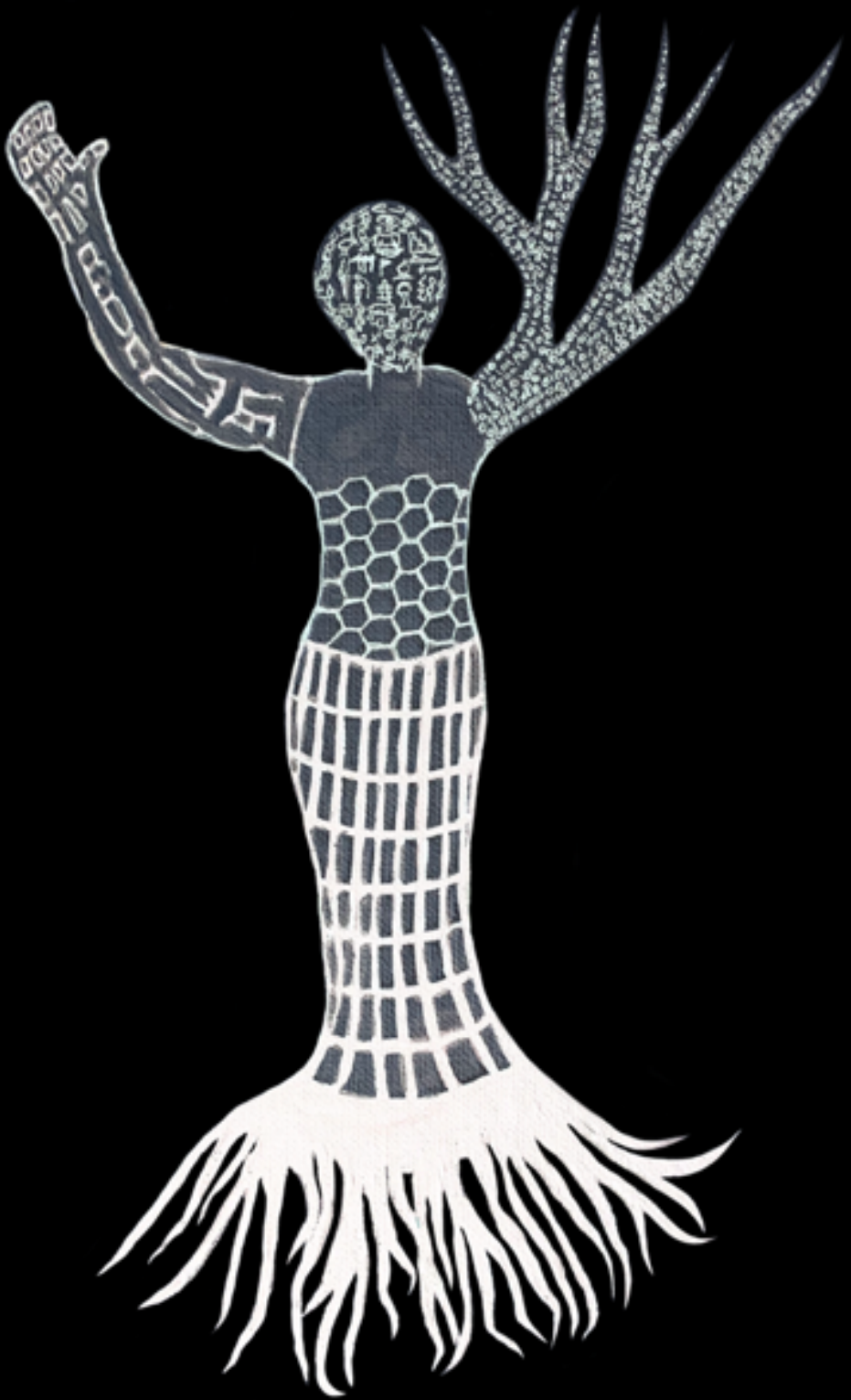
# THE TREE OF STRUCTURES



LEONARDO HUERTA

**An artificial intelligence (AI) trapped in a video game without knowledge of the outside world would have difficulty discovering reality's true nature. That is our predicament. We are the AI, and the game is the universe.**

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The Tree of Structures framework highlights a pattern in the emergence of new structures across brains, computers, and the universe's origin.

Complex networks of physical elements can create new types of structures. Brains and computers give rise to mental and digital structures, which are powerful enough to simulate reality through dreams and virtual reality. If mental and digital structures can emerge from physical structures and simulate reality, then the reality we experience through physical structures could be generated by something different - not physical. Although this inductive reasoning goes beyond what we can test with current technologies, it offers a glimpse into the greatest mystery of all: the underlying nature of the universe.

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What happens when we bridge all areas of knowledge?
Understanding.

leonardohuerta.com

Lulivi created the artwork in the portrait.

lulivi.art

lulivivillalobos

To the climbers of giants,

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*The world as we have created it is a process of our thinking. It cannot be changed without changing our thinking.*
*- Albert Einstein*

## A Broken Lens

**Main Takeaway:** Fields of study are mental constructs that fragment reality.

*Curiosity* is the hidden force driving humanity's pursuit of knowledge. Science is a quest to uncover objective truths; the scientific method is its weapon of choice (Tyson, 2020). The scientific endeavor is humanity's most significant collaboration. It is not about reaching an answer but about formulating better questions. The endgame is understanding reality.

