

SOME NOTES ABOUT THE CONSTRUCTION OF A MECHANISTIC LANDSCAPE OF NATURE

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Abstract

This article analyzes the historical process of constitution of the mechanistic landscape of nature. With the development of the metalanguage of science, mathematical formulations gradually began to be used to describe phenomena in the physical world, based on the observation of regularities in nature. The mechanistic landscape of nature that was being formed underwent transformations resulting from theories and empirical formulations, as well as from the introduction of technologies in experiments. Subsequent to this landscape, a probabilistic and stochastic image of nature was developed, based on discoveries on smaller scales in Physics. The sources consulted were scientific articles and books written by scientists from the modern period onwards.

Keywords: landscape, science, nature, language.

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Introduction

A profound philosophical change occurred in culture after the studies of Newton were published on the movement of bodies. Galileo and Newton contributed to the creation of a background image about the of nature. These studies allowed the understanding of force relationships and the development of expressions with vectors to quantify magnitudes, as well contributed to an understanding of experiments and its reproduction.

The development of the Cartesian plane, proposed by Descartes (1596-1650) was substantial in making mathematics more operational. The introduction of the axis coordinate system produced a strong impact in the imagination about the link of mathematics with sensible reality. It is through three dimensions that humans see the world, and Cartesian plane can express axis in xyz. Considering the time axis, reality can be thought as least four dimensions: the axis “t” + “xyz”. However, more sophisticated physical theories work with several dimensions.

Newton's laws provided a unified framework for understanding the motion of celestial bodies and terrestrial objects, establishing a precedent for mathematical modeling. This produced a modification in natural philosophy at that time, because resulted in an appreciation of experience and, in certain sense, a methodological departure from the exegesis of texts from Tradition.

Galileo's science can be seen as “a science of engineering”, considering the interpretations with pulleys, ropes and levers. The laws of physics are laws that aspire to certainty, and they are based on the notion that, if the input conditions are given, the output is determined. Nature would be like in this view an “automaton”, something that was later questioned by the introduction of concepts of nature's agency and nature's

complexity. But is the universe governed by deterministic laws? For some physicists, it may be said that it is. However, it is up to the observer to make a measurement.

Symmetries in nature

Galileo's fundamental proposition is that the world would be an integrated object, so that a stone, the air and the clouds would respect the same principles. Each body would require a directional force to be moved (Chatelet, 1994, p. 58). Galileo stated that, however complicated a sensible object may be, it can be reduced, through the effort of analysis, to a representation. It would always be possible to transform a complicated volume into the sum of simpler volumes, and a larger problem could be divided into smaller problems (Chatelet, 1994, p. 60). With this, sensible reality could be seen as an intelligible structure (Chatelet, 1994, p. 61).

For Russell, throughout the XVIII century and based on the reverberations of scientific production in culture, three factors are particularly important for the slow modification of structures of thought by a more literate portion of societies: 1. the affirmation that facts should be based on observation and not on authority; 2. the world would act as an autonomous system that would perpetuate itself in accordance with natural laws and without external control; 3. Earth would no longer be the center of the universe and man would not be its purpose (Russell, 1953, p. 17).

A consequence of the transformations in the XVIII century is the work of David Hume (1711-1776) in the sense of valuing empirical experience as criteria for the truth. For empiricists, someone could never “prove” something to be physically true without resorting to experience, so it was necessary to look to experimental results to obtain confidence in the

assumptions or to get back to it the mathematical review of the propositions (Sagan, 1995).

The observation of phenomena in the natural world depended on the construction of instruments, such as Galileo's telescope, used to view the surface of the Moon. The observation of phenomenas was also done by scholastics within the baroque tradition, however, little by little the notes on the natural world led to the isolation of phenomena from transcendental forces. Small experiments led to a more austere view of the world and to a discourse of autonomy of the physical world in relation to human's intentions (Russell, 1953, p. 21). It would be necessary to isolate the phenomena into their related variables to understand them, as was the case with the gravity.

With the experiments of motion, Galileo established the necessity of experimentation in physics and began the disintegration of Aristotelian physics (Tipler, 2008, p. 1). Galileo's notes divided the motion into smaller parts, and proposed analyzing it in terms of vectors and their magnitudes. He saw the universe as governed by physical and mathematical laws, not by a final cause or cosmic reason (Kuhn, 1987).

Within a hundred years, Isaac Newton generalized the results of Galileo's experiments in his three laws of motion, which were spectacularly successful. Newton demonstrated that all movements of the planet and inanimate matter are produced and governed in accordance with the laws of physics (Russell, 1953, p. 21).

