eutrophication). The limiting effect of phosphorus is disturbed by anthropogenic inputs, which can cause environmental problems regarding the acceleration of eutrophication processes of all types of water, since excess phosphorus stimulates the multiplication of green algae. Marine sediments are a trap for phosphorus: they receive phosphorus in the form of particles and can adsorb dissolved phosphorus.

The phosphate concentration in sediments is in the order of 0,02 to 0,1 mg/cm3. The life cycle of phosphorus is related to food chains in aquatic ecosystems, which begin with phytoplankton. This phytoplankton is eaten by zooplankton, and further by fish or mollusks. They can be eaten by seabirds that allow phosphorus to return to land (mostly through their droppings and corpses). In general, wildlife plays an important role, although it is much underestimated in the phosphorus cycle.

Fishing also contributes to the reintroduction of phosphorus into terrestrial environments.

In soils, simple phosphorus compounds (based on oxides of Fe, Al and clays) are unusable by primary consumers. For this to be feasible, it must be in the form of phosphate ions in solution. Phosphorus must be desorbed from the mineral phases of the soil, released by dissolving phosphate minerals, or organic phosphorus must be degraded by specific enzymes (phosphatases) so that phosphate ions are available to plants. This is how phosphorus enters its circuit from the terrestrial environment.

Humans have caused major changes in the global phosphorus cycle, through the industrial exploitation of phosphoric minerals and the use of phosphorus fertilizers, as well as transporting food from farms to cities, where it is lost as waste in effluents.

Climate of the planet

Climate is the statistical dynamics of all meteorological phenomena in a given place or region of the globe over a relatively large time frame (the World Health Organization has estimated that the optimal interval to define a climate should be about 30 years). The main elements that are tracked are solar radiation, average temperatures on land and in water, atmospheric pressure, air mass movements, amount of precipitation, humidity tea, latitude, altitude, sea/land ratio, existence of sea currents, dominant winds, existence of mountain barriers, frequency of occurrence of extreme weather conditions and to a lesser extent the vegetation carpet.

Climate change is usually due to external natural factors (e.g., changes in solar emissions or in the orbit of the planet, occurrence of internal system processes climate caused by various human impacts, etc.).

Classification of climatic zones._Earth's climate zones fall into 3 broad categories, each with several subcategories:

1. **Warm zone,** with subcategories of equatorial, subequatorial, tropical-dry (desert) and tropical-humid climate.
2. **Temperate zone,** with subcategories of subtropical climate (Mediterranean climate), temperate-maritime, temperate-continental and cold temperate climate.
3. **Cold zone**, with subarctic (subpolar) and polar climate subcategories.

The distribution of these climates around the globe depends on the environmental factors outlined above and illustrated in figure 111.

Figure 111. Map of the main climates at the level of the terrestrial globe (https://www.istockphoto.com/ro/vector/harta-zonelor-climatice-mondiale-infografice-geografice-vectoriale-gm1198816180-342750669)

The global climate varies relentlessly on all time scales - deep geological time (from hundreds to tens of millions of years), quaternary time (on the order of millions of years), the time of prehistory and human history (tens of thousands to a thousand years), during the current era (from hundreds to decades), depending on continuous irregular oscillations connecting more or less long periods stages and phases of relatively hot and cold more or less intense.

Apart from these major changes, there are numerous regional and local climates.

The magnitude of regional climates, which apply to regions of several thousand square kilometers that are subject to very specific meteorological phenomena (desert winds, El Nino effect) and are due to the interaction between general circulation and relief.

Local climates are established for areas of no more than a few tens of square kilometers and remain closely related to the environmental peculiarities of a small area. They depend on the presence of reliefs (for example, a mountain climate) or the existence of aquatic expanses. At the bottom of the valley, for example, at sunrise, the temperature will be much lower than at the top of the ski slopes, although it is only a few kilometers away. The circulation, exchanges between local air masses will therefore not be the same as in the neighboring valley and may be oriented differently from the sun. Today, these features may even have a human origin (such as an urban microclimate or they may be maintained by a natural environment, such as a seashore or lake, or even a forest). Gradually, depending on the nature of the living and dead plant material, but also on the hydrological and climatic conditions, local climate changes occur, which, in turn, can influence and modify the relief of the planet.

Specific microclimates can also be distinguished. They are small sites, about 100 square meters, sometimes even less, which are determined by the specific characteristics of the topographic and small-scale environment — buildings and various obstacles, degree of vegetation cover, rocks, etc., depending on the general characteristics of air currents, sun, temperature and humidity.

A particular issue is climate change. Climate change is the variation of global or regional climate. They reflect changes in variability, or the average state of the atmosphere, on time scales ranging from decades to millions of years. These changes can be caused by internal Earth processes, external forces (e.g., variations in sunlight intensity), or (more recently) certain human activities. In the context of environmental policy, the term "climate change" often refers only to changes in climate change now, including the increase in average temperature and current weather conditions, under the name "global warming".

Climate change occurs as a result of an imbalance between incoming and outgoing radiation into the atmosphere. Increasing the amount of heat-trapping greenhouse gases (e.g., carbon dioxide, methane, and nitrous oxide) in the atmosphere increases Earth's average surface temperature. Greenhouse gas levels are higher now than at any time in the past 800,000 years. As the temperature rises, more water evaporates from ocean and other water sources into the atmosphere, causing a further rise in temperature.

Carbon dioxide in the atmosphere comes from two primary sources, natural and anthropic (human-induced). Natural sources of carbon dioxide include most animals that exhale carbon dioxide as a waste product. Anthropogenic sources of carbon dioxide have been driven mainly by human activities since the early twentieth century (industrial revolution); They are an effect of the burning of fossil fuels, gas emissions from agricultural activities and deforestation. For example, the current deforestation of the Amazon rainforest each year equates to nearly one million football cover fields. Practiced mainly for agricultural purposes, it contributes significantly to global climate change.

Climate change causes a multitude of side effects for both the physical environment of the planet and living organisms around the globe. All changes in Earth's physical environment affect plant, animal and human life. Coral reefs, forests and coastal human communities are particularly vulnerable to climate change. Some of the effects of climate change may be caused by increased susceptibility to chemical pollution. Although most of the effects of climate change are negative, in some regions it may have some benefits for human health (for example, warmer winters can reduce the number of deaths).

4.1.5 Ecological laws impacting the ecosphere

Law is an activity or rule of broad applicability that emerges from research that has similar results (so law enforcement always leads to repeatable results). Because they are believed to be immutable, they are considered laws in the respective field.

The term law in the aforementioned sense exists in all sciences. The characteristics of any law are as follows (Ro-Wikipedia, En-Wikipedia, Fr-Wikipedia):

- Law is a statement describing particular relationships between observable phenomena;
- Law is the set of conditions in a particular field of scientific research;

- Law is a general and repeatable relationship between the internal processes of an activity, or between successive stages of a particular process;
- Law is an event or formula that highlights a very, relatively stable and repeatable ratio between the sides of the same phenomenon or process;
- The law causes changes of a character/repetitive, which intervene in a phenomenon or process, expressing its essence;
- Law is an inherent and determining attribute of a phenomenon or process.

It is normal that also in ecology there are a series of laws that have been developed by various specialists over the years. We present below some of the laws enunciated so far:

Barry Commoner, in his work "The Closing Circle" presented and explained four fundamental laws (Commoner, 1980):

1. ***All are related to all.***

At the ecosphere level there is a complex network of mutual links that work on the principles discovered by cybernetics, since it deals with the cycles of phenomena that coordinate the behavior of a system. Moreover, cybernetic stabilization relationships are included in ecological and biogeochemical cycles. The cybernetic composition of an ecological system depends on the frequency of relative oscillations of the component phases. Eco-friendly systems are fluctuating and rely on a flexible control system. For the system to remain in equilibrium, however, the overall cycle speed must depend on that of the slowest phase. The speeds of various processes are subject to cyclic self-regulating relationships. Most ecological systems operate on the basis of networks of informational, energy and material relations between which there are permanent mutual links. The ecological grid is a kind of amplifier (a minor disturbance somewhere can have extensive consequences at long distances, even after long intervals of time). Due to redundant processes, the more complex the system, the better it will withstand external pressures, since any ecological system has feed-back characteristics.

2. ***Everything has to lead somewhere.***

Since a law of physics states that matter is indestructible, then in ecological systems there is no "waste". In all natural systems, what is eliminated by one organism, is used by others as food. In nature nothing disappears; Everything passes from one place to another, changing its molecular structure and influencing the vital processes of other organisms in which they can stay for some time.

3. ***Nature is the best.***

In nature there is a permanent system of self-regulation and self-improvement, for nothing disappears; anything can influence all ecological processes. Because nature is based on several billion years of trial-verification-repetition experience, living beings have made complex structures of compatible parts because anything that is not "compatible" is eliminated. However, the huge variety of chemicals existing in nature in living organisms is narrower than theoretically possible (for example, in nature there are only left-handed organic substances, and only they have specific enzymes that can "destroy" them (but not the dextrogire ones synthesized by man). Therefore, all artificial dextrogire organic compounds that are biologically active should be treated with care and great caution, because any major change introduced by man into a natural system can be harmful to that system.

4. ***Nothing can be won or lost.***

Since the ecosphere is a global system with a cohesive whole, in which nothing can be gained or lost, and which cannot be improved, everything extracted from it by human endeavor must be replaced only by other elements taken from nature.

Begon and Harper (1986), Collin (1997), Godeanu (1998), Callow (1999), Doniță & Godeanu (2019) presented other ecological laws:

- Law of complexity of ecological systems (Reimers) – Ecological systems have directed their evolution by perfecting information systems, so that processes are carried out with minimal material and energy expenditure.
- Law of exclusion (Gause) – In an ecological system two species close to the point of view Ecological REs cannot occupy the same ecological niches at the same time.
- -Law of limiting factors (Liebig) – The growth and development of a system is conditioned by that element that is in its smallest quantity.

- -Law of limitation of natural resources (generalization of Liebig's law of limiting factors) – Because natural resources are limited, an ecological system uses them as judiciously as possible, in order to ensure the self-sustaining capacity of that system for as long periods of time as possible.
- Law of migration of atoms into the ecosphere (Perleman) - The migration and circulation of chemical elements in the biosphere and toposphere occurs under the action of living components of the ecosphere.
- -Law of optimality (Rosen) – An ecological system functions optimally within certain space-time limits. As a consequence, any ecological system has a limit in its degree of extent.
- Law of tolerance (Shelford) – Every process and system in the living world possesses an optimum; this lies between the minimum and maximum thresholds of action which are, in turn, dependent on numerous internal and external factors.
- -The principle of diminishing energy effort – Through complex biocenotic interactions, the effort determined to achieve the energy flow is diminished to the maximum (it is therefore about the anti-entropic character of living components in any ecological system).

Based on the systems theory elaborated by L. von Bertalanffy, N. Botnariuc enunciated three other laws of ecology (2003):

- Coexistence of ecological systems on different levels of organization. On each systemic level of ecological organization, specific ecological systems coexist and interact, which have been structured and perfected over thousands or millions of years.
- Each ecological system is subordinated to its higher level of systemic organization. According to systems theory, in nature the system has a pyramidal structure, in which any level of organization is subordinated to the higher level to which it belongs.
- All ecological processes are carried out on a spacetime scale. Nothing arises from nothing, but is a continuity carried to a higher level of existence, which may appear suddenly, but which is then perfected over long periods of time.

Vernadsky V.I., as a biogeochemist, enunciated several laws of the "biosphere." With him in the "biosphere" the main role is played by living matter and its functions:

- Main function of the ecosphere is the continuous provision of the circulation of chemical elements between soil, atmosphere, hydrosphere and living organisms. The development of life is made possible by an permanent watering with strictly necessary chemical elements, since they are in nature in limited quantities.
- The function of permanently producing oxygen necessary for both oxyphilic biological activities, production of new organic matter and renewal of the ozone layer in the stratosphere.
- The function of living matter to redistribute atoms in the biosphere through concentration processes. Many organisms have the ability to accumulate certain elements, despite their insignificant content in the environment. Carbon comes first. Many organisms concentrate calcium, silicon, sodium, aluminum, iodine, etc. which, after dying, return to the toposphere. This is how the deposit appeared coal, limestone, bauxite, phosphorite, iron sedimentary ores, etc.
- Redox function of living matter. Living organisms have the ability to carry out oxidative and reducing chemical reactions that are almost impossible to function in inanimate nature.

4.2 The emergence and evolution of the natural ecosphere

The formation of a functional ecosphere on Earth is the result of several million years of evolution, during which different forms of living organic matter and non-living matter functioned simultaneously (but at different speeds) (Heywood, 1995; Mustață, 2011; Mustață and Mustață, 2006; Odum, 1993). Meanwhile, a multitude of complex relationships and interactions took place between different types of non-living environments and the living environment. The major role was played, from the very beginning, by the information that directed the biological processes.

In Romanian literature, the main authors who addressed the theme of the emergence and evolution of life were Botnariuc,1984, Soran and Borcea,1995.

Based on their ideas, but supplementing them with more recent data (Botnariuc, 2006; Doniță *et al.,* 2020; Godeanu and Popa, 2020, but also others) we will try to follow the path that determined the existence, as it is, of the current ecospheres.

4.2.1 The emergence of life and ecological systems on Earth

I wrote more about the emergence of life in the chapter. 3.1, when I introduced the Biosphere. According to the latest studies, life appeared in the primitive ocean. The physical and chemical characteristics of the water in the primordial planetary ocean, as well as its high temperature (caused by the very thin, barely formed terrestrial crust) were conducive to the emergence of the first life forms. Since the primordial beings were very simple, the environment in which they existed had, for a long time, a major influence on them.

Due to the great variety of inorganic and organic substances, dissolved or colloidal, present in the ocean, the food used by these proto-organisms was easy to obtain and, moreover, very diverse. Moreover, since the mode of feeding was by osmosis, this allowed the simultaneous development of a great variety of organisms, which coexisted almost without competition and which can be called osmotrophs.

As their number and diversity increased, the amount of dissolved or colloidal matter that the proto-organisms could extract from their environment decreased. As an obvious consequence, competition for access to food sources arose between them at some point. This competition resulted, on the one hand, in the beginning of a specialization in the way of feeding (hence the appearance of organisms that need certain types of assimilable substances) and, on the other hand, in the development of new ways of feeding.

Depending on the way proto-organisms collected the substances necessary for their metabolism and the increasingly diverse ways of assimilating and metabolizing these substances, two new categories of living things were added to the osmotrophs:

- consumers of substances eliminated by existing proto-organisms, as products of incomplete disassimilation and consumption of dead organisms (ie detritophagous organisms);
- shortly after detritophages, predators appeared - living things that feed on other proto-organisms (consumers of other living entities). If, from the beginning, they were not selective in terms of food, gradually they began to specialize, that is, to select certain prey, mainly by size. So, the process of specialization of the teachers has started. The capture of prey by predators was at first done only by phagocytosis.

These new ways of feeding led to the development of the first interspecific relationships. They determined the creation of the first food chains, at the base of which were osmotrophs, which in turn were consumed by different predators. All these organisms became - after death - the food of detritophagous organisms.

At the same time, the biological information, necessary for the realization of the first forms of metabolism, kept improving and led to the appearance of the first inter-individual relationships, which we can call primary ecological relationships.

The multiplication and diversification of proto-organisms led to a decrease in the substances used by osmotrophic proto-organisms. Consequently, they had two alternatives, to reduce their numbers (which would have resulted in additional pressure exerted on them by predators and thus their danger of extinction) or to adapt to a new way of feeding. The most effective alternative consisted in starting the process of synthesizing one's own organic matter - so biosynthesis).

Therefore, first it was necessary for them to find and use an external source of energy (Godeanu, 2020). For this purpose, the osmotrophic organisms at first resorted to the energy obtained by the oxidation of sulfates (so an anaerobic oxidation mechanism).

The logical consequence of this new metabolic process was that they diversified even more, giving rise to new organisms, specialized in energy production – the chemo-synthesizing organisms.

Until that time, there were no true interpopulation relationships, nor was there a well-differentiated system of ecological organization. So there was no question of the existence of a planetary ecosphere either, since primitive living things had appeared and existed only in the waters of the primordial ocean. Soran and Borcea (1985) called this state, in which organisms do not form true ecological systems, the "protobiosphere" (Figure 112).

At this stage of life's evolution, biogeochemical cycles were not yet established. There is only a linear flow of matter.

Over time, biological information became increasingly complex, but it was still imperfectly organized. However, even now we can talk about the appearance of some feedbacks and the first self-regulating informational processes.

After a while, the ocean gradually reached a shortage of simple organic compounds, those synthesized purely chemically, compounds on which the phagotrophy of the protobiosphere of osmophiles was based at first.

As organic compounds containing nitrogen (an essential element for the generation of proteins) became the main limiting factors in the synthesis of living organic material, willingly (or rather by necessity), a number of organisms acquired the ability to fix free nitrogen (taken first from water, and later also from the primordial atmosphere), Life became complicated as a result of the growth and diversification of chemosynthesizing beings (which belonged to the ecological category of primary producers).

In the same period - estimated to have taken place three billion years ago - linear geochemical processes (which characterized the protobiosphere at that time) gave way to cyclic ones, and the first attempts to realize some biogeochemical processes started (Soran and Borcea, 1985) (Figure. 112).

At this time, new, more complicated ecological processes appear, which will characterize the evolution of life in the planetary ocean.