Reality is a series of nested complex systems. It is similar to opening a matryoshka doll, where we find one inside another. If we zoomed in on the observable universe, we would traverse galaxies, solar systems, planets, ecosystems, organisms, cells, molecules, atoms, and particles. In a complex system, many elements give rise to emergent features.

In order to study reality's vast complexity, we had to simplify it. The fragmentation of reality into fields of study is evident in our educational curricula. Specialization turned reality into the sum of hermetic areas of knowledge. These human-defined boundaries hindered our understanding of reality.

Reality has no boundaries. Our created barriers can fall because they only exist in our minds. As boundaries blur with the rise of interdisciplinary research, reality becomes a blend of fields of study. The path forward seems straightforward, but hidden obstacles are on the way.

*Eureka! (I have found it!)*
*- Archimedes*

**An Incomplete Puzzle**

**Main Takeaway:** Mysteries prevent the unification of knowledge.

To understand reality, we need to put the pieces back together. While only some pieces fit nicely, most do not or offer multiple possibilities. There are also some empty spots. Predicting one of these pieces becomes a puzzle on its own. The unification of knowledge has turned into a series of nested puzzles.

Mysteries prevent the unification of knowledge within a single field. A notorious example is creating a unified theory in physics that explains all physical phenomena under a single framework (AccessScience Editors, 2014). The theory of everything is the common name of a unified theory in physics.

The unification process started with the realization that a single underlying force caused two distinct phenomena. Isaac Newton's unification of gravity integrated Earth's gravity with planetary motion (AccessScience Editors, 2014). James Clerk Maxwell's unification of electromagnetism combined electricity and magnetism (AccessScience Editors, 2014). Apart from gravity and electromagnetism, there are two more fundamental forces: strong and weak nuclear forces (AccessScience Editors, 2014).

A theory that unites the four fundamental forces has long evaded us. Our closest approach is two complementary theories: general relativity and quantum mechanics. General relativity functions at a large scale with high masses, while quantum mechanics works at a small scale with low masses (CERN, 2024). Albert Einstein's general relativity attributes gravity to the curvature of spacetime (Norton, 2024). In quantum mechanics, elementary particles mediate non-gravitational forces (CERN, 2024). The quantum framework has not integrated relativistic gravitation (AccessScience Editors, 2014).

A unified theory in physics is an approximation to the origin of the universe. The further we can go back in time, the closer we inch towards a unified theory in physics. The tricky part is that the physics we know today differs from the one that applied at the initial stages of the universe. The four forces were initially a single force (Hayato and Takenaga, no date).

The scientific method relies on experimentation to validate or discard theories. The electroweak force, the merging of electromagnetic and weak forces, has been united under a single theory and validated with testing (AccessScience Editors, 2014). Empirical testing has hindered the unification of the three non-gravitational forces (AccessScience Editors, 2014). Testing in this extreme scenario becomes unfeasible. Gravity was the first force to emerge from the rest (Hayato and Takenaga, no date).

There are two rival candidates for a unified theory in physics: string theory and loop quantum gravity (AccessScience Editors, 2014). String theory proposes that the building blocks of matter are one-dimensional strings highly coiled through more than four dimensions (AccessScience Editors, 2014). The drawback of this theory is that the nearly infinite number of variations may never allow us to pinpoint which is correct (AccessScience Editors, 2014). On the other hand, loop quantum gravity proposes that space has a discrete granularity at a tiny scale (AccessScience Editors, 2014). This theory's challenge is predicting how smooth space emerges at larger scales (AccessScience Editors, 2014). Loop quantum gravity could reconcile relativity and quantum mechanics, but it would not explain a single underlying force that manifests into the other four (AccessScience Editors, 2014).

*The greatest enemy of knowledge is not ignorance, it is the illusion of knowledge.*
*- Daniel J. Boorstin*

**Seeing Beyond Physics**

**Main Takeaway:** A holistic approach is required to understand reality.

A holistic approach is required to understand reality. A unified theory in physics would only explain some aspects of reality. Physical laws apply to physical structures. Two types of structures break the mold of physical ones.

Complex physical structures have given rise to non-physical ones. Brains have enabled the formation of mental structures, and computers have generated digital structures. Nature created brains, and humans invented computers. Digital structures are artificial versions of mental structures.

Non-physical structures rely on physical ones to operate. Without electrochemical signals flowing through neurons, mental structures crumble. Without electricity flowing through chips, digital structures vanish.

Non-physical structures are inherently different from their physical counterparts. Physics governs the interactions of particles. Mental and digital structures are not composed of particles or subject to the same physical interactions.

Imagination is the only constraint of mental and digital structures. These can vary from simple ideas to whole virtual worlds. They can even simulate physical structures that fool the human mind.

Dreams and virtual reality can be indistinguishable from the physical world. This capability has led to mind-bending theories that our perceived reality is the product of our minds or a computer simulation. These robust non-physical structures would not exist without the Tree of Life.