Newton believed that a creator was needed to set things in motion and then they would continue to function according to their own laws. Over time, final causes were not supported by scientific theories, such as observations of changes in biological life due to randomness or adaptation to the environment. Darwin's work was decisive, as it was the struggle for the existence and survival of those most adapted to the environment that

allowed us to explain the historical adaptation of humans to the environment without resorting to the argument of purpose (Russell, 1953, p. 24). The analysis based on causal variation and natural selection used only efficient causes, with no final causes being necessary.

The dimension of phenomena separated from the observer does not imply disregarding the fact that science is a production of language. Wittgenstein's famous phrase, according to which the limits of the world are the limits of language, expresses that the more limited our capacity to express or understand something through language, the more limited our perception and interaction with the world around us will be. Observation of the external world depends in part on the observer, on his language, on his mind, but natural forces do not depend on the human mind.

But language does not only have the role of describing reality. According to Austin, language is also used to perform actions. Austin developed a theory of speech acts, arguing that when speaking, people not only communicate information, but performs actions such as promising, ordering or asking. Therefore, language cannot be reduced to a simple representation of the world, as it plays an active role in the constitution of meanings and in social interaction.

Although language plays a fundamental role in representing and conveying information about the physical world and human experiences, its function is much broader. Language also serves to express emotions, convey cultural values, establish interpersonal relationships, articulate abstract thoughts, and even construct social realities. In addition, language can be used creatively and symbolically, as in literature and art, to explore concepts beyond the tangible. However, when we talk about the language of science, the delimitation refers to the uses of mathematics and the technical language of scientific fields to refer to aspects of reality.

Before the XVII century, mathematicians and scientists were forced

to describe changes based on average values, referring to measurable time intervals, a process that was far from ideal. For example, to calculate precipitation in a given location, there were no precise tools to estimate precipitation variation from day to day or hour to hour. The invention of infinitesimal calculus, which allowed this type of calculation, was based on the recognition that an instantaneous variation is the asymptotic limit to which average variations tend (Guillen, 1987, p. 35).

What supported a belief was not the external reality of the world, but textual and literary elements, the readers' previous and affective experiences, and images formed in their minds through reading the texts. The tradition that was established in the past to justify myths was not a tradition based on a large framework of mathematical and experimental resources, but rather on linguistic and written resources. Little by little, changes in societies led to the circulation of other texts and references, which depended on the democratization of access to texts of natural philosophy.

The idea of creating an abstract model to talk about the world does not necessarily have to be complicated. Leonardo da Vinci (1452-1519) deduced the speed v of a body in free fall from examining a sequence of steps. Leonardo let drops of water fall at equally spaced intervals between two boards covered with paper. When a spring mechanism was disengaged, the plates were joined together. By carefully examining the sequence of water stains, Leonardo discovered that the distances between consecutive drops increased in a continuous arithmetic proportion.

Building a mathematical model of a system begins with identifying the variables responsible for changing the system (Zill, 2018, p. 19). After creating the model, we make a set of reasonable assumptions or hypotheses about the system we are trying to describe. We can choose not to incorporate all these variables in the first model built, which will result

in low resolution.

The pendulum was one of the first physical systems studied and modeled in an abstract way based on experimental observations, and was used by Galileo to investigate oscillatory motion. Galileo noticed that the pendulum had a constant period for small amplitudes, which led him to use it as a kind of primitive clock. Isaac Newton later described the motion of the pendulum with mathematical precision, using his laws of motion and the law of universal gravitation. This study of the pendulum was one of the first examples of how experiments could be used to create mathematical models that described natural phenomena.

Classical mechanics is based on the study of the trajectories of objects. It describes the movement of particles and bodies through deterministic laws, such as Newton's equations, where it is possible to accurately predict the position and velocity of a system at any time, given its initial state. A system of forces can be classically defined as an ordinary differential equation: $\frac{m \cdot d^2}{dt^2} \cdot x = F(x)$. This implies that a particle moves as a function of a force that can be described in terms of position and velocity (x,v), velocity being the derivative of position in relation to time. In the classical deterministic view, the trajectory of a small object can be determined because, from point A, it would be possible to know B.

To validate the objects constructed by modeling, the study of the mathematical model is carried out with mathematical formalizations accompanied by computer simulations. Laboratory experiments are used to test the model and obtain more data to be able to correct it based on simulations. But the question of what to do with an abstract model once it is in hand is pertinent. Scientists can create models to make predictions about a portion of reality, but not the whole. A model for how the climate works, for example, can require a lot of effort to build and, in the end, does not tell us about all of objective reality, but only about a small portion of

it.