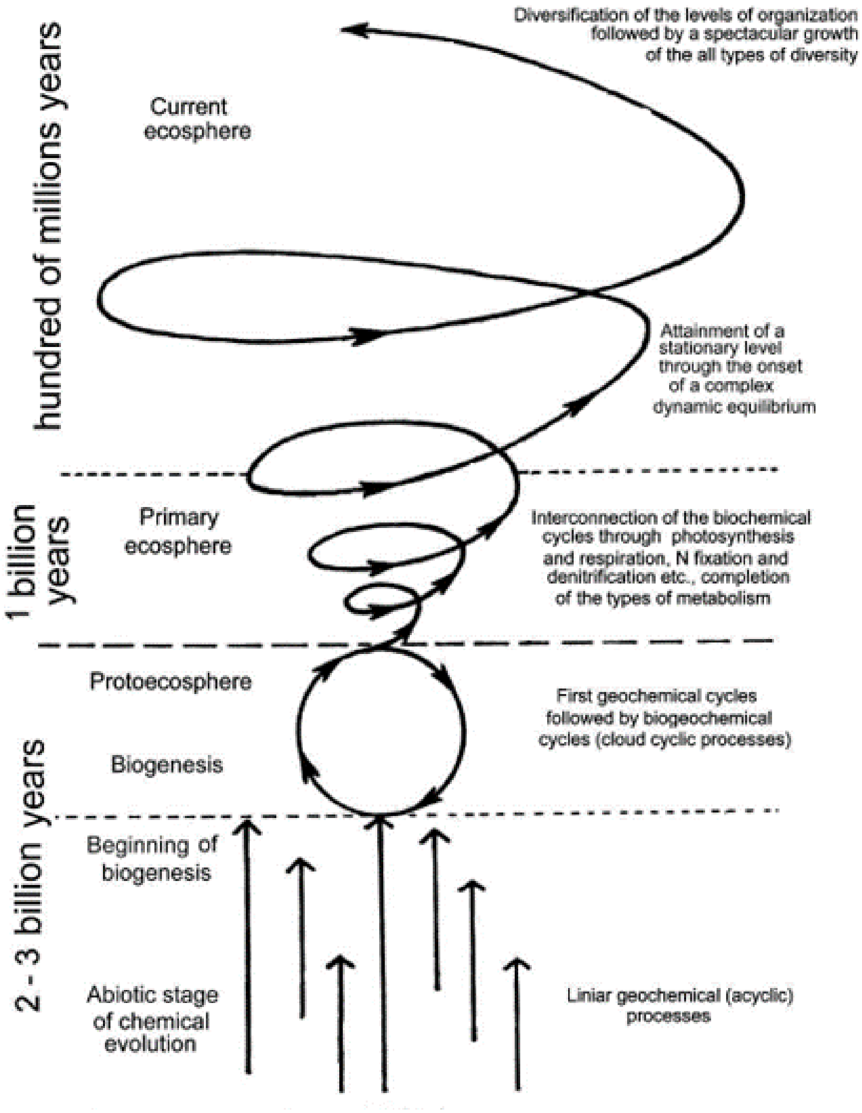


Figure 112. Material and energy flows in the evolution and complexation of living processes on Earth (after Soran and Borcea, 1985)

Emergence and evolution of the ecosphere (Godeanu and Popa, 2022).

The appearance, then the improvement of the processes of photosynthesis (a process in which the light radiation emitted by the sun was taken up by certain living organisms to serve them as a new source of energy), intervened in the synthesis of simple organic substances (such as carbohydrates of the glucose type). The development of photosynthesis led, along with the production of hydrocarbons, to the release of free oxygen - first eliminated in the waters of the planetary ocean, then, after it reached saturation, the excess was released into the atmosphere. The appearance of photosynthesis represented the first great ecological revolution, which began approximately three billion years ago (Soran and Borcea, 1985) (Figure 112).

As the result of the increasingly intense activity of photosynthetic organisms, the chemical composition of the atmosphere began to change : the amount of free oxygen increased, while carbon dioxide, carbon monoxide and methane decreased more and more. Consequently, the chemical composition of the primary atmosphere (which consisted of gaseous emissions resulting from previous volcanic activities that occurred over long periods of time and which were carried out, especially at the beginning, with great intensity (and which were anaerobic and reducing) have changed more and more, now becoming aerobic and oxidizing (Figure 113 and 114).

This new atmosphere was totally different from what the planet's atmosphere had been before. We recall that until now the primordial atmosphere had been toxic for aquatic prokaryotes (which constituted the oceanic protobiocenoses). This fact considerably delayed the conquest of the terrestrial (and aerial) environment by living organisms (Donită and Godeanu, 2021; Donită *et al.,* 2020; Godeanu, 2020, Botnariuc, 2006).

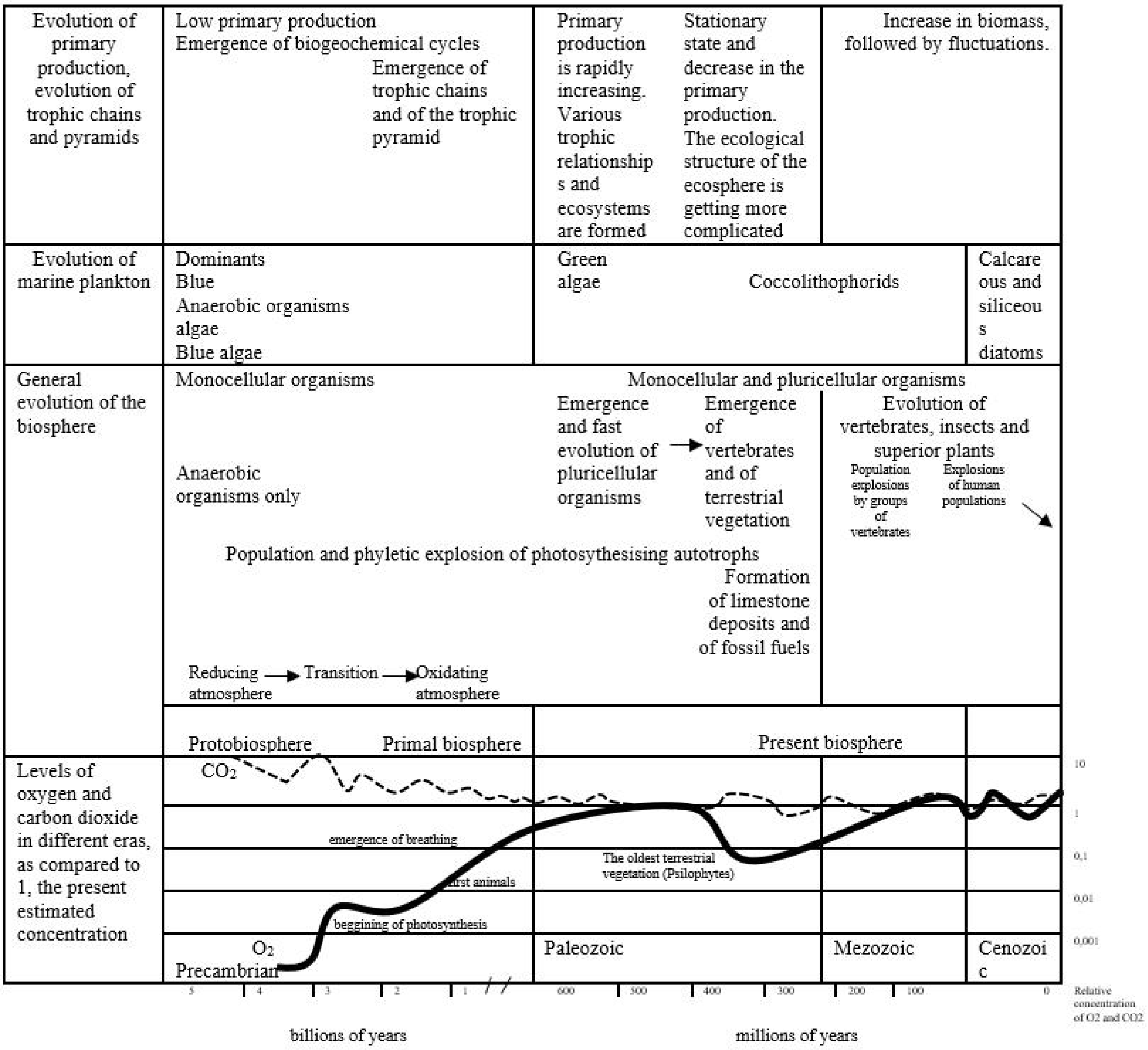


Figure 113. Major moments in the evolution of Planet Earth's biosphere and ecosphere (Soran and Borcea, 1985, modified)

Photosynthesis led to the emergece, then to the development and finally to the establishment of new biochemical processes, totally different from the previous ones (which were only anaerobic fermentation processes). About now we can talk about the appearance of the first biogeochemical cycles (Figure 112). The first to appear were the biogeochemical cycle of water and that of carbon; they occurred in the planetary ocean and primitive atmosphere.

With the appearance of photosynthesizing prokaryotes, the ratio of bioproduction carried out by chemotrophic and anaerobic organisms began to gradually decrease. We emphasize the fact that anaerobic organisms did not disappear, but continued their activity in environments that were still favorable for them (in areas where oxygen was lacking and in fermenting organic sediments deposited on the bottom of the planetary ocean waters).

After photosynthetic organisms became the main trophic link (that of primary producers), they imposed the reorganization of all trophic relationships. In the beginning the newly appeared beings had no consumers, only decomposers. This favored the excessive increase in the number of photosynthesizing organisms, which determined an accumulation of decaying necromass on the bottom of stagnant waters (a fact that initially stimulated the multiplication of anoxic organisms). Restructuring and reorganization of the ecological relationships within the planetary ocean were now taking place permanently. We recall that life was abundant in the ocean, but it had only slightly passed into the subterranean aquatic environment, where only anoxic fermenting organisms could live. The ecosphere of the planet Earth could not yet be considered to have appeared, because the ecological processes had not developed nor had they become complex, because life existed only in one living environment, the planetary ocean.

A billion and a half years ago there already existed in the ocean) two directions of matter flow and two distinct energy flows (Figures 112 and 113) (Soran and Borcea, 1985)
-on the one hand, the primordial flow - the one that took place within the existing trophic chains (and which was constantly improving), which had as their starting point the osmotrophic and chemosynthesizing organisms;
-on the other hand, the new trophic chains, which started from the photosynthesizing organisms characterized by their superior efficiency in obtaining energy.

The two directions were not opposed; they combined and at the same time diversified. Within them, interconnections between first-degree consumers were possible, and prokaryotic consumers appeared - which fed both on chemosynthesized living organic matter and on the newly emerged photosynthesizing organisms.

Over time, the anoxic biosphere was replaced by the current one, which is much more complex and balanced. The production of non-biogenic substances became less and less important, while the production of organic material resulting from the processes of photosynthesis continued to grow exponentially. This process began in the Precambrian and lasted until the beginning of the Paleozoic.

He triggered, in turn, a change in the role played by the anaerobic degrading bacteria, which had to adapt to the new conditions – that is, to also degrade the dead photosynthetic organisms. We remind you that anaerobic bacteria and fungi have not disappeared; they remain even today a particularly important category of the trophic chains, that of the degraders, effectively ensuring the decomposition of organic matter into its simple component elements, which the phototrophic primary producers then take from the environment. Thus, the functioning of those biogeochemical cycles involving most of the chemical substances that make up the lithosphere (those of carbon, nitrogen, sulfur, phosphorus and of course, that of water) was ensured.

Throughout this period of time, a new way of storing biological information appeared, which accumulated continuously, the genetic one.

We actually remind you that until about a billion years ago, the primitive biosphere existed only in the waters of the planetary ocean, where its evolution depended predominantly on external forces, namely geological, hydrological, climatic and cosmic factors.

Concomitant with the continued diversification and specialization of prokaryotic organisms, unicellular eukaryotes appeared, which were followed by the first multicellular eukaryotes – metaphytes and metazoans. In addition to the external factors already mentioned, biological ones began to play an increasingly important role in the evolution of the biosphere. These factors were specific to the activities carried out in the biocenoses that were beginning to constitute the first marine and oceanic ecosystems (especially in shallow waters, where the influence of sunlight was stronger). Intraspecific relationships, but also interspecific ones, have become more and more complicated and complex. New biocenoses appeared, which not only interacted much more strongly with abiotic factors, but also greatly changed the chemical composition of the aquatic environment and changed their physical and chemical agents.

Let's not forget that these processes were taking place simultaneously with the change in the chemical composition of the Earth's atmosphere (Figure 113).

About a billion years ago, single-celled eukaryotes (protists, represented mainly by phytoflagellates and algae) took over most of the photosynthesis activities that single-celled prokaryotes (cyanobacteria) performed, which led to a stimulation of the evolution of primitive ecosystems. For phototrophic organisms, this meant more information that had important repercussions on the level of biological information in all its forms of manifestation.

After the appearance of multicellular eukaryotic organisms (at the end of the Precambrian), the biocenotic structure became more complex, so that during the Cambrian the niches of all species were increasingly well structured and occupied by a growing range of living beings. There has been a lengthening and complexification of trophic chains at the level of all ecosystems, more and more diverse trophic networks have appeared and the use of energy transfers from living organisms has become more and more efficient.

As food was used less in the metabolic processes of various organisms, its efficiency (therefore, that of material and energy resources) gradually increased. This was a consequence of how informational capacity improved at the level of living matter.

Ecologists have determined that the current efficiency of energy transfer is as follows:

- the energy efficiency of chemosynthesizing organisms is 0.2-0.5%,
- the energy efficiency of photosynthetic organisms increased up to 1-5%,
- the energy efficiency of primary consumers increased to 5-10%,
- the energy efficiency of secondary consumers has reached 10-20%,
- the energy efficiency of tertiary consumers has reached 30-40%.

Until the Silurian, the earth's "ecosphere" was limited to the planetary ocean, while the atmosphere and terrestrial environment were devoid of living things (given that they did not have the ability to live in environmental conditions totally different from those that evolution had taken place until then).

The first important step was also achieved in the aquatic environment, because here, with time, biological processes started to intensify the oxidative processes that take place in terrestrial rocks. And here, especially through oxidative processes, all kinds of new salts appeared, which accelerated the erosion processes, and, thanks to precipitation and air currents, generated the first deposits of sedimentary material. There are several factors that further favored the tendency of marine living beings to conquer new environments: the air reached a concentration of free oxygen close to that of the current atmosphere, the protective layer of ozone appeared in the stratosphere, the atmosphere low was characterized by significant cloudiness, and the large amount of precipitation that fell on the earth influenced the climate of that period, the air being almost saturated in water vapor.

Beginning with the Precambrian (about a billion years ago), semiaquatic ecological systems (those in salt marshes and freshwater ones) appear and develop, and ecological systems appear in continental fresh waters.

Only from now on can we talk about the existence of a proto-ecosphere of the Earth. Until now, ecological systems specific to a certain living environment had been created, populated with living organisms perfectly adapted to the existing non-living system.

The first living things to leave the planetary ocean were microscopic photosynthesizing prokaryotes (cyanobacteria); they were followed by protists and photosynthesizing eukaryotes (algae). Both groups initially populated stagnant brackish waters. Only then did the more primitive multicellular eukaryotes appear, followed by the lower plants (Psyllophyta and Pteridophyta) that grew in fairly shallow and warm freshwater, and then in swamps and wetlands.

These organisms have long continued to use aquatic environments for the reproduction of gametes and the development of their spores. To leave the water, plants had to acquire a way to strengthen their body structure and develop anti-gravity systems that allowed them to rise above water and wet soil, features that were not necessary for living in the aquatic environment. The last plants to move into the terrestrial environment were mosses and higher plants (Angiosperms and Gymnosperms). Nowadays, these autotrophic groups are clearly the dominant primary producers in terms of diversity. With their appearance, the foundations of true terrestrial ecosystems were laid (those that later generated the present-day vegetation of the Earth and constitute the first link in the food chains and webs of all terrestrial ecosystems today).

Semi-terrestrial and terrestrial plant consumers also came from aquatic and semi-aquatic environments, but somewhat later. The first to develop the ability to live and feed (as adults) in an aerial environment were those that went on to reproduce and develop ontogenetically in water (eg amphibians, pulmonate molluscs, some insects). Later came the aerophilic organisms, which at first depended on a very humid environment, and only later appeared those which are actually considered terrestrial (tolerating more or less humid environments).

From that period (from the Silurian) paleontologists found the first fossils of animals that lived in swamps and strictly terrestrial environments (Figure 114).

About 600 million years ago, after optimal ecological conditions had been established, a seconde explosion of morphological biodiversity occurred. The result was an expansion of the three major kingdoms of today: plants, animals and fungi. This process was achieved as a result of a close co-evolution of primary producers with their consumers and their various types of degraders.

Emphasis must be placed on the increasing importance of decomposers in the recycling of plant necromass in terrestrial environments. Once processed and mixed with fragments of eroded terrestrial rocks, the necromass participates and contributes to a great extent to the generation of soils, the development of terrestrial vegetation, and at the same time it led to the appearance above the lithosphere of a new, very important covering – the pedosphere.

Under the action of precipitation, the necromass and part of the soil slowly penetrated the superficial layer of the lithosphere, slipping through the voids and cracks in the rocks. They created the conditions for the emergence of a new type of ecosystems, the ones that currently constitute the underground environment. These ecosystems still depend on allochtones matter and energy, that provided by the living environments existing on the surface of the lithosphere.

The conquest of the terrestrial environment has led to the emergence of new intra- and interspecific relationships, in a growing variety of ecosystems - from the first, developed in wetlands, to those that now populate deserts and mountain areas.

From now on we can talk about the existence of a complex ecosphere, specific to planet Earth.

A particularity of the most evolved beings (appearing within all the main groups of living things), is the emergence of social life, in which survival and exploitation of natural resources have reached a higher stage of energy efficiency.

Over time, the biosphere has populated the entire globe, reaching its current extent, while the ecosphere has achieved remarkable diversity.

The great diversity of the biosphere controlled and conditioned the state and quality of the ecosphere and its supra-ecosystemic levels. Within the ecosphere, biodiversity was the main factor regulating biogeochemical cycles, hydrological processes and had a profound influence on the specifics of local climates, controlled the chemical composition of air and water, contributed to soil stability, etc. All this was possible precisely because biological information is the driving factor of all informational processes at the planetary level.

Ecogenesis is closely related to the phylogenetic diversity of living organisms and the degree of refinement of interspecific relationships, as well as the relationships between organisms and their environment.

The appearance of new species determined the start of new ecological refinements and implicitly led to increased stability of all types of ecosystems, because the competition for occupying niches accelerated phylogenetic evolution. In all cases, the chances of winning this competition (aiming at the development and improvement of ecological systems) go to the organisms with the greatest capacity to adapt to the real, concrete, living conditions.

The greatest progress must be related to the complexity of interspecific relationships and to the stability of the system - thus, to the achievement of a cenotic homeostasis, which allows a more harmonious cooperation of all the mechanisms of preservation and improvement involving life in a more complex way. The environment (both non-living and living interconnected) work together in a more harmonious manner. This homeostasis is achieved through a continuous improvement of the retroactivities that work within a given ecological system and in the conditions of a very high biodiversity that brings an increasingly better developed and more efficient biological information.

The aforementioned statements are illustrated by the evolution of living matter and the natural ecosphere as shown in Figure 114.

