# INFOAUTOPOIESIS AND UNDECIDABILITY: THE LIMITS OF ARTIFACT-MAKING

Jaime F. Cárdenas-García & William B. Miller, Jr

ABSTRACT: Artifact-making is central to human existence. The mid-twentieth century inaugurated what is popularly referred to as the 'Information Age', coinciding with the introduction of digital computers. The extraordinary growth of computer technology and the burgeoning of AI systems has triggered an active debate about the potential capabilities and limits of these supposed living creations, which now include extraordinary claims of imminent AI consciousness. A productive focus on this contentious issue requires an understanding of the exact characteristics of information in living systems, how these pertain to our human artifacts, and, correspondingly, to the limits of our artifact-making ability. The critical foundation of a correct assessment must be centered within the living context of an organism in its environment and how organisms recognize sensorial signals, so as to internally analyze and create information. That discussion directly relates to the distinctions between syntactic and semantic information and their dynamic interrelationship. Information assessment in the living frame is a recursive process, forming a continuously self-reinforcing sensation-information-action cycle that serves as the basis for the infoautopoietic self-production of information by living beings. Examining these processes reveals inherent limits to human artifact-making, governed by principles of uncomputability and undecidability inherent to the living information cycle.

KEYWORDS: Infoautopoiesis; Syntactic information; Semantic information; Undecidability; Uncomputability; Claude E. Shannon; Gregory Bateson

## INTRODUCTION

Greek mythology has many stories relating to Midas, the king of Phrygia (in modern-day Türkiye). One story relates to the capture of the philosophical satyr Silenus, a favorite of the god Dionysus, who was brought to King Midas and generously hosted by him. Soon after, Midas returned a liberated Silenus to

Dionysus. As a result, Dionysus granted him one wish in recognition of his good deed. After much pondering, King Midas asked Dionysus for the power to turn everything he touched into gold. Very soon after King Midas was confronted with the reality that it was not a blessing but a curse. It was an ability that no one should have, being unable to eat, drink or even touch his loved ones. Soon after, King Midas begged Dionysus to take back his gift. "Dionysus took pity and ordered the king to cleanse himself of the remaining traces of his guilt in the source of the river Pactolus, near Sardis. Midas obeyed, and the power of transforming things into gold passed from his person into the stream, whose sands forevermore were sands of gold" (Morford & Lenardon, 2003, p. 295). The applicable moral is that greedy overreach does not end well, and the future consequences of choices must be deliberately and fully considered.

We want to use this fable to identify what we believe is a parallel, but real modern version of this story, and palpably one of the most important results relevant to the science of information, meaning-making and artifact-making. The metaphor reveals how our desire for full control over our surroundings leads us to mistakenly believe that we can achieve the impossible.

## THE RELATIONSHIP BETWEEN THE MATHEMATICAL THEORY OF COMMUNICATION AND COMPUTATION

Claude E. Shannon, in his consideration of a general communication system, described the workings of a discrete or digital system as having "… applications not only in communication theory, but also in the theory of computing machines …" (Shannon, 1948, p. 382). To illustrate, a computer science problem, specified by the input (an arbitrary bit string) and a series of rules (the program or algorithm) that specifies how the output depends on the input, parallels the communication system described by Shannon as depicted in Figure 1. The input (a message) is encoded as a digital signal and is sent from an Information Source (a microphone into which a message is spoken) that starts the communication process (algorithm). The Transmitter is an encoding device that makes the Message generated by the microphone amenable to transmission as a Signal over a wired or wireless Channel. The Channel is subject to accumulation of Noise from multiple Noise Sources. The Receiver is a decoding device that reconstructs the original message from the Received Signal. Finally, the Destination is the speaker that announces the arriving Message as the output. What Shannon achieves is a solution to the fundamental problem of communication, or "that of reproducing at one point either exactly or approximately a message selected at another point" (Shannon, 1948, p. 379).