The XX century saw a significant shift towards computational modeling and simulation. The advent of computers revolutionized the modeling process, allowing scientists to tackle complex problems that were previously beyond reach. Fields such as weather forecasting, fluid dynamics, and nuclear physics benefited greatly from the computational power afforded by electronic computers.

For Ian Hacking, throughout the XX century, probabilistic laws gradually took over a certain space previously occupied by deterministic laws (Hacking, 1991, p. 17). The analysis of macroscopic phenomena works quite well based on trajectory analysis. But at very small scales or very high speeds, the current model relies on quantum mechanics rather than classical mechanics. Quantum mechanics, constructed in XX century, deals with microscopic systems and introduces a probabilistic character, in which a well-defined trajectory for a particle can no longer be defined. Instead, it describes the probability of finding a particle at a given location.

Unlike classical mechanics, in which precise knowledge of position and velocity allows knowledge of what will happen in the future, in an hour or a day, in quantum mechanics, in principle, knowledge of a state at a given time guarantees only knowledge of how the probabilities of obtaining certain outcomes will evolve. With that, it is not possible to say where a particle will be, but if there is a high probability of it being here or there (Schrödinger, 1997). To deal with quantum mechanics, complex vector spaces are used. Depending on the phenomena, vector spaces can be described in finite dimensions, so that they can be solved in linear algebra.

Quantum physics contributed to the understanding of a stochastic background nature. Newtonian science, however, had no need for probabilities. It was only relevant as an instrument to locate underlying

causes. In modern physics, for certain problems, such as objects on a reduced scale, a statistical approach proved to be necessary and not optional.

The goal of a mechanistic explanation is to detail how a phenomenon is produced as a result of changes and interactions among temporal dimensions. According to modern notion of physics, all laws of nature are probabilistic and determinism is only a convenient approximation (Pearl, 2009, p. 48). In the field of engineering, it is more common to attack problems of a classical or mechanistic nature.

Over time, science has begun to make predictions about the future and about the behavior of natural phenomena. But, in recent decades, a science of non-equilibrium processes has also emerged, leading to new concepts such as self-organization and dissipative structures. Non-equilibrium physics studies dissipative processes, which are characterized by unidirectional time, and gives a new meaning to irreversibility. Previously, the arrow of time was associated with very simple processes, such as friction or viscosity. These processes were understood by the laws of dynamics. However, irreversibility no longer appears only in simpler phenomena, since theoretical contributions have placed it in more complex phenomena, such as chemical oscillations or laser radiation (Prigogine, 1996, p. 11).

Macroscopic processes, such as chemical reactions and transport phenomena, are irreversible. Solar radiation is the result of irreversible nuclear processes, and no description of radiation would be possible without the irreversible processes that occur in it. On the other hand, reversible processes are idealizations in which friction must be neglected in order to attribute reversible behavior to the pendulum.

The difference between reversible and irreversible processes was introduced into thermodynamics by the concept of entropy. Its statement

in the principles of thermodynamics is that "the energy of the universe is constant, and the entropy of the universe increases towards a maximum".

The growth of entropy designates the direction of the future at the level of a system, whether a local system or the universe as a whole (Prigogine, 1996, p. 26). By disregarding entropy in a process, it is possible to reduce its image to an idealized and more static, although less real, picture.

Physicists in the second half of the XX century consolidated what became known as the "Standard Model", which is a concise description of how nature works. The model is composed of four fundamental forces: I) weak nuclear force, II) strong nuclear force, III) electromagnetism, and IV) gravity. The first three can be explained using quantum mechanics, while gravity is explained by general relativity (Nogueira, 2019, p. 5).

Gravity is the only fundamental force in the universe that cannot be described by the laws of quantum mechanics, the theory that applies to all other forces and particles known in physics. Electromagnetism, which is the "strong" nuclear force that maintains the cohesion of the atomic nucleus, and the "weak" nuclear force that produces radioactive decay - are all essentially quantum forces (Folger, 2019, p. 28).

In the quantum world, particles can be in two places at the same time, which is called a superposition of states. Quantum superpositions have already been observed in the laboratory, but they are complex states, since interactions with any nearby particles cause the superposed objects to collapse into a single position (Folger, 2019, p. 31).

Feynman argued that if gravity was a quantum phenomenon, then the superposition of a particle in two places at the same time would create two separate gravitational fields. It is expected that with new experiments it will be possible to understand gravity more deeply. Currently, the theory of general relativity predicts that gravitational fields are distortions in

space-time.

The Standard Model lists all known particles and their interactions. Scientists believe that there is a mathematical structure based on the symmetry of nature that describes how microscopic elementary particles interact with each other through electromagnetic forces, strong forces, and weak forces.