Over time, as a result of a continuous evolution of biological and ecological systems, of the formation of well-organized systemic levels, a very high degree of stability and resilience has been reached - which unfortunately is now threatened by an atypical species and increasingly the most aggressive, *Homo sapiens*, whose actions have effects of an incomparable amplitude and are at the same time very difficult to counter, considering the exacerbated egocentrism of the given species.

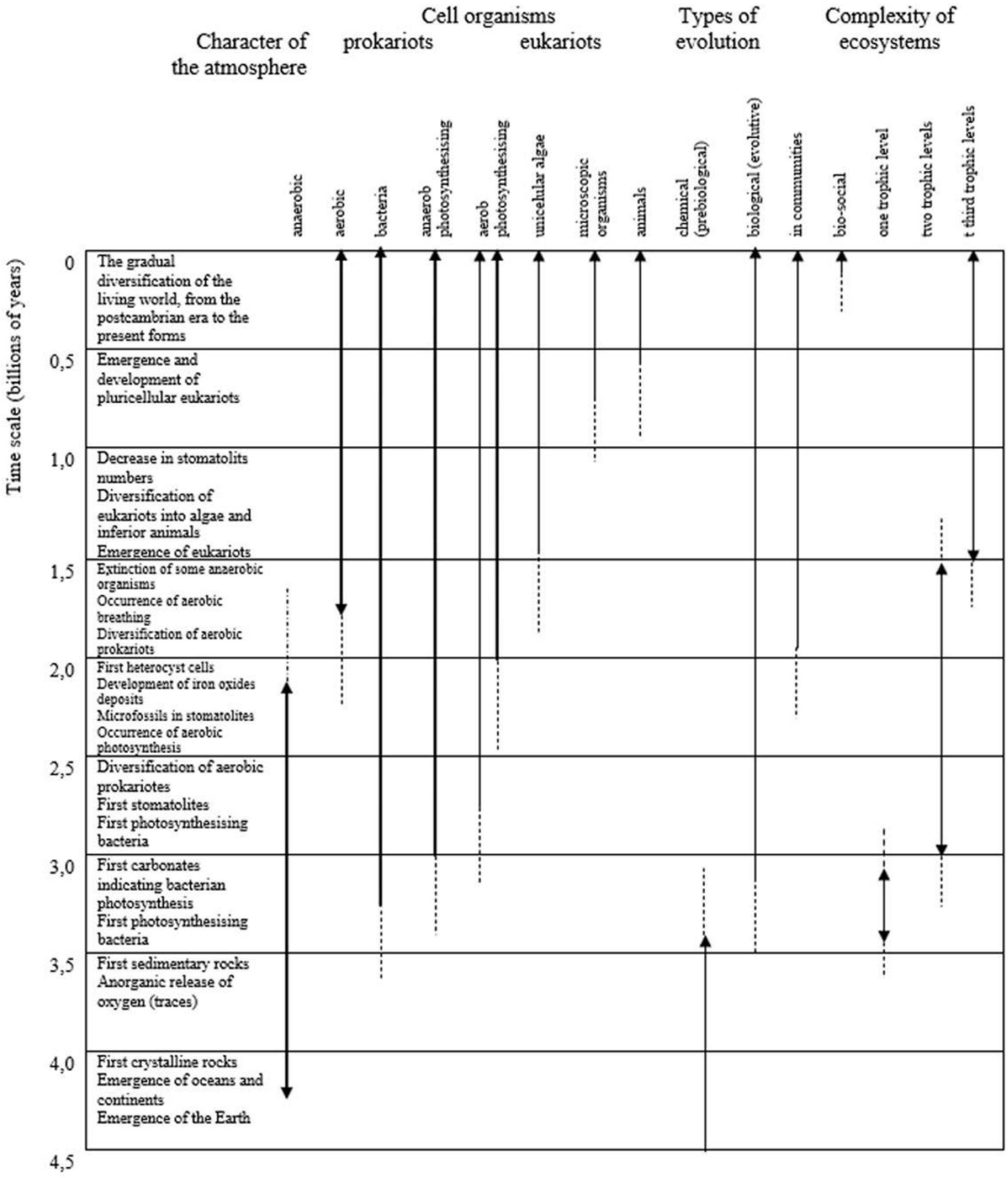


Figure 114. The evolution of living organisms, from macromolecules to the biosphere and then to the ecosphere (Soran and Borcea 1985, modified)

The current ecosphere of the earth is a natural construction that has arisen and improved continuously and that differs fundamentally from the way in which the evolution of the other planets in our solar system took place.

Its germs appeared soon after the Earth formed and its solid crust developed. Life arose in the primordial planetary ocean, as a result of the interactions of non-living factors, which initially did not differ much from those existing even now on other planets.

Life has a special ability to create a new type of informational pattern. It is characterized by self-regeneration, self-regulation and redundancy, precisely as a result of the existence and continuous improvement of the storage (memory) and information processing capacity. Through its representatives (living organisms) life very soon assumed the role of coordinator of the main processes taking place at the planetary level.

As a result, the non-living components – the atmosphere, hydrosphere and lithosphere – have been and are permanently influenced by the biosphere. Their harmonious interaction led first to the emergence of the pedosphere, and later to the genesis of the Earth's ecosphere.

The levels of organization of living matter that we currently recognize are : cell, species (through its populations), biocenosis, biolandscape, bioregion, biome, and biosphere (Figures 50 and 51). The first two levels took place only in the biological, individual stage of the organization of living matter and are studied by various branches of biology. The others appeared after living organisms, organized in forms clearly dependent on abiotic factors, are studied by both biologists and specialists from other fields of natural sciences (especially ecologists and geographers). These levels of organization of living matter took place in the ecological stage of organization of living matter, that of integration of living with non-living matter (Figure. 51)

A special role was played by the transition from the use of chemical energy (obtained by simple chemical reactions), to that obtained by reduction processes and finally by the transition to the use of the most active chemical element – oxygen – which (as a free element) was rare in the primordial atmosphere of our planet, but which was "discovered" and then consciously "produced" by living beings through the input of light energy brought by the sun of our solar/planetary system. Thus, oxygen has become the key element for the development (on a global scale) of most energy processes.

Life progressed from organic macromolecules that had the ability to metabolize and reproduce themselves, to proto-organisms, then to single-celled prokaryotic organisms, and finally to eukaryotic ones. All these types of living things still exist today; they appeared in the primordial marine environment, conquered the brackish environment, then the fresh waters, the land and the underground environment.

Living beings created two planetary shells: the biosphere (the living shell) and the pedosphere (the dead, decaying organic material, which, mixed with fragments of lithosphere, under the action of specialized organisms, became the main support of life in terrestrial and underground environments).

The interconnections between the biosphere and the non-living layers of the Earth (atmosphere, hydrosphere, lithosphere, but also the pedosphere) generated the natural ecosphere, which continues to evolve; she permanently coordinated, but subtly, under the action of biological information, the interactions with the non-living coverings of our planet. The natural ecosphere has changed the way cosmic energy currently manifests at the planetary level. Moreover, it now protects the planet from the various influences that may come from the cosmos. Solid bodies (Figure 105), constantly fall on Earth, which quickly oxidize when passing through the atmosphere, and only the largest reach the crust of the lithosphere (but in the form of small meteorites, which almost do not endanger the proper functioning of all the planet's coverings). The proof is the periods of the year when you can see showers of shooting stars in the sky. If it were not for the atmosphere, we would have had meteor showers, as they are falling on the earth's satellite, our moon.

We have something else to point out. The adjustments determined by biological information are of extreme finesse and ensure the development of all processes and a good interconnection, but within variation limits that ensure permanent fluctuations of all parameters.

We are convinced that the current biosphere, thanks to the huge amount of information it has gathered over the geological ages, will be able to ensure the stability of the terrestrial ecosphere until the appearance of larger, but unforeseen, cosmic or anthropogenic factors could endanger the continuity life of our planet.

4.2.2 The pedosphere

The pedosphere is the soil covering of the Earth. We specify from the beginning that the pedo-sphere is not part of the toposphere, but is a terrestrial product resulting from the interaction of all the components of the toposphere with the biosphere and its necromass.

The soil is the thin and loose blanket on the surface of the dry lands of the lithosphere. It is a discontinuous shell, which was formed by the destruction of rocks by the other components of the toposphere and biosphere, but which was mixed with organic matter resulting from the decomposition of dead organisms (necomasa) and functions as a result of the action of specialized organisms in achieving this trial.

At the soil level, physico-chemical, biological and biochemical processes intertwine that form the basis of the living shell created by terrestrial plants, in which they plant their roots in the soil and from where they get their mineral salts and water. Soil is not similar to the rocks on which it is formed, which gives it the quality of a complex, fertile, biologically active layer, having the ability to store air and water and, of course, the ability to protect the lithosphere.

The pedosphere has an average thickness of about 5 m (but it can vary from a few centimeters (in the area of mountains and steep hills) to several meters (in the area of forests and especially steppes in areas with temperate climates). Soil flora and fauna (pedobiota) is part of and also contributes to the development of pedogenetic processes. It is more common in the upper layer of the soil and, according to the feeding method, it is made up of chemotrophic, autotrophic, saprophagous and zoophagous organisms.

The pedosphere is that natural resource of the Earth that has the main role of providing elements necessary for the development of agriculture. At the same time, the soil located at the interface between the lithosphere, hydrosphere and atmosphere is a component of the hydrological circuit, influencing water exchanges between various compartments of this circuit. One of the peculiarities of the pedosphere is its great variability, both in space and in time. The soil is regarded as a living, dynamic, complex, porous, triphasic environment - solid, liquid, gaseous phase - phases that generally present many heterogeneities. In general, soil water and air occupy about 50% of the volume of the pedosphere, organic material from living organisms and their products about 5%, while about 45% is occupied by the mineral component.

The Solification

Soil has been defined for a long time as the layer on the surface of the lithosphere whose particularity is similar to its specific characteristic, fertility. A basic characteristic of soil fertility is its loosening. It was produced by the simultaneous action of a complex of natural factors (called pedogenetic factors).

In the terrestrial environment, the structure of the lithosphere was initially made up only of minerals and rocks that could not provide conditions for its population with living organisms. In the course of time, under the action of the agents of the atmosphere, the hydrosphere and the first pioneer living organisms, conditions appeared for the disaggregation (shredding of the components of the lithosphere) and for the alteration of their chemical composition. That's how the solification process began. Over time, bioaccumulation also took place (the accumulation of dead organic matter – especially the necromass of plants that at first only settled in the fragmented remains of the lithosphere – sand and mineral dust). As a result of the diversity of the local mineral composition of the lithosphere, over time, conditions were created for the formation of a succession of horizontal layers of the soil, which differ in color, thickness and structure, layers that pedologists now call "a certain type of profile of soil" and which differ according to numerous physico-chemical and biological factors (vegetable and animal organisms, climate, rocks, relief, phreatic and stagnant water, time, and now also man), globally known as "solification factors" .

The main factors of solification

One of the main factors of solification is **the climate**. In chapter 2.3.5. I briefly mentioned the climate as an interaction factor between the toposphere and the biosphere. The main climatic factors are temperature and humidity (they are followed by the living component) (Table 24).

Table 22. The main types of climates at the planetary level and the sum of their annual temperatures (by Neagu *et al.,* 2002)

Climate group	The sum of air temperatures over 10°C
Cold (polar)	Less than 600
Cold Temperate (Boreal)	600-2000
Warm Temperate (Subboreal)	2000-3800
Warm (subtropical)	3800-8000
Torrid (tropical)	Greater than 8000

The thermal and hydrological regime of soils, the nature and speed of climatic and biochemical processes and their biological productivity are related to these climatic groups (Xenophon et al, 1998).

The second main factor of solification is **the set of organisms that create the soil.** Plant remains (necromassa) are subjected - under the action of living organisms that populate the soil - to complex transformation and/or mineralization processes that can go as far as releasing the basic constituent elements, those necessary for the development of vegetation on these soils, i.e. carbon dioxide , water, atmospheric gases and simpler mineral salts. There are also situations when they turn into new, more complex combinations (we are referring especially to the humus in the soil).

Along with the upper vegetation, a great influence is exerted on the pedogenesis by the representatives of the soil fauna, i.e. the invertebrates and vertebrates that populate its different horizons. The following types of fauna can be distinguished in the soil (Mathieu, 2011, Chiriță, 1955):

microfauna - organisms smaller than 0.2 mm (bacteria, protists, nematodes);
mesofauna - animals with a size of 0.2-4 mm (worms, microarthropods, some insects, millipedes);
macrofauna - animals 4-80 mm in size (earthworms, molluscs, insects, ants, termites, etc.);
megafauna - animals larger than 80 mm (large insects, crabs, scorpions, moles, snakes, frogs, rodents, foxes, badgers and others).

Earthworms have an exceptionally intense action on the soil, which, through their activity, release specific biochemical compounds into the soil, not produced by any other agent in nature. Annually, they pass through their intestine (calculated per 1 hectare of soil), between 50 and 600 t of fine earth. A somewhat similar role can be played by some insects and their larvae, as well as other soil-dwelling animals. The biomass of invertebrates in the soil is about 1000 times higher than that of vertebrates.

While higher plants are the main producer of necromass, microorganisms have the basic role in its decomposition. Each type of soil has its own specific distribution (on the profile) of microorganisms. Their number and composition by species reflect the most important properties of the soil. The amount of bacteria and fungi in the arable soil layer represents up to 5 t/ha; the number of bacteria reaches billions of cells per 1 g of soil, and the length of fungal hyphae up to 1,000 m per 1 g of soil (Babieva, Zenova, 1983, cited Mathieu, 2011). The development and nature of biochemical, nutritional, oxidation-reducing, soil aeration processes, alkaline-acid reaction conditions, etc. are closely related to the action of microorganisms.

The biological component of the soil is closely related to the ecological-geographic laws of the distribution of soils on the surface of the earth and reflects the mutual relations that are established between the organic factors and the other factors in the pedogenesis process.

The local climate, the soil, the plants, the animals and especially the microorganisms that live in the soil, the relief conditions, the parent rocks, the surface water and the ground water form an extremely complex system characterized by a great interdependence.

The composition of the parent rock exerts a great influence on the granulometric, chemical and mineralogical composition of the soils, their physical and physical-mechanical properties, the air and heat regime. The interaction between the characteristics of the soils and the character of the parent rock, in the primary stages of pedogenesis, reflects the characteristics of the alteration crust (therefore of the lithosphere) on which they were formed (different soils are formed on the same rocks, in different climatic, vegetation and relief conditions) . The parent rock also plays an important role in the formation of the structure of the soil cover. Moreover, with a uniform parent material, a great uniformity of the soil cover is found, while in conditions of great diversity of parental rocks with varied relief forms, a great complexity of the soil structure and the vegetation that grows on them is noted .

The relief is one of the most important factors of soil formation, which exerts a particular influence on the genesis and structure of the soil cover, its contrast and spatial inhomogeneity. It was found that there is a close connection between the topography of the soils and the concrete landscape conditions. Pedologists have established three types of relief (Chiriță, 1955): macrorelief; mesorelief and microrelief. Each of these soil types plays a decisive role in the pedogenesis process.

The macrorelief includes the most representative forms of relief (mountains, plateaus and plains). The origin of the macrorelief is mainly related to the tectonic phenomena that took place in the lithosphere. The mesorelief is represented by medium-sized landforms such as hills, hills, valleys and terraces. The occurrence of the mesorelief is linked to exogenous geological processes (such as denudation processes and the formation of continental deposits). The mesorelief determines the structure of the soil cover of the different landforms.

The microrelief is given by the small forms of relief that occupy almost insignificant surfaces and that have relatively small oscillations of their height (mounds, depressions, roofs). They appear on flat relief surfaces as a result of subsidence phenomena, deformations caused by frost, but they can also appear for other reasons.

Relief is the main factor redistributing solar radiation and precipitation depending on exposure and slope inclination. It exerts a special influence on the hydric, thermal, nutritional, oxidizing and saline regime in the soil.

Groundwater and stagnant water are important factors in the solification process. Solification occurs under normal conditions under the action of precipitation falling in one area or another. Water from precipitation or surface runoff frequently accumulates on the surface of the soil. In the presence of excess water, solification acquires certain peculiarities: due to poor aeration, reduction processes predominantly take place, forming reduced compounds of iron and manganese. When groundwater is close to the surface and contains soluble salts, processes of salinization (accumulation of chlorides and sulfates) and alkalization (sodification) occur.

Today's soils are the product of the long and complex geological history of the Earth's surface. That's why **time** can also be considered a solification factor. Regarding the absolute age of the current soils, it is necessary to take into account the geological age at different points of the earth's surface, an age that oscillates within wide limits, practically from zero to millions of years. The land surfaces that have been freed from the waters that covered them have zero age. Surfaces covered by the lava of volcanic eruptions or the ash of current eruptions, as well as fresh sections in rocks created by man through construction works, quarries, mining, or the construction of communication routes, also have zero age.

The relative youth or age of soils can be assessed according to the degree of development of their profile, according to their degree of impoverishment in some chemical compounds in relation to the rocks of formation, according to the degree of accumulation of some components, or others, etc.

Anthropogenic activities are currently the main pedogenetic factor and also the most active. Irrational exploitation of the soil produces both the reduction of its fertility, the destruction of the natural stratification, its thinning (which can go as far as the total destruction of the soil layer) or the start of desertification processes.

The combined activity of several solification factors is the most widespread process. That is why it can be said that the soil is the result of the combined action of all the factors that intervene and influence each other. The above are illustrated in figure 115:

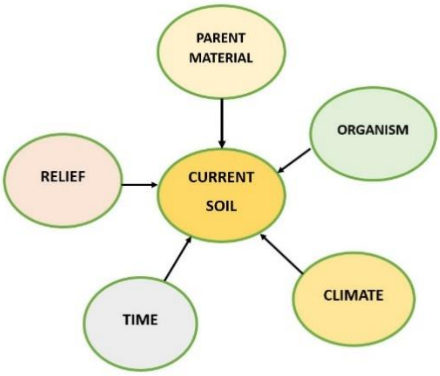


Figure 115. The main factors of solification

Pedogenesis

The pedosphere is the first stage of ecosphere formation in the terrestrial environment (Fitzpatrick, 1971; Chiriță, 1955).