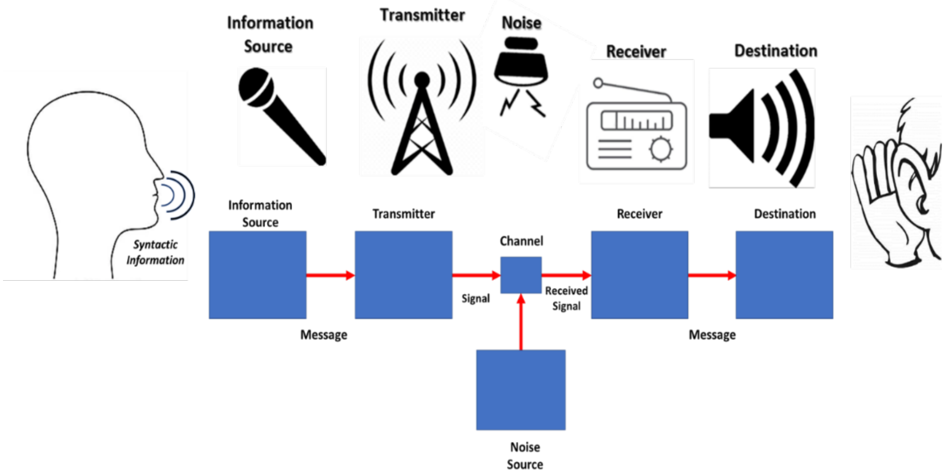


Figure 1 – The process of communication [adapted from (Shannon, 1948)]

Shannon's objective in devising this first Language Model was to probabilistically guarantee that the input was equivalent to the output. In qualifying it as a language model (LM), "… we understand the term language model (LM) to refer to systems which are trained on string prediction tasks: that is, predicting the likelihood of a token (character, word or string) given either its preceding context or (in bidirectional and masked LMs) its surrounding context. Such systems are unsupervised and when deployed, take a text as input, commonly outputting scores or string predictions" (Bender et al., 2021, p. 611). Specifically, this engineering analysis was devised to understand and solve the problem of communication, emphasizing the syntactics of communication, i.e., the spoken word as syntactic information, not the non-existent meaning of the message, or semantic information.

From a general perspective, what Shannon did in solving the fundamental problem of communication was to find an algorithm that, when receiving an input, produces the corresponding output. Using this scheme it is possible to output just one bit (Yes/No answer), which makes this problem a decision problem. Otherwise, it is called a computational problem. In addition, a decision problem is called undecidable if no algorithm solves it. Computational problems without algorithms are called uncomputable. Notice that there is no requirement for the efficiency of the algorithm. Simply stated, if a problem is undecidable or uncomputable there exists no algorithm for it. Additionally, for rigor, when we refer to a definition of an algorithm, we refer to a Turing Machine (Perales-Eceiza et al., 2025). Specifically, the fundamental problem of communication could take the characteristics of a decision problem or alternatively of a computational problem. Figure 1 is an apt illustration of a problem in computer science that takes the characteristics of an undecidable problem depending on the level of noise present in the system. If the level of noise is high/low the probability that the input is reproduced at the output is small/large. It might also be the case that if the original fidelity of the message is suspect then this will impact its probabilistic reconstruction.

One aspect of this theoretical scheme proposed by Shannon is that it assumes an existing message that gets transmitted, without specification of its origin. The implication is a situation indicative of alienation, where we don't recognize the products of our labor. In this case, our ability to conceive, design, manufacture and use a system of communication of our own making, but our inability to recognize that we use this system of communication to send messages that we create. Thus alienation may have led many researchers astray and assume that information is something that is naturally occurring in the environment (Stonier, 1997; Vedral, 2010; Wheeler, 1991; Yockey, 2005). Shannon was wise enough to clearly distinguish between the syntactics and semantics of the message so as to correctly pose and solve the problem of communication within the bounds of syntactics. The real problem to be solved needs to include the humans to the left and right of the communication system in Figure 1, the sender and receiver of the message, respectively.

Figure 2 shows a situation where a digital communication system is not used and the individuals communicate analogically directly. While this situation seems to have reduced the number of elements of what was considered to be a general system of communication as per Figure 1, closer examination determines that the same general system of communication is present in Figure 2. The Information Source and the Transmitter are the voice box (larynx) and the mouth and related organs, respectively, of the human individual on the left-hand side of Figure 2. On the other side of Figure 2 the Receiver and Destination are the ear structure and the cochlea, respectively, of the individual shown. In short, humans are at the center of the process of communication. What needs further clarification is: how does the sender of the message synthesize the message to convert it into the represented syntactic information that gets communicated? And how does the recipient of the message interpret the communicated syntactic message? While we don't intend to fully address all aspects of these questions here we note that the sender seems capable of internally synthesizing semantic information relevant only to itself, and then externalizing syntactic information. The recipient, upon hearing the message of the externalized syntactic information, interprets its content from their own unique perspective, and generates internalized semantic information, so as to be able to respond syntactically in reciprocation, if warranted. However, and crucially, that same message might have different meanings to different individuals. The implication is that infoautopoiesis (info = information; auto = self; poiesis = creation/production) is at work for this to be possible (Burgin & Cárdenas-García, 2020; Cárdenas-García, 2020).