Distant stars are formed by the same three elementary particles of matter that make up our bodies: the electron and the "up" and "down" quarks, the latter two of which form protons and neutrons (Carena, 2021, p. 29). The brightness of stars is the result of the electromagnetic force acting between electrically charged protons and electrons, which release energy in the form of light on the hot surface of the stars. The source of heat for these stars, including the Sun, is the strong force, which acts on protons and neutrons to generate nuclear fusion. The weak force acts on quarks and electrons, transforming protons into positively charged neutrons and electrons. It controls the rate of the first stage of the fusion process. The fourth force of nature, gravity, is not included in the Standard Model. Integrating it with the other forces of nature is a challenge for current physics.

The Standard Model was built over decades, piece by piece. In particle accelerators in different countries, it is possible to create and observe all the particles that the mathematical formulation requires. The discovery of the Higgs boson, made at the Large Hadron Collider (LHC), occurred a decade ago. However, the standard model is not complete, as it does not explain the 85% of matter in the universe, corresponding to dark matter, which keeps the universe cohesive, enabling the existence of galaxies like the Milky Way (Carena, 2021, p. 29).

The Model fails to explain why, at some point in the past history of the universe, matter overcame antimatter. Fermilab's Muon g-2

experiment seems to indicate that the Standard Model describes only a part of the universe, a microcosm. Muons, which are the subject of this experiment, are produced in large quantities by cosmic rays in the Earth's atmosphere. Every minute, more than 10,000 muons pass through our bodies. These particles that, every minute, pass through our bodies in a quantity of 10,000 muons, have the same physical properties as the familiar electron, but are 200 times heavier.

At Fermilab, muons are created under controlled conditions by smashing a beam of protons produced by a particle accelerator against a nickel target. This process produces pions, unstable composite particles that decay into neutrinos and muons by the action of the weak force. The muons are injected into a ring where a vacuum is created similar to that of "empty" space (Carena, 2021, p. 29). Muons carry electrical charge and have a property called "spin", which makes them behave like tiny magnets.

Physicists create muons by colliding a beam of protons with a target material to produce particles called pions, which naturally decay into muons. The muons are then injected into the experiment's ring. The circulating muons decay into electrons, whose kinetic energy indicates the direction of the original muon's spin. Experimenters use calorimeters to measure the energy and arrival time of the electrons to determine the change in the particle's spin direction.

If the muons were isolated in the experiment, their spins would not oscillate. But scientists know that empty space is never truly empty: virtual particles continually appear and disappear due to the energy fluctuations of the vacuum. It is possible to calculate how much the known particles in the universe affect the oscillation, but if unknown particles are present, they will also contribute to the oscillation. Such particles could include the muon and neutralino predicted by supersymmetry.

In the Muon g-2 experiment, many more oscillations were measured

than predicted by the Standard Model of Physics. If there were no virtual particles present, the $g-2$ factor would be zero. But due to interactions with virtual particles, g becomes greater than 2, and the direction of the muon's spin changes relative to the direction of its momentum. The result suggests that new particles may be affecting the value of $g-2$ (Carena, 2021, p. 31).

According to classical physics, measurements performed on a particle separated from another particle by a large distance would not affect the other particle, what is not different for quantum theory, because this happens all the time. In 1964, physicist John Bell published an equation to determine an aspect of quantum mechanics, which proposed a mathematical inequality. To understand Bell's work, it is necessary to consider that the proposed rules describe the behavior of light and matter on small scales. Atoms, electrons, photons and other subatomic particles behave differently from the objects we come into contact with in everyday life (Hanson, Shalm, 2019, p. 38).

Some theories based on mathematical equations have been used in recent decades to propose solutions to physical problems in cosmology, and shape part of the current understanding of the universe. The inflationary universe theory proposes that, in the first moments after the Big Bang, the universe underwent a phase of extremely rapid and exponential expansion, called cosmic inflation. This expansion would have occurred in a fraction of a second, causing the universe to expand to thousands of times its current size in an extremely short time scale.

The inflationary universe theory helps to understand how the universe went from a very small and hot state to the vast cosmos, maintaining a homogeneous and isotropic structure over large distances.

The current standard model of cosmology, known as the Λ CDM (Lambda Cold Dark Matter) model, uses the theory of cosmic inflation to explain the initial conditions of the universe. As for the singularity, the

model suggests that at the initial moment, the universe was in a state of infinite density and temperature, which leads to the notion of a singularity at the Big Bang. However, current physics, particularly quantum gravity, cannot yet accurately describe the conditions within this singularity, so the problem of the singularity remains open.