Pedogenesis takes a long time. The duration of formation of a soil layer with a thickness of 3 cm is 300-1000 years. The formation of a 20 cm soil layer can take approx. 2000-7000 years. On the other hand, the destruction of the soil under the influence of erosion or other disturbing factors of the pedogenesis process can take place in a few years, or even less (for example, tourist paths on the tops of mountains erode the thin layer of soil extremely quickly, country roads undeveloped, made directly on the ground are another local soil degradation factor, as well as floods caused by different human activities on the respective territory). The main physical process is disaggregation, which is the initial stage in soil formation (on hard rocks). The processes of a chemical nature are known as alteration, and include all the chemical transformations that the soil undergoes. Biological processes are particularly related to the accumulation of organic matter in the soil, and then to the processing by soil organisms of all the components that will constitute the future soil (Figure 116).

Figure 116. Starting the pedogenesis process on a calcareous stone by forming a biofilm of lichens, mosses or other plants

The process of soil formation is dominated by the chemical breakdown of silicate minerals, aided by the acid products of pioneer plants and organisms, as well as the input of carbonic acid from the atmosphere. Carbonic acid is produced by the carbonation reaction. It helps break down carbonate minerals (such as calcite and dolomite) and silicate minerals (such as feldspar); these reactions result in high levels of bicarbonate (HCO3), sodium ions and silica in the effluent. The decomposition of carbonate minerals is done by the subsequent dissolution of carbonic acid and bicarbonate, which leads to the appearance of carbon dioxide gas. Oxidation also contributes to the breakdown of many silicates and the formation of secondary minerals in the early soil profile (this is the so-called phenomenon of diagenesis). Oxidation of olivine releases Fe, Mg and Si ions. Magnesium is soluble in water and is carried with runoff, but iron often reacts with oxygen to precipitate hematite (iron oxide). Sulfur, a byproduct of decaying organic material, will also react with iron to form pyrite. The dissolution of pyrite leads to high pH levels as a result of the increase in the number of hydrogen ions and the subsequent precipitation of iron oxides, thereby changing the redox conditions of the environment.

The main basic mechanisms in the pedogenesis process are:

- The fragmentation process of the material from the lithosphere. The rock is progressively fragmented, a fact that favors the subsequent physico-chemical alteration
- The dissolution phenomenon. Some water-soluble minerals tend to disappear because they are carried underground by water, while others (the least soluble) remain and gradually accumulate causing soil salinization;
- The hydrolysis process. If the dissolution leads to the passage into solution of the ions originating from the minerals existing in the local lithosphere, the hydrolysis is a somewhat more complex process, in the sense that the ions in the solution provide the future soil with new minerals;
- The oxidation-reduction phenomenon. If the soil contains little oxygen, if the water is in excess for a while, some minerals (for example iron) can oxidize or reduce, which means that new oxides with different compositions and colors appear. These processes are facilitated by the metabolic activity of soil microorganisms;
- The transfer process. Many ions can enter or leave the soil either by washing or by complexing with more soluble ions;
- Precipitation processes. In the middle or lower layers of the soil, precipitation of transported elements can occur for various reasons (changes in pH, reduction of the amount of water that could transport salts deeper into the soil, etc.);
- Formation of new chemical compounds. Alteration, transfer or precipitation phenomena bring together ions that can coprecipitate creating new minerals. In the case of an environment very poor in water, calcium can associate with carbon dioxide and calcium carbonate inclusions appear, that is, limestone is formed
- Horizontalization occurs in flat areas, so in most soils that have parallel horizontal layers (distinct horizons). In sloping areas, old soils tend to slide, thereby complicating leveling. As a consequence, more complex volumes can appear in these soils (eg soil lenses characterized by a different physico-chemical composition, etc.).

The multitude of these factors that can compete to create soils, together with the occurrence of other random or short-acting factors, leads to the existence of a great variety of soils, which differ in their physical, chemical or biological properties.

The process of soil formation (pedogenesis) is shown schematically in figure 117.

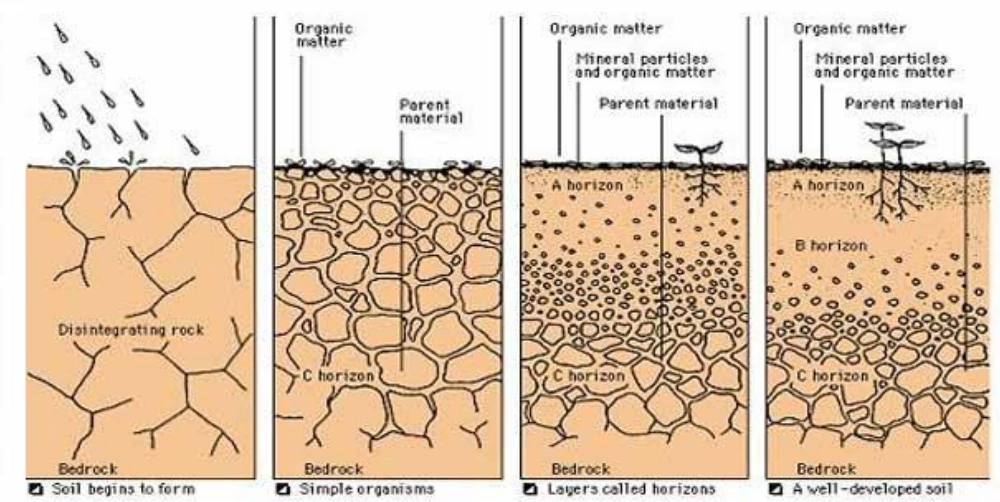


Figure 117. Stages of soil formation (pedogenesis) (https://civileblog.com/formation-of-soil/)

Soil properties

The most important property of the soil is **fertility** (a process that provides plants with nutrients, water and air, thus ensuring their good development) (Buckmann et al, 1960, Calvet, 2003).

- The color of the soil is the most important property in recognizing the types of soils and is given especially by the composition of its solid part. Depending on their composition, horizons in a soil profile have different colors.
- Texture refers to the proportion of clay, dust and sand particles. Fine texture means high clay content and coarse texture means massive presence of sandy particles.
- The structure considers the grouping of soil particles in aggregates of different shapes and sizes.
- The soil profile represents the vertical sequence of the component layers of the soil. These layers with different thickness, composition and properties are called horizons. Their number, type and sequence is specific for each type of soil (Figures 118 and 119).

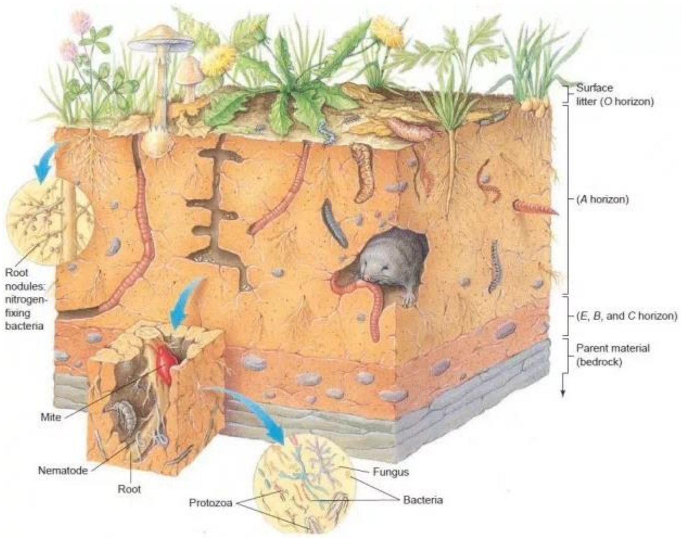


Figure 118. Soil horizons and its biota https://geography.name/soil-development)

The soil profile represents the vertical sequence of the component layers of the soil. These layers with different thickness, composition and properties are called horizons. Their number, type and sequence is specific for each type of soil (Figure 119).

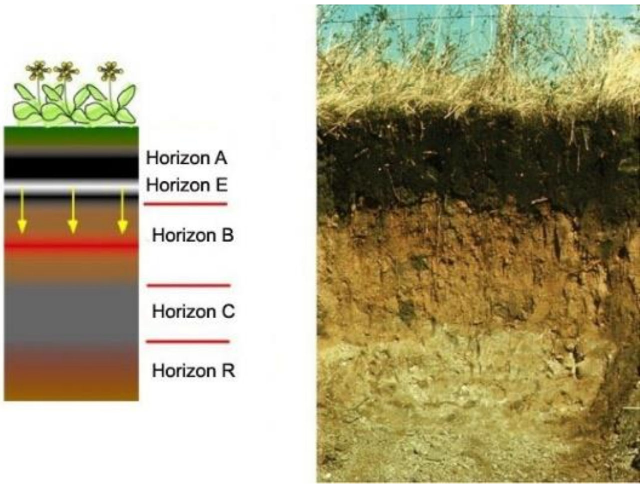


Figure 119. The main common horizons of a soil profile (Wikipedia)

The main horizons of the soil profile are:

O - horizon formed by the accumulation of decaying organic matter on the soil surface. It is also called litter box.
A - horizon composed of organic and mineral components, located on the surface of the soil and characterized by the accumulation of humus, generally having a black or dark brown color.
E - horizon composed of mineral components (mainly sand and dust) due to the washing of clay particles towards the lower horizons and being generally light in color.
B - clay-enriched horizon that originates from either substrate alteration or the accumulation of washed clay from the upper A and E horizons.
C - mineral horizon formed only by disaggregation of the substrate.
R - the hard substrate of litosphere, unaffected by pedogenesis processes.

- Solid part of the soil comprises mineral matter derived from the disintegration and alteration of the substrate and matter organic matter from the accumulation of plant and animal debris.
- The liquid part of the soil is represented by rainwater or underground water, which when passing through the soil is loaded with different soluble substances, making up the soil solution.
- The gaseous part is given by the soil air, which comes from the atmospheric air but has a different chemical composition due to the incessant biochemical processes taking place in the soil.

Pedologists have established that soils have the following properties (Chiriță, 1955):

- physical properties: texture, structure, density, porosity;
- water properties: permeability, hydrophysical indices;
- chemical properties: soil reaction, buffering capacity, soil solution;
- aeration and thermal properties: air permeability, soil air composition, thermal properties.

Types of soils on Earth

Soils do not exist on the entire surface of the terrestrial environment. Soils are absent in polar regions, in deserts, in high mountain areas with very steep relief (because here they are washed very often by precipitation (which is abundant). It is, from case to case, of different thicknesses. Soils are constantly in activity ; that's why they are sensitive to the action of different environmental factors. Currently, human actions most strongly affect the structure and quality of soils. They are best preserved when they have as thick a cover as possible with vegetation (Figure 120) (Calvet , 2003; Legros, 2007).

The distribution of soils on the globe depends mainly on their latitude, altitude and the size of the landforms on which they were formed.

1. At high latitudes, so near the terrestrial poles, there are cold zone soils. They are called tundra soils, have low fertility and are frozen for a good part of the year.
2. In temperate zones, coniferous and deciduous forests and steppes (land without forests) dominate. The following soil types are found here:
    - under the coniferous and mixed forests there are podzolic soils. They have low fertility, are acidic and contain a small amount of humus.
    - under the deciduous forests are the clayey soils. They have medium fertility and are brown or reddish-brown in color.
    - in the steppe areas of temperate-continental climate there are chernozeomic soils. They are the most fertile soils, black in color and rich in humus.
    - in the Mediterranean region are the so-called terra-rosa soils. They are soils with a fairly high fertility, red in color.
3. In the warm areas of the earth there are deserts, savannas and tropical forests. The following soil types are found here:
    - desert soils. They are thin and form especially in oases, in the vicinity of the few places where water exists permanently on the surface of the earth. They have low productivity and are gray in color.
    - soils from sub-equatorial savanna areas. They are soils with relatively high fertility and have a red color.
    - the soils of the equatorial forest areas are the so-called lateritic soils. They are poor in humus, they are in areas where abundant precipitation falls (usually daily), there is high heat, conditions that cause a rapid decomposition of plant remains, therefore making it difficult to form sustainable soils. Soils in equatorial forests are red in color.

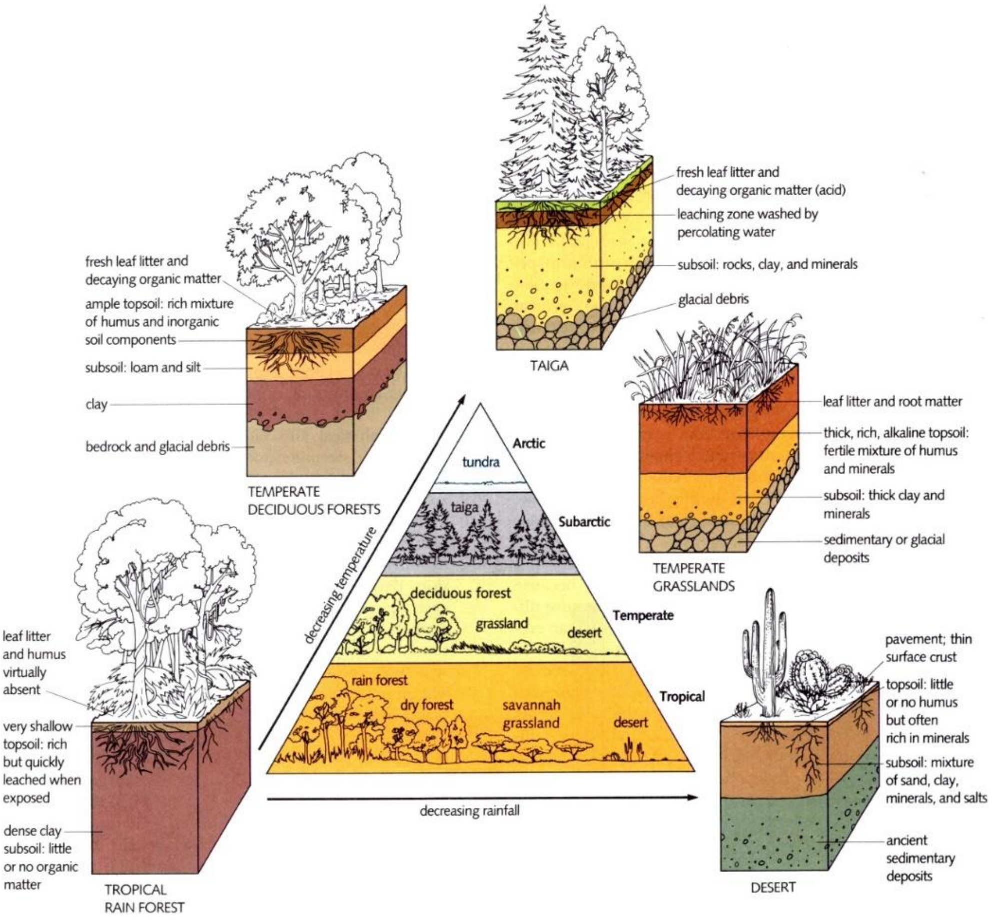


Figure 120. Soil types and their share on Earth (Levine and Miller, 1994)

The role of soil as an environmental factor

The soil, by its nature, is a support and living environment for plants, and through its content in humus, it creates the main links in the chains of the geochemical cycles of the elements, from the synthesis of organic matter to the products resulting from their mineralization.

Pollutants accumulate on the ground in the form of dust from the air, toxic gases dissolved by rain, polluted infiltration water, polluted rivers, irrigation with polluted water, accumulations of household or industrial waste. Residues of all kinds that have not been discharged into water and air can cover the land, infesting agricultural lands where they are more fertile and spoiling the landscapes so sought after for their beauty.

The destruction of the soil cover or its replacement with biologically unproductive territories, which has intensified around the globe in recent times. This will lead to important, some unpredictable, changes in biogeochemical processes and cycles, as well as in climate regimes, resulting in changes unfavorable to life in general.

If the destruction of the soil cover continues, the disturbances in the functioning of the biosphere will affect larger and larger areas, eventually leading to catastrophic disturbances. That's why specialists are currently focusing on researching the complicated negative regional phenomena of aridification and desertification, climate change, dangerous environmental pollution through acid rain or other methods, as well as on measures to prevent these phenomena.

The functions of the pedosphere in connection with the hydrosphere are very important. The soil plays an active role in the Earth's hydrological cycle by determining the ratio between evapotranspiration in the atmosphere, surface runoff in rivers and underground infiltration from the precipitation that falls on the land surface, thus participating in the local or regional water balance and implicitly, in the general one of the land.

The soil retains water from precipitation or condenses water vapor from the atmosphere forming water reserves, filters the water that percolates into groundwater or groundwater. Soil water reserves are used in the evapotranspiration process in relation to the amount of biomass that has been synthesized and the aridity of the climate. The plant cover that covers the soil causes an increase in the humidity of the air near the soil and implicitly its protection.

Percolation and seepage water dissolves many soil components influencing the chemical composition of the groundwater or rivers it reaches and carrying soluble products of weathering and solification, including metabolites of biological processes.

Depending on the type of water balance in the soil are also the characteristics of the soil and groundwater, that is:

- the evaporative or exudative type of balance, specific to arid regions, determines the formation of mineralized waters and saline soils especially in low-lying areas (to which leakages occur local)
- the percolative type of water balance in the soil, specific to humid regions, with permeable soils, leads to the formation of intensively washed soils, impoverished in mineral elements, with high acidity and low fertility;
- the accumulative type of soil water balance in marshy lowlands or around lakes or seas is responsible for water stagnation and anaerobic conditions, often accompanied by the formation of sulphides and acidity caused by the presence of aluminum sulphate.

The mode of retention, infiltration, lateral circulation, evaporation and transpiration of water in the soil represent the essential mechanisms that determine the directions and intensity of geochemical processes on a global scale, as well as plant nutrition at the local level.Through its filter function, the soil also has an important action of retaining some substances that could contaminate the groundwater, thus preventing their pollution.The production capacity of water bodies (lakes, ponds, lakes, etc.) is also greatly influenced by the characteristics and quality of the submerged soil existing in them.

4.2.3 The Gaia Hypothesis

In 1965 the chemist James Lovelock formulated a hypothesis that posited that living organisms interact with their inorganic environment on Earth to form a complex synergistic and self-regulating system that helps maintain and perpetuate the conditions of life on the planet. From 1970 the microbiologist Lynn Margulis joined him and together they co-developed this hypothesis. The name Gaia comes from that of the goddess Gaia, the primordial goddess who personified the Earth in Greek mythology (Lovelock, 2000; Lovelock and Margulis, 1974).

From the beginning the Gaia hypothesis was heavily criticized for being teleological and against Darwinian principles of natural selection. However, further refinements have aligned the Gaia hypothesis with ideas from fields such as Earth system science, biogeochemistry, and systems ecology.

Even today the Gaia hypothesis continues to attract criticism, although some scientists believe that it is either fairly well supported by the available evidence.