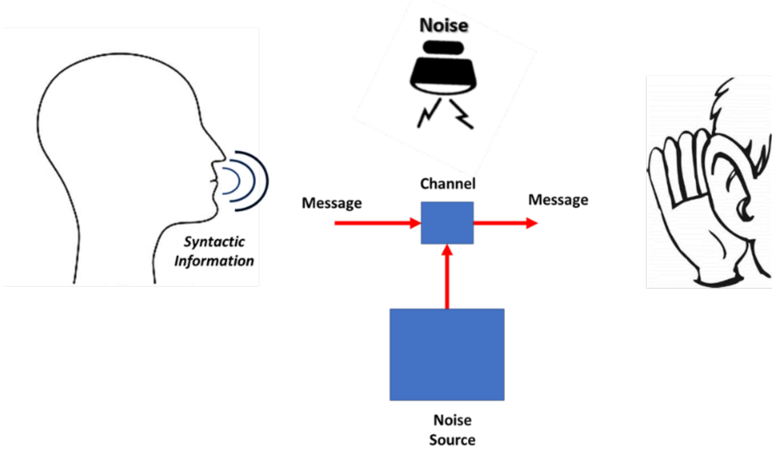


Figure 2 – The process of communication

A further clarification is necessary; Figure 2 represents the solution to the initial problem of communication over close distances between two individuals, that does not guarantee the reproducibility of the message in most instances of communication because of its direct analogical nature. Figure 1 solves the problem of communication over long distances, guaranteeing that the initial digital message will arrive at its destination with great fidelity. In both instances the interpretation involves syntactic information. In direct communication, the message includes other forms of syntactic information that might include hand and face gestures, as well as other forms of body language, which might better inform communication. These elements might be mostly missing in online or long-distance communication.

## THE MATHEMATICAL THEORY OF COMMUNICATION, INFORMATION AND ARTIFACT-MAKING

We have shown that the mathematical theory of communication involves the analysis, with a view to optimization of transmission, of syntactic information that lacks semantic content. In an attempt to gain insight into how the concept of information fits in, let us reexamine information from two other perspectives: First, etymologically; second, using Gregory Bateson's dictum of 'a difference which makes a difference' (Bateson, 1978, p. 453). The etymological origin of the word information is the Latin stem *informatio*, from the verb *informare* (to inform) in the sense of giving a form to matter and communicating knowledge to others (Capurro, 2009; Capurro & Hjørland, 2003; Peters, 1988). For an infoautopoietic organism this implies a dynamic outlook (Burgin & Cárdenas-García, 2020; Cárdenas-García, 2020). There is a before and an after when the organism engages with matter/energy. For example, the sender of the message above uses its voice box to manipulate air to create air pressure waves that allow it to form the needed syntactic information message so as to be intelligible on reception. In other words, it informs (shapes) air to achieve communication, probably a long process of development for our human ancestors. Bateson's analogous and dynamic conceptualization applies when observing nature around us to gain a perspective on its bountifulness as well as its dangers. In addition, anytime we choose to shape matter to make a useful object we take measure of our actions with every shaping action that we perform to arrive at the final shape of our design; a recursive sensing-information-action process. This is how artifact-making began and whatever its current sophistication it all goes back to informing or shaping matter. We can also identify the products of our capacity for artifact-making, which begins as semantic information in our head and results in useful objects, as objects that encapsulate syntactic information creation due to their organized form to serve a particular useful function. In short, both conceptions of information define a self-referential, interactive, recursive, evolving, and never-ending dynamic spiral of sensation-information-action (Burgin & Cárdenas-García, 2020; Cárdenas-García, 2020, 2022, 2023).

Thus, artifact-making is central to human existence. Not only does it involve the creation of language, but also the creation of artifacts that allow the projection of language over large distances, as well as all other artifacts that make our life more comfortable. Indeed, if we look around in the 21st century, it is very difficult to identify things that have not been created by us directly or indirectly. The generation of externalized syntactic information from internalized semantic information may also be achieved by more direct manual in-forming of matter/energy into useful objects. This may be construed as engaging in a process of syntactically ordering matter/energy. In other words, "the medium is the message" (McLuhan, 2008, p. 390). Correspondingly, however matter is ordered syntactically, we should be able to interpret its form and function so that we can use it effectively.