If electromagnetism is one part of the Standard Model, it is a small part of nature. On a macroscopic scale, it is necessary to remember of electric and magnetic fields, electric charges, and electromagnetic theory as a whole. Some of the main concepts of this subfield of physics were developed by Maxwell.

However, the theoretical construct of Maxwell is not enough for very small-scale problems (Einstein, 1905). In the case of an electron orbiting around a nucleus of a proton, which, while it is spinning, has a centripetal acceleration, all the accelerated electric charge emits radiation. By classical theory, this electron should start to emit radiation and, if it emits radiation, it would start to lose energy and spiral inwards, until it ends up colliding with the nucleus, which happens in a very small time interval, less than a millisecond. Since “no one person is collapsing”, this explanation applied to an atom is incorrect. It was necessary to have a mechanic that would not result in this collapse (Einstein, 1965).

While most forces of nature are represented by fields defined in spacetime, such as the electromagnetic fields characteristic of subnuclear forces, gravity is inherent to spacetime itself. According to Carroll (2022), people experience gravity “as a manifestation of the curvature of spacetime”. If General relativity is Einstein's theory of space, time, and gravity; then Special relativity is a theory of the structure of spacetime, the background against which particles and fields evolve (Carroll, 2022, p. 3).

In quantum mechanics, space is treated as a background structure within which particles and fields evolve. As for the nature of space itself,

quantum mechanics introduces concepts such as quantum fluctuations, uncertainty, and entanglement, which can challenge our classical intuitions about space as a continuous and deterministic entity.

At very small scales, quantum effects can lead to phenomena such as particle-wave duality, where particles exhibit both particle and wave behavior, and the uncertainty principle, which places limits on our ability to precisely measure certain pairs of properties, such as position and momentum.

Scientists are currently conducting experiments to prove whether gravity and spacetime should be quantized at the Planck scale. The quantum nature of gravity is expected to be real (Folger, 2019, p. 33). If this is proven, quantum spacetime would no longer be the smooth continuum described by the theory of general relativity, but would instead be coarse-grained. If scientists can place two spheres in superposition, they will be able to test how their gravitational fields would interact. If the results show that the particles are entangled, this could prove the nature of quantum gravity.

Planck-scale distances are 100 trillion times smaller than a hydrogen atom. At this scale, quantum spacetime itself is likely no longer the smooth continuum described by general relativity, but would instead have a coarse grain, like a digital photograph that begins to show pixels when magnified further. This grain is due to the confinement of energy, momentum, and other properties of particles into discrete bits, or quanta (Folger, 2019, p. 29).

Unfortunately, there is no way to observe phenomena at the Planck scale. The higher the energy scale of the experiment, the smaller the distance we can investigate. Investigating at the Planck scale directly would require a machine 15 times larger than CERN's Large Hadron Collider (LHC), the largest particle accelerator ever built, which has a

circumference of 27 kilometers. If it were to reach the Planck scale, the accelerator would have to be the size of a galaxy (Folger, 2019, p. 29).

As scientific inquiry became increasingly interdisciplinary, models evolved to address complex interactions within and between disciplines. Biological models, for instance, expanded to include systems biology approaches, capturing the intricate dynamics of living organisms. Similarly, economic models embraced complexity and behavioral factors. In the XXI century, models face new challenges, including the need to incorporate big data and deep learning. The translation of concepts from one area to another led to the development of science.

Observing the use of mathematics in constructing interpretations about the world and models for specific phenomena, different theoretical views on models can be highlighted. For Bas van Fraassen (1980), “constructive perspectivism” would be an approach that highlights the constructive role of scientists in creating models. In this case, scientists build models to represent specific aspects of reality, but these models do not need to be true or give an accurate representation of all of reality. With this, van Fraassen defends a strict empiricism, based on the idea that we should only accept entities or processes that are empirically observable. Scientific models, for Van Fraassen, are instruments to explain and predict observable phenomena, but they should not be interpreted as true representations of the underlying reality or same mirrors of reality. They fulfill pragmatic purposes and do not need to correspond to the totality of reality.

The laws of nature would work, but there would be no commitment of nature to certain laws, making it difficult to isolate or blind certain non-observable phenomena in the analysis (Van Fraassen, 1980). A model or theory cannot be seen as a necessity because it cannot be tested in a certain sense against what did not occur. There is always the possibility

that something new may appear that affects the laws and that cannot be absolutely eliminated and that could produce responses different from those observed.

For Van Fraassen, if the agent wanted to test necessity, he would have to see what happens in another possible world, which would be unfeasible. As the most viable path would be to make predictions, they are not completely conclusive. However, science can be trusted pragmatically, as it allows for modelling and physical action. Science explores the concept of symmetry and seeks explanatory functions of certain models, however, for Van Fraassen, an expansion of what is understood to be a model must occur because in this search for symmetries, the process of separating what is relevant and irrelevant is not simple (Van Fraassen, 1980).