Although more than three quarters of a century have passed, she still remained in the attention of scientists. After more than 30 years of disputes, four international conferences were organized at which the participants came up with many communications confirming this hypothesis (In 1985, the first public symposium at the University of Massachusetts Amherst, in 1988 was held at the University of Massachusetts Amherst the second conference, in 2000 the third conference was held in Valencia, and in 2006 the fourth international conference on the Gaia hypothesis was held at George Mason University in Arlington). Gaia, but the Gaia theory, which over time, has been consolidated.

Based on this hypothesis, the authors sought to explain how the biosphere and the evolution of organisms affect global temperature stability, seawater salinity, atmospheric oxygen levels, the maintenance of a liquid water hydrosphere, carbon dioxide processing, and other environmental variables that affect viability. Earth, so the interaction of life with life on our planet.

The Gaia hypothesis assumes that the Earth is a complex self-regulating system involving the biosphere, atmosphere, hydrosphere, and pedosphere, tightly coupled as a single evolving system. This system seeks an optimal physical and chemical environment for contemporary life.

Gaia evolves through a cybernetic feedback system operated by the biota, resulting in the broad stabilization of the biota's operating conditions into full homeostasis. Many processes on Earth's surface, essential for the conditions of life, depend on the interaction of living forms, especially microorganisms, with inorganic elements. These processes establish a global control system that regulates Earth's surface temperature, atmospheric composition, and ocean salinity, fed by the global thermodynamic disequilibrium state of the Earth system.

Another concept that is taken into account in Gaia theory is that of homeostasis. The concept of homeostasis has now come to denote any search for a state of equilibrium within a cybernetic system.

The existence of a planetary homeostasis influenced by living forms has previously been observed in the field of biogeochemistry and is also being investigated in other areas of the Earth sciences. The originality of the Gaia hypothesis is based on the assessment that such a homeostatic balance is actively pursued in order to preserve the optimal conditions of life, even when possible terrestrial or external events threaten them.

Lovelock's model is rooted in systems theory, a theory itself born out of Norbert Wiener's cybernetics. The Gaia theory, corresponds to all the properties of a system that has the ability to regulate the temperature and composition of the Earth's surface to ensure and keep it favorable for the existence of living organisms. The self-regulation of this system is an active process that works thanks to the energy provided by solar radiation.

Organization is the arrangement of a whole according to the distribution of its component elements on hierarchical levels (see Bertalanffy's theory – 1960). In Lovelock and Margulis' conception, interaction with subordinate dynamical systems is an integral part of Gaia theory.

Lovelock and Margulis found that the composition of the Earth's atmosphere, its temperature and pH are regulated by living organisms to optimize their reproduction. The originality of the Gaia hypothesis is based on the view that such a homeostatic balance is achieved in order to preserve the optimal conditions for life, even when various situations on the planet (or outside it) threaten them.
Lovelock's working hypothesis can be summarized as follows: Earth's entire planetary system is regulated by a complex web of interactions and feedbacks.

So far the Gaia hypothesis has come up with evidence for how global temperature regulation was ensured at the contact between the lithosphere and the atmosphere, how the salinity of the oceans remains almost stable for millions of years, explains the appearance and presence of oxygen in the atmosphere and hydrosphere, how carbon dioxide circulates in the global carbon cycle, explains the fact that many combinations of chemicals, including oxygen and methane, exist in stable concentrations in the Earth's atmosphere, etc.

4.3 Man created the Anthroposphere

The anthroposphere is that part of the natural or modified environment that is used by humans in their interests. As man now populates the entire planet, he marks his land in his own way, so that the influence of men manifests itself over the entire surface of the Earth, and includes our culture, technology, built environment and all associated activities.

Aspects of the anthroposphere include: mines from which minerals are obtained; oil and gas deposits; agriculture that produces the necessary food for over 8 billion people); forestry, but also landfills; air, water and soil pollution; satellites (here we include both active satellites and space junk left by cosmonauts); all technical products and technologies created by people, factories, urbanization; all transport systems (roads, highways, means of transport, vessels plying on all types of water); nuclear installations; the wars. It also includes books, software, computer-based systems, including the Internet; educational systems; all created techniques and technologies, communication systems, etc. (Figure 121).

Figure 121. View from New York today

The anthroposphere can be seen as the human-generated equivalent of the ecosphere or biosphere. While the biosphere is the total biomass of the Earth and interacts with its non-living systems, the anthroposphere is the total mass of human-generated systems and materials, including the human population interacting with all living and non-living systems of the Earth. But while the biosphere is able to efficiently produce and recycle matter taken from the toposphere through processes such as photosynthesis and the decomposition of debris, the anthroposphere, because it arose solely out of the interests of the human species, is very inefficient at maintaining itself. As human technology becomes more advanced, the negative impact of human activities on the environment increases exponentially. Over several thousand years, man, despite the fact that he is not the best adapted to his environment, due to his social life, communication skills (language) and, above all, due to his intelligence, conquered and then he subjugated, using only for the purpose of his strict interest the whole planet, in a way that was not done by any of the other living beings. In a very short time - on a planetary scale - as a consequence of the development of technique, he moved to change most of the relations created by the ecosphere on a planetary scale.

The natural environment is the environment not transformed by man; it was made by nature over millions of years. It is now called the ecosphere. Human activities have determined changes that have led **to the replacement of the natural environment with the humanized environment.**

The anthroposphere is the youngest shell of the Earth, but it has had and still has an enormous impact on the planet and all its shells. It is created more or less consciously, with tenacity, efficiency and, unfortunately, with a great degree of unconsciousness and self-centeredness.

The term anthroposphere was used for the first time, like the biosphere, also by Eduard Suess in the 19th century.

4.3.1 History of mankind and the anthroposphere

Over the years, from the need to define in a certain way the period of time in which humanity became the driving factor of all processes on earth, numerous names have been proposed, all given by people according to their specialty/field of activity of those who proposed it. We are not making a history, but only a review of the various terms used.

Anthropization began soon after the appearance of man on Earth and is evolving at an exponential rate. It arose from the moment when the human population grew large enough for the effects of its activities to become apparent on its surrounding environment. If at the beginning these effects were imperceptible, their magnitude increased over time and from a certain moment they became obvious. It all took place in a few millennia. The first hominids - australopithecines - fed on grasses, roots and small animals that they chased and killed. Over time, man began to make tools, use stones and use fire, so that by the Pleistocene the practices of gathering plants, hunting and fishing were already well developed. Although at the time these activities performed a purely subsistence function and had a negligible scale in terms of environmental impact, they nevertheless represented the first step towards the exploitation of the environment and which developed progressively over the centuries with the imagination, then the creation of increasingly advanced technologies.

The beginning of plant cultivation - the emergence of agriculture - is one of the great events that changed the history of mankind. From that moment man turned into a sedentary worker: he began to build the first shelters, work the land, sow and plant grains, vegetables and fruit trees. Hunting and fishing completed their daily menu. Later, the breeding of domestic animals also appeared. Human settlements were small; they consisted of very simple dwellings, and the people, having a social way of life, formed groups of tens, hundreds, rarely thousands of inhabitants.

In Sumer, then in Egypt, and later in Greek and Roman antiquity, the phenomenon of urbanism appeared for the first time. In the Roman Empire, Rome reached one million inhabitants for the first time. There were one-story villas in the city, as well as multi-story homes. The Roman model significantly influenced the environment by intensifying agriculture, building roads and bridges for communications and commerce, as well as building aqueducts and infrastructures, laying the foundations for what would be the beginning of how environmental modification in the modern sense began.

In the Middle Ages, depopulation and population dispersion reduced the phenomenon of urban centralization, so that Rome and other cities drastically reduced their number of inhabitants. Due to the change in the political system following the collapse of the Western Roman Empire, the decentralized communities tried to exploit the territory mainly for defensive purposes, leading to the birth of new models of civil architecture such as the village and the castle, or religious ones such as the parish church and the monastery . These residential realities were based on the clear division between inside and outside, marked by walls: inside all activities were concentrated around a central core of buildings, while outside the spaces for agriculture and work were distributed radially.

The Renaissance brought about a recovery of the ancient Roman lifestyle, which included the development of language, philosophy, architecture and also urban redevelopment. The various "ideal cities" imagined or physically created during that period were mainly based on the concept of both internal and external harmony in relation to the surrounding environment. In the extra-urban area, a slightly more technically advanced agricultural activity has been consolidated.

The industrial revolution, which started between the end of the 18th century and the beginning of the 19th century, led to the transition from an agro-craft economy to an industrial economy and consisted in transformations of social and political organization , of the cultural patterns and individual behaviors that still characterize the developed areas of the contemporary world today. Industrialization started in England. The fuel used in the furnaces was coal, and attempts to replace coal with coke produced by distilling fossil coal encountered difficulties related to the qualities of the coals. It is not difficult to imagine how serious the repercussions of industrialization were on the environment.

The idea of human influence on the environment appears in 1873, when Stoppani first imagines a new geological era, the Anthropozoic. The concept of the technosphere was later proposed by the geologist and engineer Haff.

In 1922 the geochemist Vernadski, together with the geologist Teilhard de Chardin and the mathematician and philosopher Le Roy gave a new name, the noosphere (sphere of the human spirit), by which they understand the growing influence of the power of the human intellect and technology on the biosphere. Also in 1922, the geologist Pavlov describes a new geological period, which he calls anthropogenic / anthropocene (after the term anthropozoic previously given by Stoppani).

In 1972 James Lovelock launched the Gaia hypothesis highlighting the role of anthropogenic influence on biogeochemical cycles (see more details in Chapter 4.2.2).

As ecologists, we consider that the terms regarding the interaction between the living and non-living shells of the last century entitle us to consider that the most appropriate terms are the ecosphere for the natural interaction of the biosphere with the toposphere, and the anthroposphere for the interaction made in the last centuries of humanity with the living and non-living environments at the planetary level.

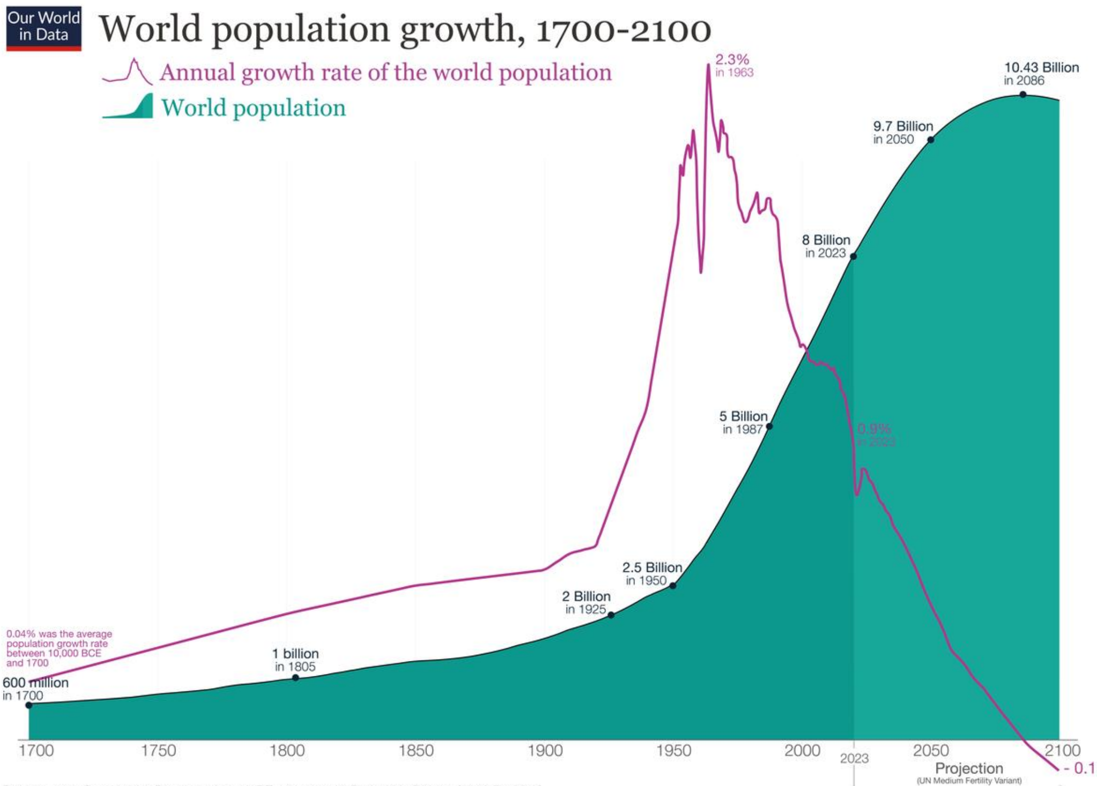
As a result, over several tens of thousands of years man, this product of our planet, due to his social life, communication skills (language) and, above all, due to his intelligence, conquered and then he made the entire planet strictly subject to his interest, in a way that no other living thing had done. In a very short period - on a planetary scale - as a consequence of the development of technology, it has become one of the most disturbing dangers for the development of living and non-living processes at the planetary level, because while the biosphere (ecosphere) is able to produce and efficiently recycle all matter taken from the toposphere through processes such as photosynthesis and decomposition, the anthroposphere is very inefficient at maintaining itself. As human technology becomes more advanced, the negative impact of human activities on the environment increases exponentially. The anthroposphere, although it is the youngest shell of the Earth, has had and still has an enormous impact on our planet and all its natural shells.

The use of energy from fossil fuels (coal, oil and natural gas) and the many technologies they put into operation have played a major role in amplifying the influence of the anthroposphere on the Earth. It has allowed humans to mine resources such as iron ore and bauxite, which are used to build automobiles, skyscrapers, and countless gadgets that are part of modern life. Humans, through everything they have done, have extended the influence of the anthroposphere thus negatively affecting the natural ecosphere and have provoked the process of global warming. As the impact of global warming develops, the anthroposphere will be characterized by the emergence of extreme climates.

4.3.2 Overpopulation of the planet

Earth's human population began to grow only after 10,000 BC. The beginning of civilization coincides roughly after the end of the last glacial period, so from the Holocene. The development of agriculture allowed population growth in many parts of the world, including Europe, the Americas and China, but this growth was, with small fluctuations, quite slow.

After the beginning of the Industrial Revolution, even during the 18th century, the population growth rate began to increase. At the end of the 18th century, the world's population was estimated at just under 1 billion. 200 years later, at the beginning of the 20th century, the world's population had reached about 1.6 billion. After another 50 years, in 1940, this figure rose to 2.3 billion. A more dramatic increase begins in the 1950s and coincides with the intensification of food production as a result of the industrialization of agriculture. The human population growth rate in 1964 was about 2.1% per year. Human population growth has since evolved exponentially: recent additions of a billion people have occurred very quickly: 33 years to reach three billion in 1960, 14 years to four billion in 1974, 13 years to five billion in 1987, 12 years for six billion in 1999, 11 years for seven billion in 2010 and 12 years for 8 billion (toward the end of 2022) (Figures 122 and 123). This growth is now believed to be mainly due to medical advances and productive growth fathers on the agricultural lands.



Data sources: Our World in Data based on HYDE, UN, and UN Population Division [2022 Revision]
This is a visualization from OurWorldinData.org, where you find data and research on how the world is changing.

Licensed under CC-BY by the authors Max Roser and Hannah Ritchie.

Figure 122. Human population growth 1700-2100(https://en.wikipedia.org/wiki/Projections_of_population_growth)

Figure.123. Humans are the only species whose presence is also observable from space. While humans are distributed over most of the earth, the contrast between the light and dark regions of the continents reveals the disparities in human development at the planetary level (Photo: NASA)

Using the Ecological Footprint, some world organizations have estimated that since 2006, mankind has been using 40% more than what the planet can naturally produce and regenerate as food for mankind. Therefore, to make room and feed these billions of surplus people, the anthroposphere has expanded to occupy more land for housing, industry, and agriculture.

There is a striking discrepancy between the way other plant life and the way humans use natural resources (Table 23).

Table 23. Comparison between the way the life processes of living things in the ecosphere and humans in the anthroposphere unfold (Godeanu and Doniță, 2023, modified)

Parameters	Ecosphere	Anthroposphere
Population size of a species	In close correlation with the resources of the living and non-living environment	Independent of resources, through the chaotic over-exploitation of all environments on the planet, on arbitrary criteria, but still justified ethically or morally, and now especially from an economic and pecuniary point of view. The lack of natural limits to the reproduction of the human species will lead to overpopulation, with serious negative consequences.
The way of perpetuating the species	Reproduction at certain times of the year and only by the best individuals from a qualitative point of view.	Exacerbation of the sexual process, which has become an end in itself. The absence of a certain period of the year in which reproduction takes place, which has become uncontrollable. Altering the human genome. Selection based on arbitrary criteria. Degeneration of males due to wars (where the best die). Unnatural selection (cultural, religious, social, etc.).
The lifetime	As long as the individuals are useful for the survival of the species. After that, eliminative natural selection acts.	There are no logical limits, nor is the interests of the species, the population, or the supporting capacity of the natural environment of which they are a part taken into account.
The way metabolic processes are carried out	Strict dependence on available natural resources. Organisms can be herbivores,carnivores/parasites, detritivores or symbionts.	Natural resources (as much as possible), then concern only for resources created by humans: agricultural, zootechnical, through artificial synthesis or through artificial technological processes.
Mode of exploitation of resources	Within the limits of the needs of the species and its individuals (but never in excess).	By interest and pleasure. Extensive, with technological machinery foreign to the environment. There is a "vision" only in the short term.
The type of interactions with the environment -abiotic - biotic	Sense organs Genetic and adaptive information Extrasensory information Biogeochemical cycles There is no pollution; everything is consumed or recycled	Deprivation of natural resources, Overexploitation, Sensory organs, Sensors and technical equipment, Genetic and adaptive information (extrasensory information disappeared) Historical experience (verbal and written) Domestication Friendship vs. Enmity (no more indifferent species) Man produces pollution, which is very difficult to recirculate or only partially
Other behaviors (shelter, climatic conditions, ethical factors)	Permanent or temporary shelters, hibernation, migrations	Technical, genetic, spiritual, cultural manipulations, breaking away from the living environment, creating artificial relationships, chasing money, excessive technicalization
Technological comfort	This problem does not even arise	Maximum technological comfort, Varied systems of construction, transportation and spending time Exploitation of many unnecessary resources from the lithosphere, hydrosphere, biosphere, pedosphere, etc.