The implication is that not only are we able to communicate by our speech and writing, but we are also able to communicate by our creations in all areas of the arts and sciences. This also implies that most of what we artificially create and surrounds us is identifiable as syntactic information, i.e., Shannon/syntactic information is a metaphor for all human creations. This finding is demonstrably one of the most important results relevant to information and meaning-making, i.e., internal semantic information unavoidably requires transformation into external syntactic information in an endless process of sensation-information-action if we are to live in a social environment. The central dogma of information summarizes this by stating: "infoautopoiesis results in endogenous semantic information that irreversibly becomes exogeneous syntactic information" (Cárdenas-García, 2022).

The artificial nature of our technological creations might also be expressed as follows (Ong, 2002, p. 81),

> To say writing is artificial is not to condemn it but to praise it. Like other artificial creations and indeed more than any other, it is utterly invaluable and indeed essential for the realization of fuller, interior, human potentials. Technologies are not mere exterior aids but also interior transformations of consciousness, and never more than when they affect the word. Such transformations can be uplifting. Writing heightens consciousness. Alienation from a natural milieu can be good for us and indeed is in many ways essential for full human life. To live and to understand fully, we need not only proximity but also distance. This writing

> provides for consciousness as nothing else does.
>
> Technologies are artificial, but—paradox again—artificiality is natural to human beings. Technology, properly interiorized, does not degrade human life but on the contrary enhances it.

In short, our syntactic creations not only allow us to change the world around us, but also unavoidably, they impact us in ways that we might initially not be aware of, in a never-ending cycle of progressive development.

## IMPLICATIONS OF OUR CAPACITY FOR SYNTACTIC CREATION

To gain a measure of what we mean when we refer to syntactic information elements in our environment, we quote Pattee when he states, "For my argument here, I will mean by matter and energy those aspects of our experience that are normally associated with physical laws" (Pattee, 2012, p. 213). In other words, when we observe our environment and apply science and the scientific method to make sense of what we observe, we build an understanding that is based on our syntactic conceptualizations. We observe, experiment, and theorize using our syntactic creations, including mathematics, physics, and chemistry to gain access to the world that surrounds us so that we can change it in our own image to serve our needs. This is akin to what Dale Purvis identifies as empirical or trial-and-error learning (Purves, 2021; Purves et al., 2015). What this means is that all that we discover and build is subject to interpretation by someone, so we have to teach every new generation how to understand and interpret our scientific creations. This chain of knowledge may sometimes be broken. Such was the case when we were unable to decipher Egyptian hieroglyphic script. The finding of the Rosetta Stone, the first Ancient Egyptian bilingual text recovered in modern times, allowed us to gain access to the inscribed knowledge. The explanations and practical achievements of science need to be constantly reevaluated since they all are the result of syntactic creation. In short, syntactic creation is only able to explain other syntactic elements in our environment.

According to a recent study, the mass of all our stuff—buildings, roads, cars, and everything else we manufacture—now exceeds the weight of all living things on the planet. And the amount of new material added every week equals the total weight of Earth's nearly 8 billion people (Elhacham et al., 2020). In addition, Pappas (2020) states,

> Roads, houses, shopping malls, fishing vessels, printer paper, coffee mugs,

> smartphones, and all the other infrastructure of daily life now weigh in at approximately 1.1 trillion metric tons—equal to the combined dry weight of all plants, animals, fungi, bacteria, archaea, and protists on the planet. The creation of this human-made mass has rapidly accelerated over the past 120 years: Artificial objects have gone from just 3 percent of the world's biomass in 1900 to on par with it today. And the amount of new stuff being produced every week is equivalent to the average body weight of all 7.7 billion people.

We currently are surrounded by our artificial creations and are looking for creative solutions to gain control over our artifact-making capabilities.

If we revisit conceptualizing the problem of communication as falling within the theory of computing machines, meaning that the problem can be specified by an input (an arbitrary bit string) and a series of rules (the program or algorithm) that specifies how the output depends on the input, we can also extend this type of conceptualization to our capacity for artifact-making. Specifically, we can define any problem related to making artifacts as consisting of inputs, an algorithm, and corresponding outputs. In this context, we are then able to talk about undecidable and uncomputable problems if we are unable to find an algorithm that allows for the creation of an artifact.