On the other hand, for Hilary Putnam, the entities postulated by successful scientific theories must be considered as existing, even if they are not directly observable. Putnam recognizes that models are representations of the world, but believes that they can provide a true or approximate representation of reality, especially when theories that incorporate these models achieve predictive and explanatory success. Putnam formulated the “miracle argument” to support scientific realism. This argument suggests that, given the predictive success of scientific theories, it would be a “miracle” if the entities postulated by these theories did not exist (Putnam, 1975).

In the past, numerical simulations were carried out to use certain patterns to hypothesize behaviors in nature based on observed mathematical patterns. It is clear that numerical simulations are important and also the gold standard in certain contexts. However, one could believe that experimental observation would be replaced by the mathematical exercise of logical and formal construction, believing that mathematics would be sufficient in itself to say about nature. After some

studies that shook the foundations of mathematics, people increasingly sought a connection with the physical world to avoid hanging in the sky.

Mathematical language concerns what humans are capable of interpreting, that is, their consciousness. However, mathematicians argue that there may be mathematics independent of our ability to understand and, therefore, that they are not merely a human production.

On the other hand, humans are biologically limited by the data processing capacity of the world in which they are inserted (Nicoletis, 2001). In this sense, if consciousness is like software embedded in biological hardware, we have limits of understanding associated with the biological structure that has been conserved and modified to adapt to the environment over time. Language also went through the same biological process of adaptation to the environment, being hampered or adjusted by practical needs to preserve life and optimize energy expenditure.

A development in mathematics in the XX century occurred through Kurt Godel, starting with his "non-completeness" theorems of 1930 and 1931. In 1938, Godel demonstrated that if restricted set theory is consistent, so is conventional set theory. If it is possible to find a contradiction in conventional set theory, then there must be a hidden contradiction in restricted set theory.

Cantor worked on the so-called 'continuum hypothesis', according to which there is no infinite cardinality that lies between the cardinality of the natural numbers and that of the real numbers. Gödel showed that if the continuum hypothesis, combined with the axioms of restricted set theory - such as ZFC - led to a contradiction, then this contradiction would already be present in set theory itself.

Putnam argued that scientific theories seek to represent an objective reality independent of us, while acknowledging that observations and theoretical constructions are mediated by language and human conceptual

categories. However, conventionalists, such as Henri Poincaré, argue that what we consider "real" in science is largely the result of linguistic conventions and arbitrary choices, rather than a direct correspondence to an objective reality.

For conventionalists, many scientific laws and theories are constructs based on conventions that are adaptive and socially negotiated, rather than discoveries from a pre-existing reality. They propose that many truths are determined by human conventions or agreements, suggesting that the truth of certain propositions is established by linguistic or social conventions, rather than their relationship to objective reality (Stein, 2003). For example, the value attributed to certain units of measurement, such as kilograms or meters, are social conventions, not absolute truths.

If humanity discovered a set of rules through mathematical and physical language, and could apply them to a computer, to provide answers from a set of data, training an artificial intelligence network, then someone who believed in the computationalist aspect would defend that consciousness would be obtained by the machine just like humans. However, for Nicolelis and Cicurel (2015), the human brain cannot be reduced to a computer, because the brain computes temporally as a whole not in sectors (Nicolelis, Cicurel, 2015).

For mathematicians, who are more concerned with the objective character of mathematics, the evaluation of a mathematical work is more objective and less subjective. Philosophers can be seen as those who semiologize mathematical reality and dissolve it from its concrete character, dismantling part of the structure of mathematical architecture. For a positivist philosopher, what exists must be observed, or at least observable, so that mathematics must be justified by its indispensability for natural science, which is proven by empirical experience.

Although the position of mathematical realism also has

exaggerations, and the opposite can also be said - that it is based on a loss of memory of fictional elements in the history of mathematical development - on the other hand mathematics after the XVIII century, or part of it, sought to contribute to the description of reality and the construction of methods and tools to solve problems and the development of pure mathematics but without disregarding the methods of science. In this sense, its vocation has always been closer to science as a language, and its historical development has implied the construction of a language more capable of creating models that are independent of man's fiction, or that attenuate the authenticity of each man or his personality.

Can science be done without mathematics? Can mathematics be removed from science? Since it cannot, it exists and is justified, by the Quine-Putnam indispensability argument, at least in more simplified terms. If science is a successful company, given the technological progress of the modern and contemporary world, mathematics is also a successful company. In this sense, if mathematics is seen as a tool for solving problems, it is a means by which men were able to make simplifications and generalizations and solve problems that, without it, would be insoluble.