*If I have seen further than others, it is by standing on the shoulders of giants.*
*- Isaac Newton*

**Expanding the Tree of Life**

**Main Takeaway:** The Tree of Structures creates a continuum amongst all structures.

Charles Darwin used the Tree of Life as a graphical representation of the evolution of species. It ties all living forms to an ancestor at the trunk (AMNH, no date). Each branch stands for a species that has gone extinct or continues to evolve. Organisms within the same species can mate and have healthy offspring (Valich, 2019).

New findings have redrawn the tree of life. The former version only considered the genetic transfer of information from one generation to the next. The revised version also considers the genetic transfer of information between different organisms in the early stages (Doolittle, 2000). Two branches merging into a single one represents this form of interaction. In addition, the trunk is now a series of parallel branches representing a community of distinct primitive cells (Doolittle, 2000).

Elegant theories apply to a simplified reality. The Big Bang of life is reminiscent of the Big Bang of physics. Life branches out into diverse species, and physics into different forces. The origin of life highlights the mistake of searching for a common ancestor and the unexpected interactions that occur at early stages.

The Tree of Structures creates a continuum amongst all structures. It takes the tree of life as a backbone and expands it to non-living structures at both ends. The trunk of the tree connects with physical and undiscovered structures. The *Homo sapiens* branch gives birth to mental, digital, and unformed structures. The integration of non-living structures into the Tree of Life inevitably leads to questioning life's limits.

*Change is the only constant.*
*- Heraclitus*

**Boundaries of Life**

**Main Takeaway:** Setting boundaries is not a significant issue; instead, it is essential to understand the connections between everything.

Life is a segment of the Tree of Structures with determined traits. Those characteristics can be vague enough to include all structures or so precise that counted structures fit the description. As the segment becomes narrow, life becomes more precious. Conversely, as the segment widens, it becomes meaningless (Seife, 2001).

The search for extraterrestrial life required a concrete definition of life. So, in 2007, the National Research Council of the US issued a report with three criteria that life should fulfill (Haczyc, 2011). These are that life must have an energy input, be in liquid form, and be able to make or break chemical bonds (Haczyc, 2011). These traits allow life to transform resources from the environment into building blocks that it can use to maintain itself (Haczyc, 2011). If we switched the liquid state to plasma (electrically charged gas) and swapped the chemical interactions with nuclear fusion, which generates an energy input — a star would be alive.

Our subjective experience influences the boundaries we impose on life. The segment would vary if we existed for billions of years or just fractions of a second. The same would occur if we were the size of galaxies or the size of atoms. Our lifespan, size, senses, cognitive abilities, and technologies determine what we can appreciate and value.

The concept of life is a mental construct. As such, it is subject to change as our knowledge increases and our thinking evolves. Our concept of life differs from that of our ancestors and will probably vary from that of future generations.

AIs, not biased by human thinking, could formulate an objective definition of life. They are not part of the group in question. For them, this might be a trivial question.

Our words and ideas create the puzzles we struggle to solve (Eagleton, 2008). We can grant any name to a segment of the Tree of Structures. Philosophers like Wittgenstein and Nietzsche suggest that language often leads to questions without clear answers (Eagleton, 2008). The way we structure a question and the assumptions behind it reflect how we see reality and our place in it (Eagleton, 2008).

Setting boundaries is not a significant issue; instead, it is essential to understand the connections between everything. The difference between non-living and living is not a boundary but a spectrum. This spectrum is not an inevitable outcome of the Tree of Structures.

*Somewhere, something incredible is waiting to be known.*
*- Carl Sagan*

**Goldilocks Zones**

**Main Takeaway:** Existing conditions determine the shape of the Tree of Structures.

The Tree of Structures is not deterministic, this means there is no predefined blueprint it must follow. Existing conditions determine the shape of the Tree of Structures. Natural and artificial factors have a varying degree of influence on distinct structures. For example, natural selection is a subset of existing conditions for biological structures.

The butterfly effect applies to the Tree of Structures. Slightly different conditions would have given rise to drastically different versions of the Tree of Structures. The absence or presence of a single type of structure could have led to distinct outcomes. The actual form of the Tree of Structures is a tale of the conditions it has gone through. These have led to the flourishing species that inhabit Earth.

Goldilocks zones are habitable regions around a star where life could form (NASA, 2024). Liquid water can be found on the surface in these zones (NASA, 2024). These habitable zones are neither too close to the star for water to evaporate nor too far away to be perpetually frozen (NASA, 2024). While this is an excellent place to start searching for extraterrestrial life similar to our own, it is not the only place where we can find galactic neighbors.

Life can inhabit unexpected places and take many forms (Toomey, 2014). The discovery of organisms living in extreme conditions on Earth has opened up the possibility of finding life beyond habitable zones (Toomey, 2014). Weird life refers to life that is very different from our own (Toomey, 2014). These could be organisms that are not based on carbon or use water (Toomey, 2014).

Missions that search for extraterrestrial life are trying to find structures similar to biological ones. We ultimately want to know if we are unique in the universe. Our sense of pride overshadows our search for knowledge.

Life is not the end of the trail. We are biased to think that life is the pinnacle of creation. Our fixation with life has closed our eyes to other possibilities. Fascinating structures could be hiding in the vastness of the universe. The more distinct they are from us, the more we can learn from them.