Recall that artifact-making falls within the constraints of syntactic creation. What this perspective allows is for us to be able to determine the feasibility of solving practical problems by determining whether a specific artifact or syntactic creation is feasible. For example, recently, ChatGPT made headlines and brought to the fore the potential for the achievement of artificial general intelligence (Hutson, 2022; Roose, 2022). A question then arises: can IA generate new meanings of the world, i.e. semantic information? ChatGPT and all recent variations of Large Language Models depend for their deployment on computer hardware and software. Since the design, construction, and use of computing machines also fall under the umbrella of syntactic creations, it means that the nature of artificial intelligence (AI) is also syntactic. This would seem to put a damper on the near or far-term realization of artificial general intelligence, while realizing that this does not preclude the development of many interesting AI applications (Listgarten, 2024; Shojaee et al., 2025). In short, by examining our limitation to only be able to create syntactic artifacts, we can ask the question as to whether or not whatever we propose to create falls within the context of syntactic creations or not.

In this regard, life is an element in nature capable of semantic interpretation for its own benefit as well as capable of syntactic creation to share its internal life. This is what permits life to complete the sensation-information-action cycle to close the circle of its metabolic connection with nature. This explains why our ability for syntactic creation limits our capacity to explain life, since life falls outside the realm of our syntactics-based scientific understanding. This has the implication that all efforts to use chemistry to attempt to create life are doomed to failure (Criado-Reyes et al., 2021; Miller, 1953).

Another common argument that is made is that we live in a computer simulation (Bostrom 2003). This argument assumes the existence of an advanced civilization of unknown superbeings that has developed the computational capacity to simulate anything it wishes. The result is that they choose to simulate us and the world in which we live. Great effort in this argument is devoted to making the case that we are the product of someone's imagination and creativity and are part of a computer simulation. Everything depends on highly developed computing resources. This whole contention can be very readily dispensed with since computer hardware and the software to run it are human syntactic creations; as such, they only have the capacity for syntactic creation under human supervision. There is no possibility of semantic creation. This applies to all living being creations, whether from an advanced civilization or not. In summary, we do not live in and were not created as part of a computer simulation.

## SUMMARY AND CONCLUSIONS

The Midas touch, where everything that is touched turns into gold, is a reminder of the impact that human greedy overreach without deliberate consideration can have on our own well-being. Similarly, our ability for artifact-making yields a limit to our creative abilities: our actions on matter/energy can only yield syntactic creations. Can we refer to this limitation as Syntactic touch, or our inescapable ability to turn everything that we touch into syntactic information? This far-reaching yet counterintuitive finding haunts our ability to make our dreams become reality by setting limits to what is possible to create. Examining these processes reveals that there are inherent limits to human artifact-making, governed by principles of uncomputability and undecidability inherent to the living information cycle.

Generally, when we find engineering or science problems impossible to solve, we always hope to find a solution that is just around the corner, if we are willing to invest the effort and resources to achieve it. In the creation of syntactic information we may be faced with an undecidability problem, i.e., we are unable to produce a way to achieve our result whatever method we try. One such problem is developing the ability to do magic, building artifacts capable of generating semantic information, synthetic life, or artificial general intelligence.

I would encourage anyone to suggest counterexamples that will remedy our inability to create other than syntactic information. Can we cure being blessed and/or cursed by Syntactic touch? Should we teach that there is a limit to what humankind thinks it is possible to create? What is the moral of this story?

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## DEDICATION

JFCG dedicates this work to the memory of JCCN who inspired me to think about novel fundamental universals.

## REFERENCES

Bateson, G. (1978). *Steps to an ecology of mind; collected essays in anthropology, psychiatry, evolution, and epistemology*. Ballantine Books.

Bender, E. M., Gebru, T., McMillan-Major, A., & Shmitchell, S. (2021). *On the Dangers of Stochastic Parrots: Can Language Models Be Too Big?* Proceedings of the 2021

ACM Conference on Fairness, Accountability, and Transparency, Virtual Event, Canada. https://doi.org/10.1145/3442188.3445922

Burgin, M., & Cárdenas-García, J. F. (2020). A Dialogue Concerning the Essence and Role of Information in the World System. *Information*, *11*(9), 406. https://doi.org/https://doi.org/10.3390/info11090406

Capurro, R. (2009). Past, present, and future of the concept of information. *tripleC*, *7*(2), 125–141.