Even a simple model, like the pendulum, is not perfect after a few places after the decimal point. Even computers with great computational capacity are capable of creating models that work accurately up to a few places after the decimal point. With the development of experiments, theories and computers, the possibilities for building mathematical models have increased. However, many mathematical works have errors, so that mathematics can be seen as the set of grains in the entire desert, in which the portion of grains that solves a specific problem is, with luck, the one that fills a cup.

In many cases, the formulated mathematicians were able to verify the

physicists' conjectures, but the proofs dealt with each individual case and ignored the general picture that governs the physicists' intuition. The basis of physicists' intuition is their belief that quantum field theory and the underlying string theory is self-esteem consistent mathematical structure (Deligne et al, 1999, p. 2). Physicists believe in the reality of these physical theories and, therefore, in the existence of mathematical foundations for them (Deligne, 1999, p. 2).

The historical process of establishing a scientific language and incorporating mathematics is, above all, a process of contact between men/women and culture. Culture is both a learned behavior and a way of thinking, feeling and believing, which modifies the way of being of a people and through which men can weave webs of meaning (Geertz, 2008, p. 10). In this cultural and historical process, the meaning of the terms is modified and modified the cultural matrix of naming the things and universe. For example, the meaning of certain words changed after the first decade of XX century. It was proposed that there would be packets of energy, or "quanta", called photons. In this sense, Einstein and Planck realized that the photon behaved like a particle. Gradually, discussions about the wave nature of particles began to be carried out with other small concrete particles as well. (De Broglie, 1949).

The early stages of the development of most sciences have been characterized by continuous competition between several distinct conceptions of nature, each being partially derived and all only approximately compatible with scientific observation and method (Kuhn, 1995, p. 22). Observation and experience may constrain the range of admissible beliefs, but they do not by themselves determine a similar set of beliefs. Subsequent to the mechanistic landscape, a probabilistic and stochastic image of nature was developed, based on discoveries on smaller scales in Physics.

Brains and adaptation to the environment

Among all the impacts produced on collective thought in the modern period, one of the greatest was due to the concepts of evolution (Coyne, 2009, p. 10). The publication of “Origin of the species” occurred first in 1859. It was, however, studies with later fossil and molecular evidence that solidified evolution in the second half of the XX century.

Life on Earth evolved gradually from a primitive species, possibly a molecule capable of replication that lived beyond 3500 million years ago. This form of life branched out over time, producing more species and generating diversity, so that the main mechanisms for most evolutionary change were natural selection and genetic drift (Coyne, 2009, p. 22). Over time, scientists collected fossils and observed anatomical variations in the musculoskeletal structure of animals. With this, it was possible to understand that speciations occurred and that there are distinct groups of living beings, such as reptiles and birds, which are quite ancient, and that mammals, of which primates are part, came later (Coyne, 2009, p. 24).

Evolution is the change in frequency of DNA alleles from one generation to the next. In this sense, it is the change in frequency of characteristics of a population from one generation to the other. There are selection mechanisms, some random and others non-random, such as genetic drift. When the environment filters characteristics, another mechanism occurs, that is natural selection. Evolution is a continuous adaptation to environmental challenges, without a value judgment about what is “better” or “worse”. The concept of progress or improvement is often mistakenly associated with evolution, but what really happens is the adaptation of species to their environment, not a “scale of progress” (Coley, 2009).

For the first half of the history of life on Earth, the only species were bacteria. Complex multicellular organisms appeared very recently in chronological terms considering the time spectrum in which life existed on Earth after the appearance of organic conditions for its existence.

According to Coley, human behavior can have evolutionary explanations. Before the more than 250 generations of urban societies, with established agriculture, there were around 300 thousand generations of hunter-gatherers who lived in small social groups, considering the period in which the human lineage is separated from the chimpanzee lineage (Coley, 2009, p. 299). The use of symbolic language, in which words are abstract symbols of actions and objects, results from the growth of certain structures in the brain over thousands of years. This change did not occur on a scale of hundreds of years ago, as the changes occurred earlier, thousands and thousands of years ago.

Humans have many more sweat glands than any ape, and as interferes with the cooling produced by the evaporation of sweat, this may be one of the factors that led to hair loss in humans. It is believed that there have been changes in the climate and that in the drier climate, closed jungles gave way to more open habitats, with savannas, herbaceous systems, forests or even deserts. In this scenario, bipedal evolution gradually occurred, which allowed it to cross forests with greater speed. Being able to walk became a selective advantage, as it freed up hands to transport food. Walking on two parts may also have been advantageous for temperature compensation by allowing a smaller area of the body exposed to the Sun (Coley, 2009, p. 277).