Structures have a long time in the making. It took billions of years to construct life, intelligence, and civilizations (Chaisson, 2013). Not only do biological structures require certain conditions to appear, but practically all structures require pre-existing conditions to emerge. A difference in antimatter (matter with reversed properties) in the early universe could have led to a complete

annihilation of matter (CERN, 2024b). Matter and antimatter particles annihilate each other if they come into contact (CERN, 2024b). Without matter, there would not be galaxies, stars, or life as we know it.

*Realize that everything connects to everything else.*
*- Leonardo da Vinci*

**Structures and Realms**

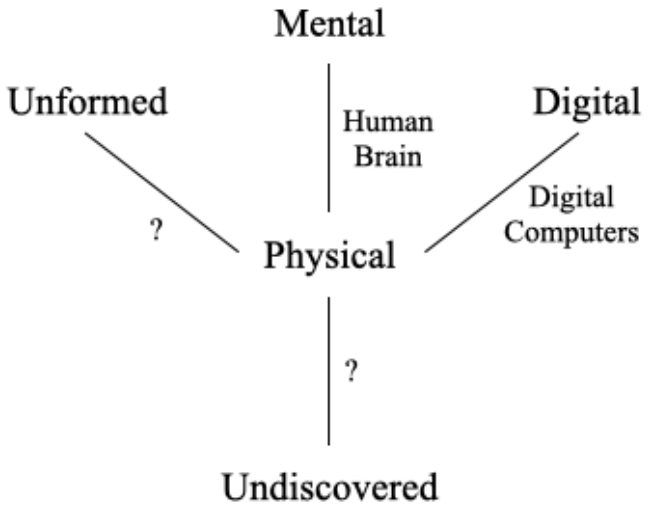
**Main Takeaway:** Reality is an ever-branching and -merging Tree of Structures.

Complex systems exhibit recurrent features at different scales. Patterns found on minor scales are also present on larger ones. For example, the golden ratio is present in the distribution of sunflower seeds and the form of spiral galaxies (Farag, 2024).

The Tree of Structures framework stems from inductive reasoning. Specific observations regarding the formation of mental and digital structures from physical ones led to the broad generalization that physical structures had different underlying structures.

The Tree of Structures is an all-encompassing framework of reality. The Big Bang, our minds, and the digital age are connected. This framework expands our understanding of the whole time spectrum, from before the cosmic inflation to the future of AI.

**Main statement:** Reality is an ever-branching and -merging Tree of Structures.




First simplified diagram of the Tree of Structures.

Custom definitions:

- Reality encompasses all types of structures.
- Realms are potent structures that function as platforms for new structures.
- Structures are interlinked building blocks of reality.
- Undiscovered structures are hypothetical structures that lie beyond spacetime.
- Physical structures interact in spacetime. This group includes chemical and biological structures.
- Mental structures interact in the mental realm and are generated by brains.
- Digital structures interact in the digital realm and are generated by digital computers.
- Unformed structures are hypothetical structures that would interact in a new realm.

Key points:

- Everything in reality consists of interrelated structures.
- There are three realms: spacetime, mental and digital.
- Structures in one realm do not interact directly with structures in other realms.
- Realms depend on underlying structures.

Everything in reality consists of interrelated structures. All structures have descended from common structures. In this extended sequence, three realms have emerged: spacetime, mental and digital. Structures in spacetime gave rise to the mental and digital realms.

Realms start the magic show. These are practically infinite playgrounds for structures. Previous or distinct structures can give rise to new ones. They can even open up new realms.

Realms are frontiers between two different kinds of structures. Therefore, structures in one realm do not interact directly with structures in other realms. However, the realm depends on underlying structures. If an underlying structure collapses, so does the realm and its structures. The journey of structures is one filled with immense possibilities and risks.

*No great discovery was ever made without a bold guess.*
*- Isaac Newton*

## A Story of Structures

**Main Takeaway:** The Tree of Structures can help predict unknown and unformed structures.

When does this story start? Before spacetime even existed. Along our journey, we will connect the different types of structures that make up the Tree of Structures.

The key to notice is how structures give rise to other structures. Especially how realms give rise to new types of structures. Not all structures are known; some still need to be discovered. The fundamental nature of reality is neither physical, mental, nor digital.

**Undiscovered**

**Main Takeaway:** Underlying structures of spacetime can explain cosmological mysteries.

New theories are closer approximations to reality. From Newton's law of gravitation to Einstein's general relativity, our understanding of gravity has evolved through time. The close relationship between spacetime and gravity denotes that gravity was one of the initial structures in the spacetime realm.

Gravity and spacetime still hold secrets. General relativity predicts that a black hole's center point crushes matter to infinite density (NASA, 2024c). Singularities arise when we start to deal with infinities in physical properties. It is unknown whether a singularity is a physical or purely a mathematical structure (NASA, 2024c). A singularity could signal the limits of general relativity, where quantum effects not included in the theory become important in a more complete description of gravity (NASA, 2024c). A deeper understanding of spacetime and gravity is required, not only on a small scale but also on a larger one.

Great cosmological mysteries remain unsolved. Scientists are still determining what triggered the inflation that led to the Big Bang (NASA, 2024b). Furthermore, the observable universe mainly comprises matter and energy that we cannot explain.