All living things satisfy their metabolic needs, defend themselves from enemies, ensure the perpetuation of the species within the limits of available natural resources, and their individuals are useful to the species as long as they ensure its indefinite survival and provide mutually useful contacts with the living and non-living environment. If we make a comparison with what the human species does, we find that everything is arbitrarily modified (with a lot of moral and cultural justifications), and free will has become the general norm of living. Don't you think that it is necessary to walk here, in order for man to survive on our planet?

A number of scientists have long argued that human impact on the environment and the unjustified increase in resource consumption threaten the world's ecosystems and the survival of human civilization. The statement of the Interacademic Commission on Population Growth, which was ratified by 58 member national academies in 1994, but also many scientists suggest that the overall human impact on the environment after 1950 (especially due to human population growth, economic growth, consumption excessive, pollution and the proliferation of more and more technologies), believes that all of these exacerbate many environmental problems, including rising levels of atmospheric carbon dioxide, global warming and pollution. All analysts argue that the most serious impact of overpopulation is the effect it has on the environment. This situation was also revealed by the Global Assessment Report on Biodiversity and Ecosystem Services, published by IPBES in 2019. IGI Global found that human population growth has caused the encroachment of wildlife habitats leading to their destruction, "presenting a potential threat for biodiversity components". Wilson, for example, expressed concern since the human population had reached six billion because, he believed, the biomass of humans exceeded that of any other large animal species living on Earth by more than 100 times. dry.

Many scientists have attributed the depletion of non-renewable resources (land, food and water) to overpopulation and suggested that this could lead to a decline in the quality of human life. There is a need to develop renewable energy resources. People everywhere need to understand that rapid population growth damages the Earth's resources and diminishes human well-being. Some proponents of overpopulation warn that the expansion of agricultural production could have a substantial impact on the environment, and have expressed their concern by calling for the limitation of land areas usable only for agriculture.

Water scarcity, which threatens agricultural productivity, is a global problem that some have also linked to population growth. Aldous Huxley speculated as early as 1958 that democracy was threatened by overpopulation and could give rise to totalitarian governments. Albert Allen Bartlett of the University of Colorado Boulder warned as early as 2000 that overpopulation and technological development are the two major causes of the decline of democracy. John Harte argued that population growth was a factor in many social problems, including unemployment, overcrowding, poor governance and declining infrastructure. Other scholars have suggested that since World War II, countries with higher population growth rates have experienced the most and greatest social conflicts.

We do not discuss here the effects on economic aspects, poverty, human health, nor the measures that humanity must take to restore the natural balances on a planetary level, as these are the subject of other areas of human knowledge.

4.3.3 What the anthroposphere brings to the planet and humanity

In the following we will review the good and the bad aspects determined by the growth of the human population at the planetary level, as well as the expansion of human interests in the way of resource management and the way in which the environmental factors are currently managed by humans on our planet.

The good parts

Among the positive effects of human activities, it should be mentioned the arrangements intended for a good use of agricultural land, the expansion of forest formations, the realization of arrangements intended to reduce land erosion and concern for the reduction of floods, the arrangement of watercourses, the prevention of landslides, the development of controlled irrigation, the use of techniques the most advanced in order to better protect the environment, concerns aimed at protecting nature, etc.

The bad parts

Among the negative effects of human activities, we should mention climatic, hydrological and pedological changes determined by various human activities, changing the chemical composition of air, water and soil, accelerating the disappearance of species, facilitating the expansion of anthropophilic species and those that are useful for humans, eliminating the deliberate removal of species that are considered harmful, the degradation and replacement of natural ecosystems with new ones (which only serve human interests), the creation of new varieties of plants and animals through genetic manipulations, and lately the premature transition to the manipulation of the human genome, the challenge and the conduct of wars, etc. (Baker, 1995; Cogălniceanu, 2003; May *et al.,* 1995; Mooney *et al.,* 1996; Heywood, 1995).

Technofossils are another interesting aspect of the anthroposphere. These can include technological objects containing a wide range of metals and man-made materials, raw materials (such as aluminum or plastics) that do not exist in nature, and agglomerations of non-biodegradable plastics in different areas of terrestrial, underground or aquatic environments.

4.3.4 The effects of human activity on other spheres of the planet

Here are some of the global changes determined by human activities on the other shells/spheres of the planet:

Global changes

Climate changes are the most visible. Climate affects the ecological niches of all living species and as a result its fluctuations influence their distribution around the globe. Climate change can lead to a reduction in the biodiversity of all ecological systems on earth, a fact that can cause the expansion of euryotic species to the detriment of other types of species (which are more stenotic or the most strictly specialized), a fact that will cause an intensification of the extinction 4.3.4. process and reducing the number of strictly specialized species.

Climate change can change the variety and distribution of soils. Gradually, they will become uniform, reduce in diversity and implicitly lead to the transformation in an undesirable sense of the plant cover at the planetary level and the extension of the desertification processes.

Currently, humanity acts extremely carelessly on the lithosphere, whose structure it modifies with a rapidity that has not happened since the formation of the planet. This phenomenon can be seen through the changes in the sediments, through the mining operations, the correction/modification of the terrestrial relief and the coastline of the seas and oceans, the abusive extraction of materials for the realization of as many constructions as possible.

A predictable climate change as of now is the change in the course of oceanic currents, which will cause profound restructuring of the world economy, massive migrations of human populations (but which may generate new wars and profound economic transformations at the level of continents).

A serious problem is the modification of planetary biogeochemical cycles. Those that are affected now - and that foreshadow what will happen in the near future - are the biogeochemical carbon cycle (Fig. 124) and the water cycle. It is not long until the biogeochemical cycles of nitrogen, phosphorus or sulfur will also be affected, but also the appearance of new cycles, determined by other elements necessary for man, which he extracts from the earth's crust.

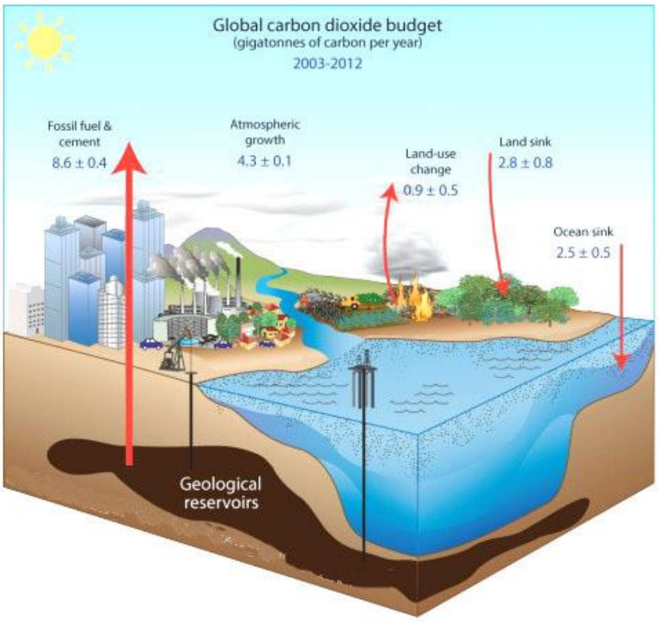


Figure 124. Schematic representation of the disturbances of the biogeochemical carbon cycle caused by various anthropogenic activities in the period 2003-2012 (according to the data presented by the Geosphere-Biosphere Program in 2009)

Other extensive transformations at the planetary level are the reduction, destruction, degradation and other changes of natural habitats, ecological fragmentation determined by demographic developments, urbanization, industrial development and that of ocean and land transport networks, underground explosions, etc.

This category also includes the reduction of the planet's forest cover (Figure. 125), the creation of artificial forests and grasslands, the over-extension of agricultural crops, the expansion of industrial parks, etc.

Figure 125. Excessive deforestation in forests (https://www.google.com/search?client=firefox-b-d&sca_esv=574765094&q=defri%C5%9F%C4%83ri&tbm=isch&source=lnms&sa=X&ved=2ahUKEwi6q6bv4lGCAxWBxQlHHUyXDAMQ0pQJegQIDRAB&biw=1046&bih=575&dpr=1#imgrc=Xw8LfPrI2AR3vM)

An important negative role is the transformation of agriculture into a quasi-industrial system based only on economic considerations, that is, into an industry producing plant and animal foods, which will stimulate the application of more and more fertilizers and pesticides, will accelerate the genetic creation of new varieties of plants and animals, so it will implicitly affect the entire pedosphere.

Excessive fishing, carried out only for commercial purposes, turns from a food supplement for mankind into an exterminator of aquatic fauna; this can cause extremely important disturbances in the structure of natural balances in the seas and oceans.

All these imbalances, apparently local at first, can accumulate causing an explosion of invasive species, harmful ones and those introduced (intentionally or accidentally) by humans.

Lithosphere

The mineral and energy resources of the geosphere fueled the industrial revolution that allowed the human species to grow so rapidly numerically. Exploitation of fossil fuels has increased our standard of living, but an unintended consequence of this action may be climate change and global warming.

The development of the anthroposphere can determine the alteration of many geological and/or geochemical processes, such as the expansion of erosion phenomena, the expansion of mining activities for the purpose of extracting useful substances, in obtaining more and more resources necessary to obtain fossil or nuclear energy or different kinds of materials for constructions, the disappearance of the vegetal carpet, the washing of bare soils, the creation of new weapons usable in various wars, etc.

A problem we will return to is the emergence and explosive development of many forms of pollution, a phenomenon that did not exist on the planet before the appearance of humans. Now, from the local, point-like pollution of soils, we have reached forms of generalized pollution with a global character, which mark the terrestrial environment on a global scale.

Human settlements are now a problem related to the state and quality of the terrestrial environment. With the multiplication of people, the size and density of human settlements increased greatly (Figure. 126). For their existence, mankind takes construction materials from the environment (wood, gravel, clay, materials intended for the construction of road or rail transport routes and, with the incessant modernizations that are being made, they throw more and more non-recoverable solid waste on the surface of the lithosphere, which are released in it and which have led to many unwanted changes. Toxic substances continue to be released through chimneys into the atmosphere by industries around the world. Combustion processes, which take place in industries, heating and transport systems, release large amounts of carbon dioxide, sulfur dioxide and nitrogen dioxide into the atmosphere, changing its chemical-physical structure.

Figure 126. Așezare urbană (https://www.google.com/search?client=firefox-b-d&sca_esv=574765094&q=impacte+asupra+biodiversit%C4%83%C8%9Bii&tbm=isch&source=lnms&sa=X&ved=2ahUKEwilsIb93IGCAxURgP0HHd5XAmEQ0pQJegQICxAB&biw=1046&bih=575&dpr=1#imgrc=pMRrx8wK2cLbyM)

Atmosphere

Since then, industrial and agricultural activities have changed the composition of the atmosphere. For example, the concentration of carbon dioxide in the atmosphere has increased by 26% and the concentration of methane has doubled. Chlorofluorocarbon production negatively affects the Earth's ozone layer.

Anthropogenic pollutants emitted by mankind into the atmosphere come from different types of sources (stationary or mobile, linear or point), such as chimneys of thermal plants, heating boilers, processing plants, furnaces and dryers, exhaust shafts, deflectors, pipelines ventilation, etc., exhaust pipes of diesel locomotives, motor ships, aircraft, vehicles and other devices in motion on roads and streets along which vehicles move, ventilation systems, windows, doors, buildings, etc., through which impurities can reach the atmosphere (Figure.127)

Figure. 127. Effects of anthropogenic pollutants in a city (https://www.google.com/search?client=firefox-b-d&sca_esv=574740318&q=poluan%C8%9Bii+antropici&tbm=isch&s)

The ozone layer is at an altitude of 12 - 50 km (in tropical latitudes at 25-30 km, in temperate latitudes at 20-25 km, in polar areas at 15-20 km). It has the ability to absorb the harshest part of the ultraviolet radiation coming from the sun and which could otherwise reach the surface of our planet affecting all life forms. For some time there has been a thinning of the ozone layer, and over Antarctica there is now a large hole in this layer (Figure.128).

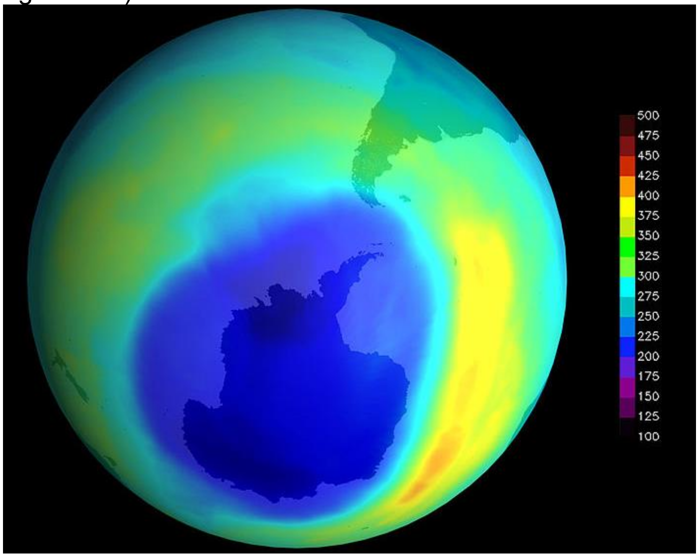


Figure 128. The ozone hole over Antarctica (https://www.google.com/search?client=firefox-b-d&sca_esv=574740318&q=Gaura+de+ozon+de+deasupra+Antarcticii&tbm=isch&source=lnms&sa=X&ved=2ahUKEwjm-_w1oGCAxUINuwKHdqRC4EQ0pQJegQIChAB&biw=1046&bih=575&dpr=1#imgrc=kAazXo56-55XvM)

The greenhouse effect is determined by an increase in the average annual temperature as a result of the accumulation of greenhouse gases in the atmosphere (carbon dioxide, methane, freons -6%), gases that prevent long-wave thermal radiation from the planet's surface to it is lost in the cosmos (heat exchange with the cosmos is interrupted). Recently, the values of the greenhouse effect have increased significantly due to the progressive deforestation suffered in some increasingly vast areas of the Planet, but also as a result of the burning of coal, oil, methane and other gases generated by agricultural and industrial production systems. As a result, the desertification of vast territories in the equatorial and tropical regions is increasing, as well as the overheating that accentuates or causes the risk of a possible future rise in sea level due to the melting of the polar ice, which can have catastrophic effects.

Acid rain. Acid rain is formed as a result of industrial emissions of sulfur dioxide and nitrogen oxides into the atmosphere, which combine with atmospheric moisture to form sulfuric and nitric acids. Acid rain extracts nutrients from the soil, leading to the release of heavy metal compounds that reduce soil fertility and lead to the accumulation of heavy metals in food chains (Figures 129 and 130).

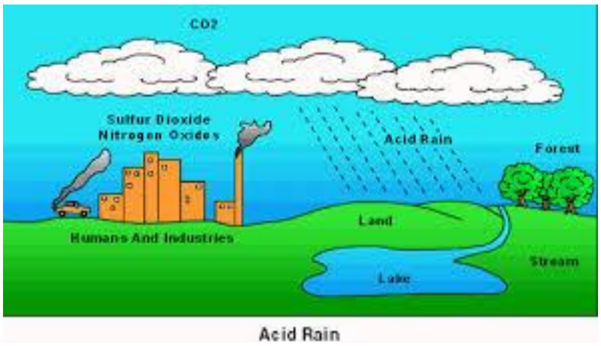


Figure 129. The effect of acid rain (https://www.google.com/search?client=firefox-b-d&sca_esv=574740318&q=ploi+acide&tbm=isch&source=lnms&sa=X&ved=2ahUKEwjtifm52IGCAxUb9bsIHdUSADkQ0pQJegQIDRAB&biw=1046&bih=575&dpr=1#imgrc=m8nPJIhjfkqjxM)

Acid rain profoundly alters ecological balances, and the presence of other toxic substances in the air prevent the normal performance of the vital functions of all organisms, including humans. In the last decades it could be observed that there was an increase in the degree of acidity of the waters of rivers and lakes. This phenomenon is mainly due to the petrochemical industries that use quite harmful fuels and which, in contact with water in the form of vapors in the air, turn into acid precipitation, which creates unfavorable living conditions for aquatic and terrestrial organisms. Acid rain also affects monuments and works of art made of stone, whose corrosion is greatly accelerated.

Figure 130. The effect of acid rain on forests (http://www.cunoastelumea.ro/cum-se-formeaza-ploaia-acida-si-ce-consecinte-are-asupra-mediului)

Under the impact of atmospheric pollution produced by the human population explosion, the planet's overall albedo (the ability to repel solar radiation) is decreasing dramatically.

The synchronous action of pollutants in the air manifests itself most prominently in the so-called smog (Figure 131). This is a foggy veil that forms over industrial enterprises and cities that occurs as a result of the appearance of sulfur dioxide. There is winter smog (London type) and summer smog (Los Angeles type). The prerequisites for the formation of winter smog are calm weather, which contributes to the accumulation of vehicle exhaust and low stack emissions. Summer smog (also called photochemical smog) is caused by nitrogen oxides and hydrocarbons, from which, under intense sunlight conditions, photooxidants are formed.

Figure. 131 Smog in a city (https://www.nature.com/articles/climate.2009.115)

Hydrosphere

Water is one of the extremely important factors for humanity and for many of its social, economic or cultural activities. As the human population increases over time and the intensive and extensive use of water resources capable of providing drinking water, the problem of water usable by people for their increasingly varied needs has become a vital problem of mankind.

In humans, almost 72% of human body mass (without fat) is water. To function properly, the body requires between 2 and 7 liters per day to avoid dehydration, the exact amount depending on activity level, temperature, humidity and other factors. The human body needs water that does not contain too much salt or other impurities. Common contaminants include chemicals and/or dangerous bacteria (such as Cryptosporidium). However, some substances are acceptable and even necessary as a presence in water to enhance the taste and to ensure the necessary electrolytes.

Water is extremely important from an economic and industrial point of view. Water transport was and still is the backbone of trade and economy. The volume of fish caught in 2017 from natural waters and aquaculture exceeded 170 million tons. Hydroelectric plants represent an important cornerstone of sustainable development, the total hydroelectric capacity of the world in 2015 being 1,212 GW.

In addition, water is used in cooling, heating and thermal power plants. The applications of water in the chemical and pharmaceutical industry are also very diverse. Water is an essential solvent, reaction medium in inorganic and organic syntheses and even reactive (synthesis of HNO_3, H_2SO_4). Intensive research is also focused on the production of oxygenated water.