The evolution of characteristics did not occur in a linear or uniform manner, but reflects the diversity of adaptation that different groups developed in response to needs imposed by the environment. Considering forms of life that previously existed on the planet on a very distant time

scale, it can be mentioned that dinosaurs were quadrupeds and, over time, became bipeds (Brusatte, 2018, p. 50).

Archeopteryx (2017) is one of the oldest fossil records found and represents a transitional Jurassic hybrid linking reptiles to birds. From the comparative anatomy studies that led to the cladistic reconstruction, combined with molecular studies, it was possible to see the development of bird anatomical structures in the specimen, situated in a period of environmental changes that may have influenced the structural changes in the animal after exposure. of factors over generations. In this sense, evolution would have made birds from dinosaurs.

In nature, great changes rarely survive. In general, small changes in the genes of animals that later express characteristic survives. A mutation in a gene is the basis for change in an animal that may or may not survive the process of selection of traits by the environment (Dawkins, 2010).

The first species of humans emerged in Africa and dispersed to Asia and Europe. Fossil records found in Dmanisi, Georgia, a location on the border between Europe and Asia, were dated to a period between 1.8 million and 1.7 million years ago, making it the oldest fossil record located outside of Africa to this day. (Neves, 2018). Around 2.8 million years ago there was a differentiation of the genus Homo, some groups left Africa and arrived in Asia, and gave rise to a new species 1.8 million years ago. Around 1 million years ago, groups spread across Europe. Fossils were found in northern Spain between 1.2 million and 800 thousand years ago in the Atapuerca mountain range; and show that human ancestors moved from Africa to Europe.

The anatomical form and physiology of modern humans was described in fossil records of hominids from 200,000 years ago, and modern humans have a percentage of DNA similar to that of other animals and also to the ancestors of the genus Homo. Little progress was made

until the discovery of how to manipulate fire, but when it was possible to use it for cooking and protection, as well as the improvement of stone tools, further progress was made. Around 50,000 years ago, there was an explosion of innovative practices in relation to the practices of previous hominids.

The development of language distinguished man from other species, his ability to collaborate and preserve the knowledge obtained from previous generations were decisive for the survival and material development of communities. The management of information about animals and plants and, mainly, the practice of agriculture allowed more time and conditions for humans to specialize in other activities. With the guarantee of food supply through developed agriculture, it was possible to plan future actions with more conditions (Neves, 2018).

The causal perception of external reality is based in a repertory of knowledge accumulated throughout human experience, and constituted by notions of Physics, Biology and other sciences. Humans, in turn, are conscious to the extent that they can control their actions through the brain before deciding to move, possessing inhibitory control to decide in certain terms (Nicolelis, 2015). At the same time, they are determined by their biological and neural constitution, which defines how humans see the world and it shape some of human senses.

Considerations

The causal perception of external reality is associated with thinking guided by evidence and considers that nature is based on principles that can be described by formal language. The language of science has been developed to build more accurate search heuristics, models that support

societies to do things more safely and efficiently, considering the scarcity of available resources.

Considering that evolution is already established as a regular model, and not just a theory with poorly supported facts or evidence, it can be said that modern science is an indirect consequence of evolution and the specialization of human activity. The mechanistic landscape of nature that was being formed underwent transformations resulting from theories and empirical formulations, as well as from the introduction of technologies in experiments. Subsequent to this landscape, a probabilistic and stochastic image of nature was developed, based on discoveries on smaller scales.

There are characteristics of the Standard Model that have not yet been explained, as well as the functioning of the brain and consciousness. Several technologies used in medicine are still in their early stages and need to mature. However, each year, new scientific works are produced and reflect characteristics of the scientific activity, interested in to understand the external reality and contribute to human community.

Algumas notas sobre a construção de uma paisagem mecanicista da natureza

Resumo

Este artigo analisa o processo histórico de constituição da paisagem mecanicista da natureza. Com o desenvolvimento da metalinguagem da ciência, formulações matemáticas passaram a ser gradualmente utilizadas para descrever fenômenos do mundo físico, a partir da observação de regularidades na natureza. A paisagem mecanicista que se formava passou por transformações decorrentes de teorias e formulações empíricas, bem como da introdução de tecnologias em experimentos. Posteriormente a essa paisagem, desenvolveu-se uma imagem probabilística e estocástica da natureza, a partir de descobertas em escalas menores da Física. As fontes consultadas foram artigos científicos e livros escritos por cientistas a partir do período moderno.

Palavras-chave: paisagem, ciência, natureza, linguagem.

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