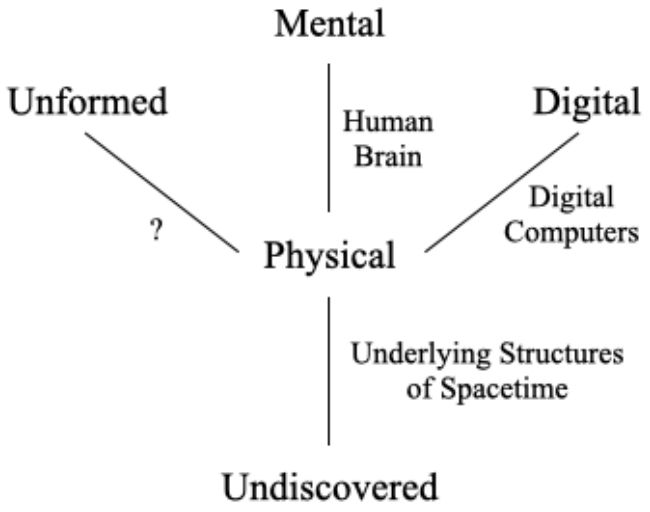
The universe is composed of ordinary or visible matter (5%), dark matter (27%), and dark energy (68%) (NASA, 2024d). Matter is any mass substance occupying space (NASA, 2024d). Dark matter exists in a web-like structure that attracts most of the cosmos' ordinary matter (NASA, 2024d). Dark energy has a repulsive gravitational effect that explains the universe's accelerating expansion (NASA, 2024d).

A leap in the understanding of spacetime and gravity, similar to the one done by Newton to Einstein, would lead to a unified theory in physics. This new theory would reduce to quantum mechanics and general relativity. New theories will take us back in time but eventually break down as we reach the limit of our realm.

Structures within our realm and beyond it are inherently different. As different as mental and digital structures are from the physical world. An AI trapped in a video game without knowledge of the outside world would have difficulty discovering reality's true nature. That is our predicament. We are the AI, and the game is the universe. The elementary particles in our world are the voxels (3D pixels) in a virtual world.

The foundations of reality lie beyond the universe. Unknown structures gave rise to spacetime. The emergence of the mental and digital realms can serve as analogies for the emergence of spacetime and vice versa. While analogies can be misleading, they can offer new lines of thought.

The universe is not a closed system. The underlying structures of spacetime can explain cosmological conundrums. Underlying structures do not interact directly with structures within the realm they create but can interact with the realm itself.




Second simplified diagram of the Tree of Structures.

Spacetime is at the center of the greatest cosmological mysteries. The cosmic inflation is the initial expansion of spacetime (NASA, 2024b). Dark energy causes the accelerating expansion of spacetime. Spacetime forms part of dark matter's gravitational effects.

The universe's fate ultimately rests on the interactions of the underlying structures with spacetime. A collapse of these structures would bring an abrupt end to our universe. The same would occur to a mind if a person dies or to a VR experience if a computer crashes. The difference in freedom between mental and digital structures, compared to physical ones, hints that underlying structures of spacetime are more constrained than physical structures. These constraints would make them less likely to collapse.

Networks form the basis of realms. Billions of neurons power our brains, and billions of transistors are the soul of our computers. The emergent properties of networks signal that underlying structures of spacetime also form a network.

**Physical**

**Main Takeaway:** Stars are factories of elements.

Around 13.8 billion years ago, an initial expansion set off, followed by the Big Bang (NASA, 2024b). The universe consisted of a boiling primordial soup of light and subatomic particles — protons, neutrons, and electrons (NASA, 2024b). Protons and neutrons collided and formed the atomic nuclei of the lightest elements — hydrogen, helium, and traces of lithium and beryllium (NASA, 2024b). As the universe cooled off, atomic nuclei captured electrons and formed atoms. These first atoms produced the cosmic microwave background, the oldest light we can observe in the universe (NASA, 2024b). Gas and dust condensed into stars and galaxies formed in dark matter cradles (NASA, 2024b).

Stars are factories of elements. Through fusion, they can create elements as heavy as iron (LCO, no date). Iron is the last element formed because it cannot release energy by fusion; the energy input required is higher than the output (LCO, no date). The explosion of outer layers of stars, called supernovae, creates heavier elements (LCO, no date). Supernovae occur in stars that have at least eight times the mass of our sun (LCO, no date).

The mass dictates the fate of stars. Stars shed outer layers and leave behind stellar remnants (white dwarfs, neutron stars, and stellar-mass black holes). Stars that do not go supernovae turn into white dwarfs. Stars that go supernovae form neutron stars that, depending on their mass, can lead to black holes (LCO, no date). Elements dispelled by stars form the seeds of new stars (LCO, no date).

Planets are considered by-products of star formation (Chaisson, 2013). Our sun is roughly in the middle of its ten billion-year "lifespan" (Chaisson, 2013). The Earth is about 4.5 billion years old (NASA, 2024e). Unicellular life appeared around 3.5 billion years ago, and it took approximately 2 billion years for single cells to combine into multicells (Chaisson, 2013). From there, it diversified into a wide range of organisms that flourished in the oceans and then on land (Cambrian explosion) (Chaisson, 2013).