Humans have affected the hydrosphere by withdrawing from it large amounts of fresh water that they use for drinking, navigation, fishing, in agriculture, for obtaining energy and last but not least for various recreational uses. The water is also used for the evacuation of a very wide range of waste that causes the pollution of all types of water bodies.

In the category of humanity's negative influence on the hydrosphere, we mention the various forms of disruption of the water cycle in nature. This was achieved by cutting down forests (which has the effect of reducing the evapotranspiration processes that take place at the level of terrestrial vegetation), overexploitation of underground water reserves, but also excessive irrigation, because the irrigated plants cannot retain all the administered water, and the excess water administered by humans destroys soils.

Last but not least, mankind has used water to eliminate/get rid of all kinds of pollutants, which has led to the deterioration of the physical and chemical qualities of all waters (Figures. 132, 133). We should mention domestic pollution (that produced by waste of all kinds collected in people's households), industrial pollution (that which brings residues and by-products of industrial activities into the waters), agricultural pollution (fertilizers, pesticides and residues from agricultural activities, animal husbandry and from the processes industrial preparations of food products), urban pollution (waste, predominantly liquids from human settlements), pollution with hydrocarbons. To reduce the various forms of water pollution, people have developed technological purification systems that use physical, chemical and biological methods, both oxidative and fermentative.

Figure 132. Pollutants dumped on the shore (https://en.m.wikipedia.org/wiki/File:Litter.JPG)

Figure. 133. Plastics in tropical waters (https://ecotourism-world.com/tag/marine-conservation/)

Another form of water damage is the provoking, for various reasons, of eutrophication processes (development of the algal mass, increase in the amount of dissolved and particulate organic substances in the water. All this leads to the death of aquatic flora and fauna; as a result, the accumulation of organic sediments that decompose predominantly anaerobically, and, as a consequence, the impossibility of being able to use too eutrophicated waters by mankind (Figure. 134).

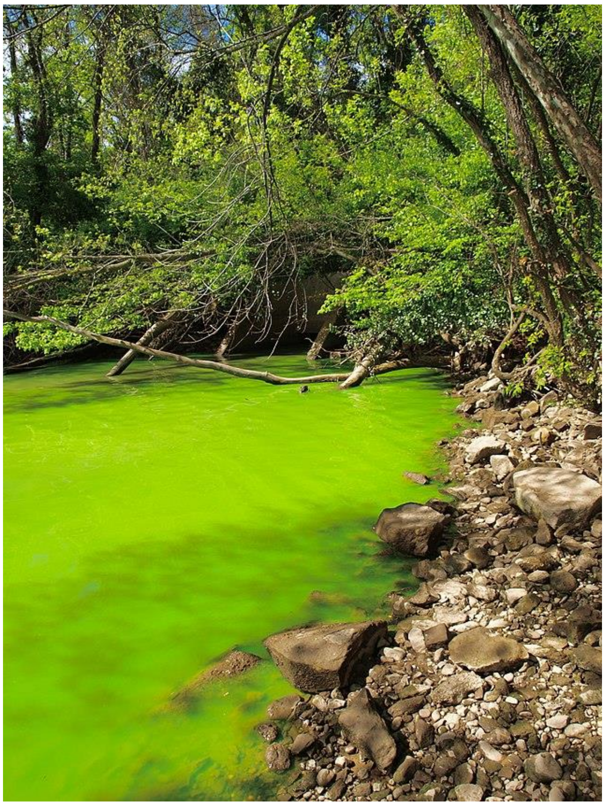


Figure. 134. A strongly eutrophicated water (https://ro.m.wikipedia.org/wiki/Fi%C8%99ier:Potomac_green_water.JPG)

Since most of the goods used by humanity are transported on water - and now - the coasts of the seas and oceans have been modified, docks and harbors have been created, flowing waters have been regulated. All these works also have a significant impact on the quality of water and its biota.

The pedosphere.

There are numerous human activities that affect the pedosphere. The most important are agricultural works, the construction of human settlements (with all their variety of buildings built for administration, health, education, culture, entertainment, etc.) and industrial, the construction of road and railway transport routes, the creation of green spaces and special grounds for leisure, tourism and various sports activities.

Affecting the pedosphere is manifested by:

Deforestation and works of the uncultivated land for the purpose of producing vegetable food for mankind. It is about all the variety of work that is carried out in agriculture, including irrigation, the administration of fertilizers, pesticides, insecticides and herbicides, the creation of protected crops in greenhouses, which have as a side effect the destruction of the natural stratification of soils, the horizontalization of agricultural land, the removal of vegetation natural herbs. More recently, in the category of the industrialization of agricultural crops, the genetic manipulation of the genome of most types of crop plants has been carried out, a situation that does not take into account the impact they can have on the human genome (because we are the first-order consumers of agricultural crops). An aspect not without importance is the excessive use of underground water, which has the effect of increasing the intensity of the land salinization process.

Modern animal husbandry technologies involve the construction of shelters, the artificial storage and "creation" of animal feed, and the excessive use of preventive drugs administered to animals in farms.

Deforestation of tree cover for various reasons (for wood used in construction and furniture creation, procurement of firewood, gaining land for the expansion of agricultural crops) are different ways of damaging forest soils. The expansion of land areas intended for the expansion of human settlements and all related activities (including dumping or storage of solid waste on the ground - Figure. 135) that are intended to achieve better living conditions for people can seriously affect soils.

Figure 135. Storage of solid waste on agricultural land (https://www.conservationinstitute.org/soil-pollution)

Since industrial activities are particularly important to the needs of mankind, many lands are intended for the realization of parks or industrial units. During their construction, the soil on these lands is removed or moved to other locations.

We must not forget mining operations, which extract economically useful substances from the lithosphere, but which leave behind huge volumes of tailings, waste and produce open cavities in the lithosphere (Figure. 136).

A **B**

Figure 136. A Lands in Romania affected by mining (https://www.google.com/search?client=firefox-b-d&sca_esv=580120143&q=Minerit+la+suprafață),**B** Surface mining in Chile (https://news.sky.com/story/chile-miners-may-be-rescued-in-days-10491569)

The conveyance system (on water or on the surface of the land) alters the relief and flowing waters significantly. To them is added the pollution caused by the fuel losses from the means of transport, as well as the waste from all the maintenance works of these communication ways and the machines used on them.

Due to the ability to support plant life, the soil is the main means of sustaining the existence of terrestrial life on this planet, but also of the development of human society in the future. The soil must provide people with food, raw materials, shelter, medicine, but also other requirements.

The anthropic factor is particularly important in the solification processes. By taking the soil into culture, man directly influences the genesis and evolution of the soil and, as time goes by, the soil begins to acquire more and more the characteristics of a product of human activity.

The influence of the anthropic factor consists in:

- the formation of psammosols by fixing mobile sands;
- almost complete modification of the soil profile or mixing of the horizons, in the case of deep plowing, in order to establish fruit tree or vine plantations;
- formation of peaty soils by drying draining of peatlands;
- the many changes occurring in the process of silification as a result of taking the soil for cultivation through the clearing of forests and the clearing of meadows.

Human intervention can be viewed under three aspects:

- Most of the time, human intervention has a positive effect, leading to an increase in soil fertility. It is achieved by plowing or loosening the soil, it causes the mixing of the horizons on the surface and their loosening. In this way, the biological activity is intensified, the aero-hydric regime is improved, etc. By applying mineral and organic fertilizing substances, the nutrition regime is improved, making the necessary nutrients available to the plants. The amendment corrects the extreme reactions of the soil, which are harmful to the growth and development of plants. Through irrigation, in arid areas, the water regime of the soil is improved and the necessary nutrients for cultivated plants are ensured.
- In some cases, however, the positive effects of human intervention are also accompanied by negative effects, such as, for example, irrigation provides the necessary water for plants, but secondary soil salinization is also favored (through irrigation with mineralized water or in the conditions of a reduced depth of groundwater). The use of pesticides determines the destruction of weeds and animal and plant pests, but at the same time it also causes the death of other organisms, reducing the biological activity in the soil and, as a result, produces nutritional imbalances, phytotoxicity phenomena, etc.
- Sometimes human intervention is totally negative, leading to a decrease in soil fertility. Such are inappropriate agrotechnical works (ploughing from hill to valley, etc.), irrational practices on land with too high slopes, total deforestation or those carried out on too large an area, etc.

Biosphere

Man has clearly modified the natural biosphere through various activities, which have resulted in a major, clear, well-established objective of mankind today: the protection and conservation of biodiversity.

Affecting biodiversity is not a new process, but perhaps the oldest, since mankind, multiplying, began to unconsciously affect the surrounding world. It started with the cutting and burning of forests (especially in tropical areas, but also in the past for firewood. The proof is that in all areas where great human empires once flourished, tree vegetation was destroyed , in its place now being only remnants of forest plantations carried out later by humans.

Among the impacts on biodiversity, we mention first of all the degradation of all ecological systems - from the level of ecosystems to the biomes still existing on Earth. This primarily determines a simplification and uniformity of biodiversity (a fact that is increasingly evident all over the globe); secondly, there is a reduction in the diversity of life forms (more and more species become "endangered", or enter the "relict" category, while others narrow their range, and then, gradually, disappear.

A newer term used is that of "functional uniformity", which refers to the loss of exploitation strategies of some ecological niches. Everything starts from reducing or simplifying the primary production of the ecological niches of the dominant species. This phenomenon amplifies along the trophic chains, so that it is difficult to detect in time and therefore to prevent - or it becomes obvious too late to be able to do anything. Instead of some productive ecosystems, desert or semi-desert lands settle over time.

A newer form of biodegradation is the overexploitation of the planet's living resources. Currently the most obvious is the overexploitation of the resources in the seas and oceans (Figures. 137 and 138). In the past, whaling was the main activity in the harvesting of marine fauna (two or three centuries ago, most fishing vessels were whaling ships). Gradually the number of whales has decreased so drastically that now they are fully protected, and their fishing is prohibited in almost all oceans. Another example: in the Black Sea turbot was the food of the poor, and sturgeons were caught only after they exceeded 100-200 Kg. Now turbot is a delicacy, and large sturgeons are no longer even found in the Black Sea. Ocean fishing is in decline in all the waters of the planet, and freshwater is increasingly being replaced by intensive aquaculture.

Figure 137. Industrial overfishing (https://upload.wikimedia.org/wikipedia/commons/6/6c/Trawlers_overfishing_cod.jpg)

Figure 138. Fishing as "hunting" in the ocean (https://pbn.co.id/article-news/teknologi-penangkapan-ikan-tuna)

3-4000 years ago, hunting was the main way for people to procure meat (primitive people lived by gathering, hunting and fishing - that's what it says in all the history books). Nowadays, hunting is an elitist "sport" for people who make hunting a means of pleasure, and game meat is a specialty that many people cannot even afford.

I close this chapter on human impacts on body diversity with two quotes from David Skripak, a modern Czech author: *"The species known as "Homo sapiens" is the only one on this planet that is actively seeking to eradicate itself and its habitat. All life support systems on earth - soil, water and air - are in decline as a direct result of our current economic activity, which is designed to extract as much as possible from the sacred earth, without regard for the consequences that follow."*

"Our consumption-based economic model, which we devised and are now enslaved to, causes perpetual deficiencies—resource depletion, biodiversity loss, and toxic contamination, all of which wreak perpetual havoc on man, his ecosystems, and the environment."

We have nothing to add to what was written above.

4.3.5 The future of the anthroposphere and humanity

The material presented above is not at all optimistic. However, we believe that he reflects a cruel reality. And I didn't exaggerate anything (maybe even I came up with insufficient details).

It is certain that humanity is in a situation where, for subjective and especially subjective reasons, especially moral and economic, we lie to ourselves and avoid being objective. This material deserved to be written in a black border.

Our opinion is that the anthroposphere is a super-egoistic process, devoid of logic, lacking a sufficient information base (it is only the human information base, adapted to local interests) and going on wrong paths. We also hope that everything will be solved on scientific bases and on new, better, more efficient technologies. In reality we do not have enough knowledge, we do not have any optimistic perspective, we are subordinated to economic and political interests and we act only emotionally. So, the conclusion we have reached is that the anthroposphere is killing itself slowly but surely (and we don't even know how long it will last), for absolutely random reasons / thoughtlessness. After the disappearance of humanity, slowly but surely and at the same time with great certainty, the ecosphere will return to erase the traces of humanity and gradually restore the ecological balances disturbed for a short period (relative to planetary times) by us.

4.4 Conclusions on the ecosphere, pedosphere and the anthroposphere

The ecosphere is a natural construct that differs fundamentally from the way the other planets in our solar system evolved.

Life appeared shortly after the Earth formed and developed on its surface in the waters of the perimordial ocean after its solid crust solidified.

Life is characterized by self-regeneration, self-regulation, redundancy and a great capacity to store and process information. Through its representatives (living organisms) life very soon assumed the task of coordinating the main processes taking place at the planetary level, preventing them from fluctuating chaotically.

As a result, the non-living components – the atmosphere, hydrosphere and lithosphere – have been subtly modified by the biosphere. Their interaction, always harmonious, led to the genesis of the Earth's ecosphere.

Ecological evolution is as old as informational, energetic and morpho-physiological evolutions (we consider that there is a permanent co-evolution between these three types of evolution). It arose from the necessity for the survival of all forms of life, from the appearance of the simplest forms of organization of living matter until today.

Several stages can be distinguished in ecological evolution (Figure 139):

The first stage: organic macromolecules that had the ability to metabolize began to respond appropriately to the characteristics of their environmental environment in the planetary ocean. It lasted until the appearance of the first organisms that switched to a new form of energy, so until the appearance of photosynthesizing organisms.

The second stage: the photosynthesizing proto-organisms started the production of molecular oxygen in the water, and after it was saturated, the release of excess oxygen into the primordial atmosphere began. The release of oxygen molecules is the result of the metabolic activity of living organisms that lived in the upper layers of the primordial ocean. It was also now that the first relationships between different types of organisms appeared. First of all, the producer-decomposer relationship appeared, then the prey-predator relationship, and later it moved to the next stage.

The third stage is the formation of food chains. From now on, we can speak of a diversification of living-living and living-non-living interrelationships, in the sense that autecological processes have started, processes that still exist today. Two major ecological processes have now emerged: biogeochemical cycles and food chains and webs (processes that have been highlighted by ecology and have been grouped under the name adaptive ecological evolution) (Figure 114 and 139); they are studied under names such as demecology or the ecology of individuals and populations).

The fourth stage: the first ecosystems appear in the seas and oceans (first in the ocean area where sunlight penetrates, i.e. in the photic zone, then also in the aphotic zones in the depths of the seas and oceans). The ecological stage of living-living integration appeared after stable biocenoses appeared within the ecosystems.

The first level of systemic organization in ecology is considered to be the ecosystem. It appeared at the moment when the living things belonging to different types of populations had from the very beginning clear systemic properties, universally valid, with all the characteristics recognized by the systems theory (Botnariuc, 1976, 2003).

The fifth stage: begins during the period when molecular oxygen becomes the gas at the level of the planet's atmosphere that allows the manifestation of oxidative processes, and aquamarine life forms begin to populate environments where energetic processes are based on molecular oxygen from fresh waters and the atmosphere. It is the source of the oxidation processes of many rocks, of creating the oxides of a wide range of substances from the lithosphere, a fact that determined the intensification of the erosion processes and the formation of sediments. Some important geological processes later started on this basis.

The first environments populated by organisms from seas and oceans are lakes and paramarine salt marshes. The stagnant brackish waters followed, and then the flowing ones (those in the vicinity of the confluence of fresh and marine waters, so those subject to the influence of the tides). The marine environment has been a constant support for many stenothermic organisms.

The sixth stage begins with the appearance and development of two layers of the earth's crust, the pedosphere and the aerial biosphere. With the conquest of the terrestrial environment by organisms, their dead biomass, mainly the necromass of photosynthetic plants, become the source of food for degrading organisms, which, in the course of their activity, mix the fine mineral material from the surface of the lithosphere with the detritus created by the necromass, generating the soils. In it the photosynthetic plants were able to fix and grow, and their germinal forms were able to begin their development.

Functional ecosystems already existed in the marine environment. Based on the biological information accumulated during their realization, in the living environments newly conquered by living things, ecosystems with new, specific characteristics were formed, which perfected the mechanisms and ways of functioning of the flows of matter and energy.

The creatures from the seas and oceans not only conquered the dry and aquatic terrestrial environment, but, thanks to the water that seeped into the fissures of the lithosphere, they also came to populate the subterranean environment represented by fissures, water courses and underground water basins. These ecosystems have one characteristic: the absence of their own primary producers. That is why, even now, in the underground environment, the trophic chains always start from the necromass brought by the water from the precipitation or from the one that comes from the infiltration of the water through the soils or from the one stored in the above-ground water basins.

In the seventh stage: terrestrial ecosystems are organized in the levels of supra-ecosystemic organization known today: landscape, ecozone, eobiome and ecosphere (Doniță *et al.,* 2019, 2021; Godeanu *et al.* 2016, 2022; Turner *et al.,* 2001, Vernadsky 1986).

The eighth stage of the evolution of ecological processes corresponds to the "Gaia" hypothesis, as defined by the American paleontologist J. Lovelock (Lovelock, 1986, 2010; Lovelock and Margulis, 1974, Barrotta *et al.,* 2011), the one in which takes place a refinement and homeostatization of the ecological processes at the planetary level (see Chapter. 4.2.2). According to Lovelock, our planet currently behaves like a living being, and has its own hierarchical organization, with all the characteristics of biological and ecological systems (Lovelock 1986, 2010; Botnariuc, 2003).