Capurro, R., & Hjørland, B. (2003). The concept of information. *Annual Review of Information Science and Technology*, *37*(1), 343–411. https://doi.org/https://doi.org/10.1002/aris.1440370109

Cárdenas-García, J. F. (2020). The Process of Info-Autopoiesis – the Source of all Information. *Biosemiotics*, *13*(2), 199–221. https://doi.org/10.1007/s12304-020-09384-x

Cárdenas-García, J. F. (2022). The Central Dogma of Information. *Information*, *13*(8), 365. https://doi.org/https://doi.org/10.3390/info13080365

Cárdenas-García, J. F. (2023). Info-Autopoiesis and the Limits of Artificial General Intelligence. *Computers*, *12*(5), 102. https://doi.org/https://doi.org/10.3390/computers12050102

Criado-Reyes, J., Bizzarri, B. M., García-Ruiz, J. M., Saladino, R., & Di Mauro, E. (2021). The role of borosilicate glass in Miller–Urey experiment. *Scientific reports*, *11*(1), 21009. https://doi.org/10.1038/s41598-021-00235-4

Elhacham, E., Ben-Uri, L., Grozovski, J., Bar-On, Y. M., & Milo, R. (2020). Global human-made mass exceeds all living biomass. *Nature*, *588*(7838), 442–444. https://doi.org/10.1038/s41586-020-3010-5

Hutson, M. (2022). Could AI help you to write your next paper? *Nature*, *611*, 192–193. https://doi.org/https://doi.org/10.1038/d41586-022-03479-w

Listgarten, J. (2024). The perpetual motion machine of AI-generated data and the distraction of ChatGPT as a 'scientist'. *Nature Biotechnology*, *42*(3), 371–373. https://doi.org/10.1038/s41587-023-02103-0

McLuhan, M. (2008). Chapter 26: The Medium is the Message. In C. D. Mortensen (Ed.), *Communication Theory* (2nd ed.). Routledge. https://doi.org/https://doi.org/10.4324/9781315080918

Miller, S. L. (1953). A Production of Amino Acids Under Possible Primitive Earth Conditions. *Science*, *117*(3046), 528–529. https://doi.org/doi:10.1126/science.117.3046.528

Morford, M. P. O., & Lenardon, R. J. (2003). *Classical mythology* (7th ed.). Oxford University Press.

Ong, W. J. (2002). *Orality and Literacy - The Technologizing of the Word* (2nd ed.). Routledge.

Pappas, S. (2020). Human-Made Stuff Now Outweighs All Life on Earth. *Scientific American*. Retrieved April 8, 2023, from

Pattee, H. H. (2012). Evolving Self-reference: Matter, Symbols, and Semantic Closure. In H. H. Pattee & J. Rączaszek-Leonardi (Eds.), *Laws, Language and Life - Howard Pattee's classic papers on the physics of symbols with contemporary commentary* (pp. 211–226). Springer. https://doi.org/10.1007/978-94-007-5161-3_11

Perales-Eceiza, Á., Cubitt, T., Gu, M., Pérez-García, D., & Wolf, M. M. (2025). Undecidability in physics: A review. *Physics Reports*, *1138*, 1–29. https://doi.org/https://doi.org/10.1016/j.physrep.2025.06.004

Peters, J. D. (1988). Information: Notes Toward a Critical History. *Journal of Communication Inquiry*, *12*, 9–23.

Purves, D. (2021). *Why Brains Don't Compute*. Springer International Publishing. https://doi.org/https://doi.org/10.1007/978-3-030-71064-4

Purves, D., Morgenstern, Y., & Wojtach, W. T. (2015). Perception and Reality: Why a Wholly Empirical Paradigm is Needed to Understand Vision [Hypothesis and Theory]. *Frontiers in Systems Neuroscience*, *Volume 9 - 2015*. https://doi.org/10.3389/fnsys.2015.00156

Roose, K. (2022). The Brilliance and Weirdness of ChatGPT. *New York Times*. Retrieved April 2, 2023, from

Shannon, C. E. (1948). A Mathematical Theory of Communication. *The Bell System Technical Journal*, *27*, 379–423, 623–656. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x

Shojaee, P., Mirzadeh, I., Alizadeh, K., Horton, M., Bengio, S., & Farajtabar, M. (2025). The Illusion of Thinking: Understanding the Strengths and Limitations of Reasoning Models via the Lens of Problem Complexity. https://arxiv.org/abs/2506.06941

Stonier, T. (1997). *Information and Meaning - An Evolutionary Perspective*. Springer-Verlag.

Vedral, V. (2010). *Decoding Reality - The Universe as Quantum Information*. Oxford University Press.

Wheeler, J. A. (1991). Sakharov revisited: "It from Bit". Proceedings of the First International A D Sakharov Memorial Conference on Physics, May 27-31, Moscow, USSR.

Yockey, H. P. (2005). *Information theory, evolution, and the origin of life*. Cambridge University press.