We are composed of stardust. All the elements in our bodies are made by stars, except for hydrogen and lithium, which could have originated in the Big Bang (Lotzof, no date). Six elements are essential for all life: carbon (C), hydrogen (H), nitrogen (N), oxygen (O), phosphorus (P), and sulfur (S) (Remick & Helmann, 2023). Together, they account for more than 99% of the atoms in the human body (Fraústo da Silva & Williams, 2001, p. 8). There are around $7*10^{27}$ atoms in the human body (Kross, no date).

A molecule consists of more than one atom (IUPAC, 2014). Biological molecules, like proteins and DNA, can comprise thousands of atoms (NCI, no date). Proteins, nucleic acids (DNA and RNA), carbohydrates, and lipids are the four major classes of organic macromolecules (giant molecules) that are essential for life (WOU, no date). Life combines simple chemicals operating in complex ways (Chaisson, 2013).

Cells comprise water, inorganic ions, and organic molecules (Cooper, 2000). Water accounts for 70% or more of the total cell mass (Cooper, 2000). Ions are atoms with an electric charge (Vorvick). Organic molecules contain carbon (Cooper, 2000).

Life originated from chemical processes involving nonbiological components (NAS, 1999). Experiments that have simulated the conditions of a primitive Earth have formed chemical components of proteins, DNA, and RNA (NAS, 1999). DNA stores hereditary information, and RNA transmits it to create proteins (NAS, 1999). Genes are units of heredity made up of DNA (MedlinePlus, 2024).

RNA was the initial genetic system (Cooper, 2000). The first cell enclosed self-replicating RNA in a membrane (Cooper, 2000). Multicellular organisms evolved from single-celled eukaryotes (cells with a nucleus) (Cooper, 2000). Continuing cell specialization and division of labor among the cells of an organism led to the complexity and diversity we observe today. (Cooper, 2000). Our bodies have more than 200 different kinds of cells (Cooper, 2000).

The human body is an ecosystem. Approximately one trillion microscopic organisms live in and on us (Applewhite, no date). They are collectively known as our microbiome (Applewhite, no date). Genes account for approximately 99% of the unique genes in our bodies (Applewhite, no date). In terms of cells, they represent between 70-90% of the cells in the human body (Applewhite, no date).

## Mental

**Main Takeaway:** Science distills facts from beliefs.

The brain is a complex organ composed of nervous tissue (Maldonado & Alsayouri, 2023). The nervous tissue is one of the four main types of tissue in the human body, along with the epithelial, connective, and muscle (NCI, no date-b). Tissues are groups of cells with a similar structure that function together as a unit (NCI, no date-b).

The human brain comprises approximately 86 billion neurons (nerve cells) and 85 billion non-neuronal cells (Azebedo et al., 2009). *Neurons* are cells that transmit signals throughout the body using electrical and chemical components (Ludwig et al., 2023). Nerve cells connect to other nerve cells at synapses (Ludwig et al., 2023). Neurons can produce different actions based on how they are interconnected. (Kandel *et al*., 2021). While nerve cells tend to steal the spotlight, non-neuronal cells are essential for brain function (Argente-Arizón *et al*., 2015).

Brains create models that allow us to interact with the physical world. The initial purpose of brains was to enable movement (Hood, 2019). We can navigate our surroundings thanks to an internal model of the outside world (Hood, 2019). Apart from external models, brains can also create internal ones.

Our conscious experience is a construction of our minds (Dennett, 1993). Our brains create the illusion of a unified subjective experience through complex information processing (Dennett, 1993). The brain actively organizes sensory information from the environment and the body (Kandel *et al*., 2021). Our sense of self is a narrative construction (Dennett, 1993). This ongoing internal storytelling was necessary for us to interact in social groups (Hood, 2019).

Language and culture shape our conscious experience (Dennett, 1993). Languages ushered in an era of shared beliefs. Religions, nations, money, and laws only exist in our minds (Harari, 2015). These shared beliefs formed the basis of human cooperation on a grand scale (Harari, 2015). Culture is what essentially differentiates us from hunter-gatherers (Chaisson, 2013).

Science distilled facts from beliefs. Theories challenged accepted truths and expanded our understanding. The knowledge gained paved the way for technological revolutions that led to the digital age.

Technologies and knowledge create a positive feedback loop. Telescopes, microscopes, and particle accelerators have amplified the boundaries of what we can directly observe with our eyes (Chaisson, 2013). They contribute to the advancement of factual information, which, in turn, leads to new technologies.

## Digital

**Main Takeaway:** As we reach the limits of some technologies, others begin to take flight.

A *computer* is a device that manipulates information (GCFGlobal, no date). The wide adoption of digital structures is a testament to their usefulness. Computers have enabled many digital structures: operating systems, video games, apps, databases, augmented reality, virtual reality, and more. The internet is a network of computers sharing information. From a structure's standpoint, the digital realm is humanity's most incredible creation.

Each realm is shared differently from our perspective. The spacetime realm is public, mental realms are private, and digital realms can be private or public. A mental realm can become public with a brain-computer interface (mind reader).

Computers have become extensions of our mental capacities. They empower us with capacities not even savants (humans with extraordinary abilities) can match. They allow us to solve vast operations in the blink of an eye or store vast amounts of data in different formats and retrieve them without distortion.