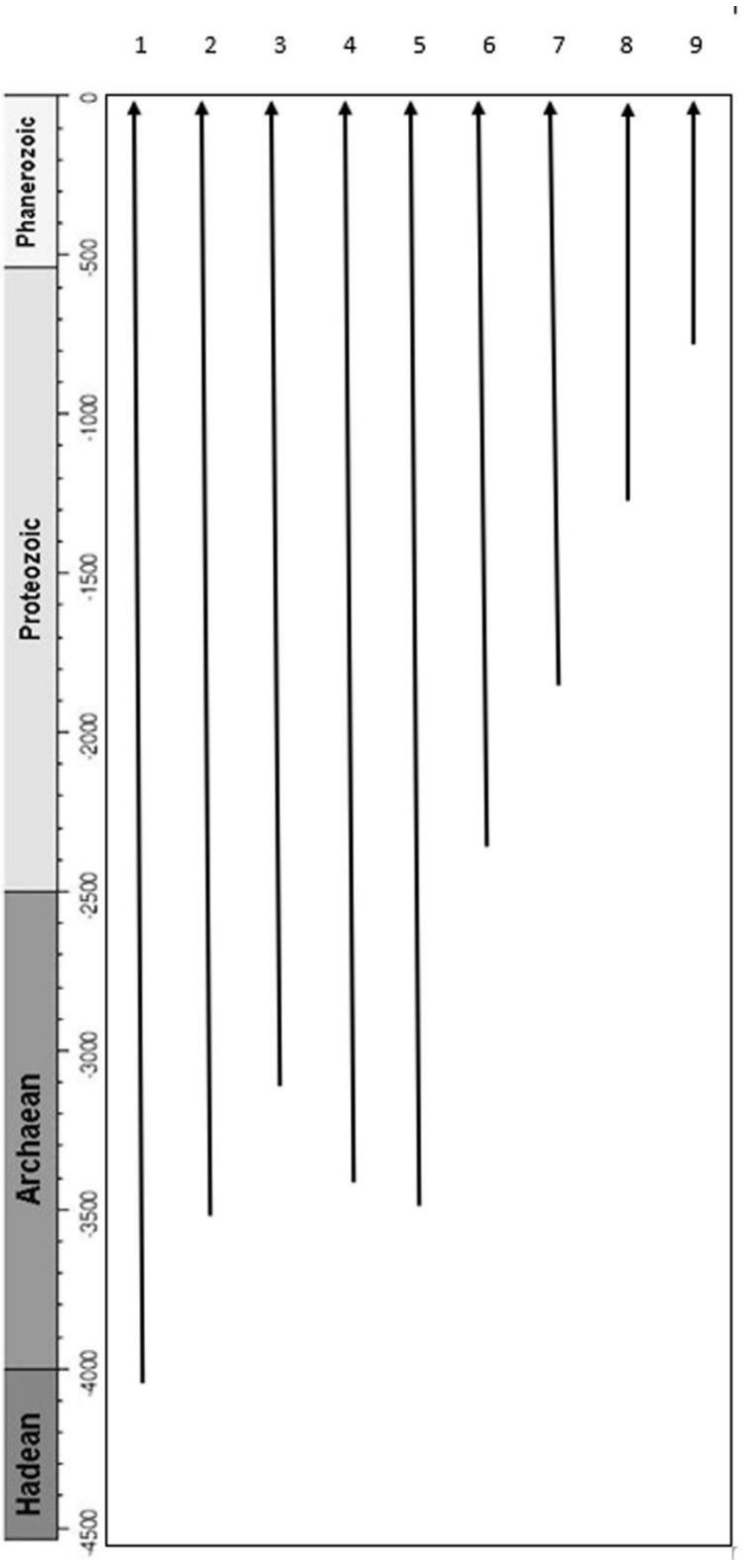


Figure 139. The stages of ecological evolution of life and the environment throughout the geological ages. 1- The appearance and spread of molecular oxygen in water and the atmosphere, 2- Food chains, 3- Biogeochemical circuits, 4- Food webs, 5- Ecosystems in the seas and oceans, 6- Soil formation and the constitution of the pedosphere, 7- Terrestrial ecosystems, 8- The formation of supraecosystemic ecological levels, 9- The emergence and evolution of the ecosphere (Gaia) (Godeanu and Popa, 2022)

5 WHAT WILL HAPPEN ON OUR PLANET IN THE FUTURE

Before proceeding with the presentation of this problem, a clear distinction must be made between the geosphere and the ecosphere. The geosphere is understood as the set of physico-chemical and geomagnetic phenomena that took place, have and will take place on this planet, and the ecosphere is understood as the way in which life appeared on our planet, the biosphere was formed, how the biosphere evolved and interacts with the toposphere forming the ecosphere, that is, how it appeared and how the living interacts with the non-living on the level of our planet, now and in the future.

Therefore, in order to understand what the future of the Earth is, we will first recall the life cycle of the sun in our solar system, then how it influences the planet Earth, seen from two different points of view: the evolution of the geosphere and then the ecosphere.

Astronomers have followed by radiometric methods how our solar system was formed, then how the sun of this system has evolved, and based on the comparison of the data with the situation of the suns of other solar systems in our galaxy, they have predicted the future evolution of the sun and the solar system. It has been established that it is about 4.4 billion years old, and its lifetime will be about 14 billion years (Sackmann *et al.,* 1993) (figure 140).

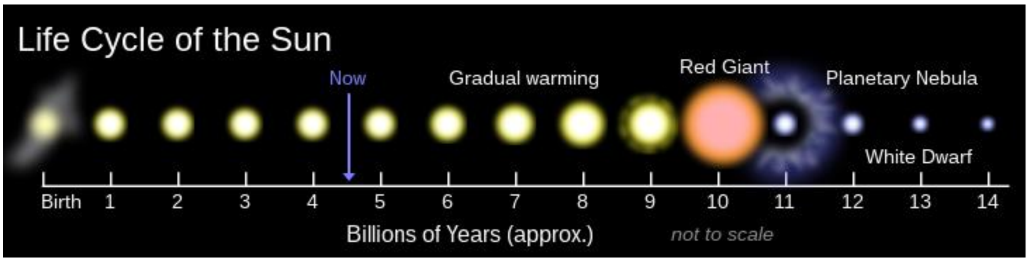


Figure 140. The life cycle of the sun (https://upload.wikimedia.org/wikipedia/commons/thumb/5/55/Solar_Life_Cycle.svg/728px-Solar_Life_Cycle.svg.png)

The existence and production of solar energy is based on the thermonuclear fusion of hydrogen and helium, which takes place in the core of the sun. From its formation to the present day, our sun has consumed almost half of its original amount of hydrogen, and the rest of its mass is made up of helium. As a result of the gradual transformation of hydrogen into helium, the stellar mass decreases, thermonuclear reactions will not only continue, but will even intensify, because now new thermonuclear reactions are triggered that cause helium to give rise in turn to new chemical elements that transforms the sun from a strictly gaseous mass, into a semi-solid one that is constantly changing and complexing.

Its light intensity is constantly increasing, by 1% every 110 million years, so in 3 billion years it will be 33% higher than it is now. Hydrogen fusion in the sun will end when its luminosity reaches 121% of its current value. Permanently it will increase its diameter, it will become a subgiant sun, then it will evolve into a red giant, because after that, that is, about 11 billion years after its formation, it will implode and contact itself becoming - about 12 billion years - a dwarf sun.

Increasing the intensity of thermonuclear reactions and the energy released by the sun, simultaneously with the increase of the geomagnetic attraction of the planets in circumsolar orbits, they will be, one by one, attracted to the mass of the sun and will be destroyed (that is why Mercury currently has such high temperature values , because she will be the first to disappear in the hot mass of the sun). Venus will follow, and then, on the same schedule, it will be our planet's turn.

Aware of this inexorable evolution, we can predict what processes will occur, when and how.

By extrapolating the scientific data at our disposal, we have a series of data related to the progress of the nuclear fusion processes that take place in the core of our planet, to the cooling processes that will take place inside the Earth, to the gravitational interactions that can take place between large objects and small ones from our solar system, from the danger of uncontrollable movements of the various solid bodies that make up our solar system (which can cause direct impacts / collisions on the planet), from the continuous increase in the energy and brightness of the sun, from the increase in geomagnetic forces that will exercise on the sun planet and the other planets, planetoids and lunar formations. To these data we can add, on the one hand, the action of biological information regarding the development of new ways of self-protection developed by living matter, but also the possible effects of geoengineering built by mankind in the future (unless we, from excess zeal or from unconscious, we will self-destruct much sooner).

Capitalizing on the conclusions of other researchers, but also taking into account our own opinions, we can formulate a hypothesis regarding the future of our planet and its ecosphere.

It seems that in the near future the planet's ellipse around the sun and circadian rotations will maintain seasonality and general planetary rhythms, but global warming processes will continue, which will cause the desertification process to intensify. According to the parameters elaborated by Milanovici, as long as the Holocene lasts, there will be more glacial periods, so the planet will undergo large-scale climatic transformations, which can, for a while, curb the thermal impacts caused by the sun.

The movement of the tectonic plates on the surface of the planet will continue, movements that may determine, in the long term, the creation of one or two supercontinents in the next 250-350 million years (figure 141), which is possible that their tectonic plates will be thicker big.

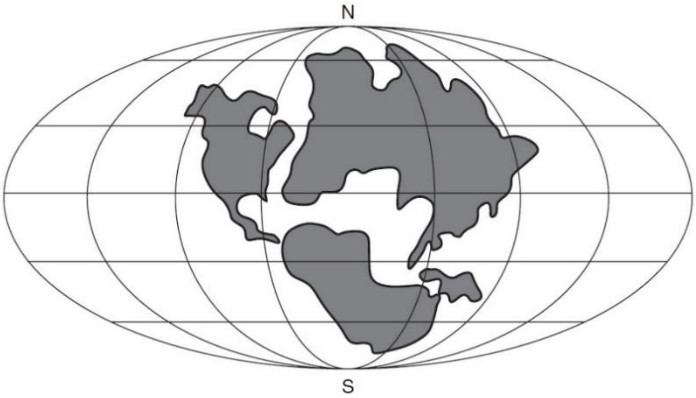


Figure 141. A probable estimate of the shape of Earth's two future supercontinents (https://www.google.com/search?client=firefox-b-d&sca_esv=583637472&q=viitorul+supercontinent+de+pe+pamant&tbm=isch&source)

The thermonuclear reactions inside the planet will gradually decrease; as a result, a slow cooling process of the mantle and the lithosphere will begin, which will cause a decrease in the temperatures of the toposphere (of the lithosphere, hydrosphere and atmosphere).

Over time, volcanic eruptions and earthquakes will decrease, which will slow down the translation of continents and the movement of tectonic plates above the earth's mantle.

Liquid water will pass more and more frequently into the solid phase, but the volume of fresh continental waters will not decrease, nor will those of the planet's oceans and seas (where their salinity will increase, due to the lack of fresh water input from the atmosphere and terrestrial environments). There will continue to be an input of water from the other objects that make up our solar system. There will be a reduction in the physico-chemical processes that take place in the lithosphere and hydrosphere, as well as the erosion processes caused by precipitation, which will implicitly determine the decrease in the intensity of the formation of sedimentary rocks of a mineral nature, with all that erosion processes will continue to take place, or even intensify.

There will be an intensification of the alteration of silicates in the lithosphere, which will lead to a reduction in the amounts of carbon dioxide and carbon in the atmosphere and carbonates in the lithosphere.

The anthroposphere will rapidly disintegrate after the disappearance of mankind from the planet's biosphere, as a result of the low volume of information on which it is based. Its demise will be hastened by the ecosphere's ability to replace it quickly and efficiently. This extinction will not affect the ecosphere, which may even be stimulated.

The reduction of the amounts of organic material determined by the drastic reduction of the biosphere, will lead to the reduction of oxygen production by organisms; this will have very strong effects on the oxygen content of the atmosphere and the reduction of the protective ozone layer against cosmic radiation. The loss of temperature by the planet will increase, the thickness of the terrestrial atmosphere will decrease, the disappearance of the hydrosphere will increase and at the same time the penetration of ultraviolet rays through the atmosphere will intensify, which will lead to the intensification of the photodissociation processes of water and the release of hydrogen from the terrestrial atmosphere.

Planet Earth will end up resembling Mars today, that is, with little water, stored mostly underground and as snow and ice on the surface at the poles, but devoid of life on the planet's surface.

The lithosphere will be increasingly depleted of sedimentary rocks previously formed under the action and with the contribution of the biosphere; more and more mineral salts will accumulate in it.

In the end, Earth will be drawn more and more rapidly towards the sun in its terminal phases of existence - as a red giant -, and it will disappear.

If we look at the **future of the ecosphere**, it will be much shorter, because it is totally dependent on what will happen to the biosphere.

Organisms appeared on Earth because they benefited at a given time from a complex of factors favorable to their emergence and development: an average temperature above 0^0C, liquid water, an atmosphere that forms a dam for cosmic and ultraviolet radiation through the ozone layer created.

It is possible that in the future, after an indefinite period of time, under the influence of larger celestial bodies, the activity of the biota will be endangered, moving towards its extinction. Another disruptive factor can be volcanic activity, or the intensification of the action of cosmic radiation, which will cause, as I said before, the alteration of silicate production, a fact that will cause the reduction of carbon dioxide amounts and implicitly affect the photosynthetic production of oxygen in the next 600 millions of years. As a result of this phenomenon, the process of extinction of plants (organisms producing living organic matter) will start. This situation will lead to the deterioration of food chains, then the disappearance of consumers and decomposers. The increase in temperature coming from the sun, in the next four billion years, apart from the intensification of the desertification process, can trigger the so-called greenhouse effect, so the intensification of the increase in temperature to values that can make the development of vital processes impossible (e.g. temperature average at the surface of the soil to currently exceed 50-60^0C), a fact that will determine the impossibility of the creation of proteins by plants - that is, precisely the organic substances on which life is based. Living things will retreat, either into the depths of the seas and oceans, or intelligent life forms will retreat into the depths of the earth's crust, and life will be based on organisms whose functioning will depend only on anaerobic processes, as they functioned years ago billions of years ago the first living things to populate the planet (Worm *et al*., 2006). And so the biosphere will disappear, and with it the ecosphere.

To the destruction of the biosphere and implicitly the anthroposphere (Keys *et al*., 2019), then also the ecosphere, humanity will make a very large contribution, especially through negligence, by carrying out anti-entropic activities, atomic wars, the intensification of destruction procedures of organisms through defective genetic manipulations, or through technologies contrary to the processes of sustaining life, through the deployment of defective nanotechnologies or through the triggering of viral or bacteriological cataclysms, etc. So, people can be capable of accelerating the processes of destruction of the biosphere and implicitly of the anthroposphere at the planetary level. And that, maybe only out of stupidity, unconsciousness or ignorance. It is possible that actually humans are the main factors capable of further destruction even of our planet's biota and ecosphere long before the natural limits of normal evolution of living and non-living processes on our planet are reached.

6 CONCLUSIONS

In an attempt to unite the concepts of matter, energy and information into a coherent whole, in explaining how living matter evolved and was structured on different systemic levels, we appreciate that information appeared first and energy almost immediately. Information has always been at the basis of the evolution of various forms of manifestation of energy flows and in the way in which the circulation of matter took place.

In order to present them, it was necessary that we first clarify ourselves, then reorder the terms used in different fields of natural sciences and astronomy, but all of them seen from an ecological point of view, and only then present them according to our knowledge and our powers.

Information about the evolution of life started from strictly biological concerns, which became more complex with the ecological approach to living-non-living relationships. The interrelationships that have created ecological structures and that have conquered all environments to form a unitary whole at present have been highlighted. They could only be realized under the influence and being coordinated by the informational mechanisms, which, in turn, have continuously diversified. Information in the living world is much more complex, active and versatile than that in the non-living world. It gradually became dominant, being able to influence informational processes in the abiotic environment: physical, chemical, pedological, hydrological and climatic processes.

Biological information is constantly being improved, regardless of whether some characters (for example, the morphological and physiological ones that seem to be still changing). The proof is given by the existence of a multitude of living organisms (for example bacteria, protists), which, although they exist as viable entities, live very well even today, although apparently they seem to be unchanged for billions of years (because they, in reality constantly adapts from a functional point of view to all the changes that take place and at the same time subtly coordinates all the living and non-living processes that take place on our planet). They have been maintained because they have remained indispensable for the normal development of the processes that take place at all biological and ecological levels of the organization of living matter.

From the moment of the appearance of complex organic macromolecules, the processes of metabolism and growth and multiplication began. They then correlated with the physical and chemical characteristics of the primordial planetary ocean - the adaptive ecological stage of ecological evolution began (Figure 139).

In the first stage of biological evolution (the individual one) there was a transition of biochemical mechanisms from linear processes (as they were in the chemistry of organic molecules), to circular biochemical processes, then spiral-ascending increasingly complex and diversified (Figure 112), everything taking place under the subtle control of biological information that was constantly complexing and diversifying.

From the appearance of organic macromolecules with metabolic and reproductive capabilities to the realization of the current biosphere, seven different forms of evolution can be distinguished: that of information, that of energy, that of physiology, that of ecology, that of morphology and that of geography (of gradual occupation of the four main living environments: marine aquatic, freshwater aquatic, terrestrial and underground, as well as the lower layer of the atmosphere, the troposphere). Due to living organisms and the necromass constantly produced by it, in association with materials from the superficial lithosphere subjected to climatic and hydrological factors, a new covering, the pedosphere, appeared on the surface of the planet.

The change produced in the evolution of living systems from the individual biological stage to the ecological stage (that is, the one in which complex functional systems of living-non-living interrelationships appeared) is emphasized. An adequate presentation is given in Chapters 4.2. and 4.3.

Since life began to unfold autonomously at the individual level, we can discuss levels of organization of living matter.

Life, as probiotic organisms, then as prokaryotes and eukaryotes appeared about 3.8 billion years ago. From the beginning, it showed a special capacity for adaptation (physiological and ecological, and later also morphological) under the influence of the environmental factors in which they lived. As a result, even though so much time has passed, in reality they have been permanently perfected. That is why they still exist today, as if they are more adaptable than ever to environmental factors. It is important to underline the fact that this process was not unilateral (only at the living level), but it takes place in correlation with the abiotic environment, in both directions (living-non-living and non-living-living), but always the cooronating factor is given by the information biological.

The ecosphere is a natural construction that appeared penultimate, only after all the earth's environments allowed the development of the living world. It has been continuously perfected which differs fundamentally from the way the evolution of the other planets in our solar system has taken place.

Life has a special ability to create a new type of informational pattern. It is characterized by self-regeneration, self-regulation, redundancy, a large capacity for storage (memory) and information processing. Through its representatives (living organisms), life very soon assumed the coordination of the main processes taking place at the planetary level.

As a result, the components of the toposphere – the atmosphere, the hydrosphere and the lithosphere – have been and are permanently influenced (if necessary even modified) by the biosphere. The harmonious interaction of the biosphere with the toposphere led to the genesis and continuous improvement of the Earth's ecosphere.

Less than 10.000 years ago, the anthroposphere appeared, which, on the time scale of our planet, has existed for less than 10.000 years, and which is expanding extraordinarily rapidly, supported by the intelligence and interests of the human species (but which has only too few relations with the natural ecosphere, which he mostly ignores). So, it will exist only as long as man is present on this planet, after which the natural ecosphere will regain its rights. There is no other way of sustaining life on Earth.

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