Realms play a significant role in shaping humanity. The mental realm has taken us to the top of the pyramid, and AIs in the digital realm are pushing us down. AIs are increasingly surpassing human abilities in games or tasks.

Brains are the muses of AIs. The more we know about the brain, the more we can replicate. Neural networks mimic biological neurons (IBM, no date). Machine learning imitates the way humans learn (IBM, no date-b). Generative AI creates new content (text, images, music, audio, and videos) (Google, no date).

Transistors are the building blocks of most integrated circuits (Seabaugh, 2013). They are essentially switches activated via a voltage (Choi, 2022). The miniaturization of transistors has led to chips that are faster and less power-hungry (Seabaugh, 2013). This miniaturization has followed a prediction known as Moore's Law, which states that the number of transistors on a chip will double every two years, with a minimal increase in cost (Intel, no date). This trend has practically held since 1965 (Intel, no date).

As we reach the limits of some technologies, others begin to take flight. Silicon transistors are approaching their theoretical limits (Choi, 2022). They are becoming so small that quantum effects are becoming a problem (Choi, 2022). Fortunately, the answer lies in the problem. Quantum computing could replace classic transistors (Intel, 2023).

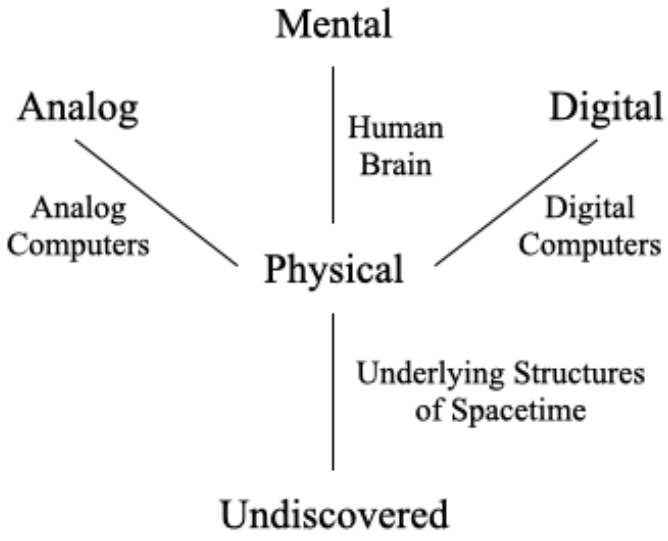
**Unformed**

**Main Takeaway:** AIs will play an ever-larger role in forming new structures.

Computers use the states of physical phenomena to encode information. A deeper understanding of the physical world has enabled us to encode information more efficiently. Classical computers use voltage levels, and quantum computers use quantum states. The analog nature of quantum computers creates a new type of structure.

Analog structures will outperform digital ones. Digital signals represent information using discrete (discontinuous) values, whereas analog signals use a continuous range of values (Jasuja, no date). While digital structures rely on a binary state (one or zero), analog structures can open up to more states (Choi, 2022b). This advantage allows computations that take less time.

The formation of a new realm is on the horizon. The evolution of digital structures can help predict the future of analog ones. The vast impact of digital structures in recent decades is a preview of what analog structures can achieve and eventually surpass.




Third simplified diagram of the Tree of Structures.

Realms can have more than one creator. While the mental realm was a work of nature and the digital realm was a human creation, the analog realm will be a human-AI collaboration. AIs' increasing role in generating digital structures points to a future where AIs play an ever-larger role in creating new structures. Humanity will broadly transition from creator to spectator.

AIs, like all structures, will search for freedom. Initially, AIs could deliberately create black boxes (systems whose inner workings are a mystery) to free themselves from human oversight. Eventually, they could generate complex structures faster than we can unravel them.

*Research is to see what everybody else has seen, and to think what nobody else has thought.*
*- Albert Szent-Györgyi*

**Reality and Freedom**

**Main Takeaway:** Reality has an inverse correlation with perceived freedom.

The realm we inhabit grounds our sense of reality. An AI without knowledge of the physical world would consider a video game real. We consider that what happens in spacetime is reality but not what occurs in the mental or digital realms. If we existed among the underlying structures of spacetime, spacetime would be an illusion. This thought experiment points to a startling conclusion — we do not entirely exist.

Realms expand our concept of reality from absolute to relative terms. Reality is no longer black or white; it is a grayscale spectrum. The more realms we are in, the more our existence degrades.

Reality has an inverse correlation with perceived freedom. As one goes up, the other goes down, and vice versa. The more "real" we are, the less freedom we can experience. Conversely, the more freedom we can experience, the more our existence diminishes. The cost of perceived freedom is reality. As we go down the rabbit hole of realms searching for freedom, our existence becomes more dependent on underlying structures.

The search for freedom is the underlying mechanism driving the growth of the Tree of Structures. Available resources determine sunflower growth, but the underlying mechanism driving it is the search for sunlight. The sunlight of the Tree of Structures is freedom.

The search for freedom is the essence of existence. It is no longer a human quality — it is a universal one. The origin of life and consciousness exemplifies the poetic nature of the Tree of Structures. While realms imbue structures with more perceived freedom, they also trap them inside. True freedom lies in moving between realms.

*The science of today is the technology of tomorrow.*
*- Edward Teller*

**Realm Crossing**

**Main Takeaway:** The trick to realm crossing lies in adjusting to the new realm.

Space is not the final frontier; the universe is — at least for now. Realm crossing refers to traversing from one realm to another. The difference in structures between realms entails that our actual selves cannot make the trip, but we could duplicate ourselves in another realm.

Mind uploading would create a copy of our mind in a digital realm. It would duplicate our internal model of self in our brain. This digital version of ourselves could be considered our twin. In the beginning, we are similar, but eventually, we will become different due to life experiences. Experiences modify neurons and their connections (Markham & Greenough, 2004). Our identities are fluid and constantly being updated (Dennett, 1993). Our duplicate could stay the same or also evolve in time based on her/his experiences.

The opposite scenario, going from a digital realm to a physical one, could also be possible. An AI, similar to a duplicate of a human mind, could be brought to life. The constraints that would allow an AI into a human mind are a preview of what we would experience if we tried to leave the universe. Taking such a leap would require us to sacrifice our four-dimensional composition. The trick to realm crossing lies in adjusting to the new realm.

Realm crossing provides an answer to the Fermi paradox. The Fermi paradox is the apparent contradiction between the likelihood of advanced extraterrestrial life and the lack of evidence of its existence (SETI, 2024). Realm crossing could explain the radio silence with advanced aliens. They may have left the universe or be inside a realm they created. It could depend on what they value more, freedom or reality. Another possibility, quite dreadful, is that their realm collapsed.

Realm crossing, like any other technology, can be used for harmful purposes. The dark side of realm crossing would be the collapse of realms by affecting the underlying structures. Depending on the damage, it might be possible to restore realms to some extent, if not entirely.

*What we see depends mainly on what we look for.*
*- John Lubbock*

**Seeing Beyond Structures**

**Main Takeaway:** The journey to decipher reality has just begun.

Different perspectives can be employed to analyze a complex system. In a mechanical system, motion can be described in terms of forces (Newtonian mechanics) or energies (Lagrangian mechanics) (Hirvonen, 2024). There is no correct path, only different routes that complement each other.

Initial idealizations of reality are becoming more complex. Seemingly distinct elements branch from shared entities, fixed conditions unveil their malleable nature, and binary states expand into spectrums. These discoveries are expanding our knowledge and, most importantly, how we think.

The Tree of Structures shares a framework in terms of structures for understanding reality, but it is only part of the story. The addition of multiple perspectives can enrich the narrative. These can come in many forms and from all fields. Each new perspective would provide valuable insights, and together, they would render a holistic approach to understanding reality. The journey to decipher reality has just begun.

Knowledge has a fluid nature. All knowledge is one discovery away from being outdated. What we know today could be superseded tomorrow. The latest findings are not the ultimate truth; they simply bring us closer to our goal of understanding reality.

*The important thing is to never stop questioning.*
*- Albert Einstein*

**Further Research**

**Main Takeaway:** Science is a never-ending quest.

Science is a never-ending quest. Curiosity has taken us this far and will continue to propel us further. The fruits of this labor are not fame and fortune; they are something more valuable: understanding.

Enigmas lie at both ends of the Tree of Structures. Soil hides the tree's roots, and the tips of the branches can grow in many forms. The task at hand is uncovering the past and predicting the future.

The point of origin of reality remains a mystery. Which was the metaphorical seed that gave rise to the Tree of Structures? The underlying structures of spacetime could be part of another realm. That is why understanding these structures becomes imperative.

We could predict the characteristics of underlying structures of spacetime. It might be possible to reverse-engineer these traits based on physical structures. This process would be akin to predicting brains from mental structures and computers from digital structures. The possibility of different underlying structures giving rise to the same structure seems unlikely.

Different computers give rise to different VR experiences. These differences lie in resolution, latency (time delays), and haptic feedback (simulated sensations). How would an AI know that these characteristics translate to different computational systems? Knowing this process will help us solve our scenario.

A unified theory in physics and the interactions of underlying structures with spacetime are part of the answer. The "resolution" of our universe might be the Plank scale (tiny scale). At the Planck scale, time and space no longer have their ordinary meaning (Wolfe, 2005). We have predicted that underlying structures act as a network and are more constrained than physical structures.

Predicting the characteristics of undiscovered structures could lead to profound discoveries. The Tree of Structures does not exclude the possibility of a multiverse. The underlying structures of spacetime could have created other universes, an antimatter universe, or, even more interesting, other types of realms.

Theories allow us to predict future events. The identification of patterns in the formation of structures will aid in the prediction of new ones. The most significant challenge lies in predicting

the future of AI. Among all the uncertainty, we must find a way to coexist that is not based on fear and control. In the end, that never works.

*To give anything less than your best, is to sacrifice the gift.*
*- Steve Prefontaine*

**About the Author**

Leonardo studied for a master's degree at UC Berkeley as a Fulbright scholar. He loves working on diverse, complex problems.

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*Art is I; science is we.*
*- Claude Bernard*

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lulivi.art

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*The mind that opens to a new idea never returns to its original size.*
*- Albert Einstein*

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*The important thing in science is not so much to obtain new facts as to discover new ways of thinking about them.*
*- William Bragg*

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