CONSCIOUSNESS

A new paper argues that consciousness likely arose as a means for humans to better communicate with each other.© Bruce Rolff/Stocktrek Images - Getty Images

- Evolution often examines animals on an individualistic level, but more modern ideas explore how evolution can impact genetics *and* cultures and societies.
- A new paper from two U.K. neuropsychologists argues that consciousness is not the simple result of evolution of the central nervous system, but that it likely arose as a means for humans to better communicate with each other.
- This societal benefit provides a different look at the *why* of consciousness, which is an important question in a world where rapidly

advancing AI is beginning to challenge our understanding of these notoriously difficult concepts.

In the era of large language models and talks of artificial general intelligence, scientists are understandably reinvigorated to understand the inner workings of human consciousness— and there are *a lot* of theories to go around.

Hypotheses like global workspace theory, integrated information theory, and high order representation theory attempt to explain the *how* of consciousness. But a new paper from two U.K. neuropsychologists instead explores the *why*—as in, why did natural selection and evolution see human consciousness as a natural advantage?

Previous theories have posited that consciousness aids in volitional movement, or the ability for someone to express their will, or simply the inevitable results of evolution of the central nervous system. Because evolution is often viewed as an individualistic enterprise ("survival of the fittest"), it's easy to see this theory as equally individualistic.

But in a new, non-peer reviewed article published in *Interalia* Magazine, as well as a deep-dive explanation of the article on the website *The Conversation*, Cardiff University's Peter Halligan and University College of London's David Oakley instead argue that consciousness actually arose for its social benefits rather than its individualistic ones.

"Consciousness may have evolved to facilitate key social adaptive functions," the authors write in *The Conversation*. "Rather than helping individuals survive, it evolved to help us broadcast our experienced ideas and feelings into the wider world. And this might benefit the survival and wellbeing of the wider species."

The authors propose say their Oakley-Halligan model aligns with the modern idea that evolution occurs on multiple levels—genetic, cultural, and societal. But their model explains how the Central Executive Structure (CES) processes information in the brain by communicating personal narratives through internal, external, and cultural broadcasting. According to the model, these processes shape powerful social ideologies, highlighting consciousness's role as a form of social evolution.

They elaborate:

“While as humans we are rooted in our biological nature, our social nature is largely defined by our roles as persons operating in society. As such the mental architecture of mind, generated by our brains remains strongly adapted for the exchange and reception of information, ideas and feelings with other brains. Applying the construct of personhood finds social expression in the multitudes of daily decisions affecting the lives and welfare of all individuals.”

Consciousness remains notoriously tricky to study, as it’s unclear how and why it arises; it also doesn’t help that when it comes to high-level consciousness, scientists are working with a sample size of just one. But understanding the nuts and bolts of humanity’s most defining characteristic is immensely important, especially as AI companies forge ahead forming machines that can, at the very least, mimic the idea of volitional movement.

But without the slow-but-steady guiding hand of evolution, or any sense of need to develop consciousness to improve social cohesion, exactly what kind of consciousness will humankind create?

A 15-year study finds nearly 25% of unresponsive patients show hidden signs of consciousness using fMRI and EEG, challenging previous understandings of awareness.© Benjavisa - Getty Images

- For nearly two decades, scientists have explored the prevalence of “cognitive motor dissociation,” a condition where patients are unresponsive to bedside cognitive tests but show evidence of consciousness when examined with fMRIs and EEGs.
- A new study spanning 15 years finds that nearly one-quarter of such patients could experience a level of hidden consciousness.

- This finding emphasizes the importance of helping these patients live more fulfilling lives despite their cognitive disorder.

Human consciousness is one of the great mysteries of science. Many theories ponder its very existence, and a few even wonder if this ineffable cognition could be the result of quantum processes beyond our current understanding. While both scientific and philosophical debates rage, experts have, at the very least, become more adept at detecting consciousness—even if someone shows no outward sign of it.

While some of these breakthroughs can be attributed to our deeper understanding of how the brain works, technologies such as functional MRI (fMRI) and electroencephalography (EEG) give scientists an unprecedented glimpse at how that bundle of neurons and fat between our ears responds to external stimuli. Now, a 15-year-long study analyzing 241 patients in an unresponsive, "vegetative" state—spread across six research institutions in the U.S., U.K., and Europe—found that nearly one-quarter of those patients showed evidence of consciousness when examined using fMRI and EEG.

This highlights the importance of the understudied disorder known as "cognitive motor dissociation," a phenomenon where patients may not respond to external forms of cognitive testing but show signs of consciousness when asked to image certain tasks. The results were published in *The New England Journal of Medicine*.

Related video: The Weirdest Scientific Discoveries That Challenge What We Know (Dailymotion)

"Some patients with severe brain injury do not appear to be processing their external world," Massachusetts General Hospital's Yelena Bodien, lead author of the study, said in a press statement. "However, when they are assessed with advanced techniques such as task-based fMRI and EEG, we can detect brain activity that suggests otherwise. These results bring up critical ethical, clinical, and scientific questions—such as how can we harness that unseen cognitive capacity to establish a system of communication and promote further recovery?"

Although the discovery of this "hidden cognition" in unresponsive patients isn't new, the prevalence of such a condition was largely unknown. In 2006, scientists detected consciousness in a patient in Cambridge, England, when they asked her to imagine playing tennis. When compared to similar scans of a healthy person imagining the same thing, the two looked remarkably similar. So to answer this prevalence question, Nicolas Schiff, a leading neuroscientist at Cornell University and senior author of the new study, set out to conduct more tests on patients in a similar state.

The researchers selected 241 patients that didn't respond to typical bedside cognition tests, which can contain a variety of tasks and questions designed to measure consciousness but also executive function, memory, and attention. Like with the patient in 2006, the researchers asked the study patients to imagine a task (i.e. "imagine opening and closing your hand") and then asked healthy volunteers to perform the same function. Once the data was gathered, they then sent the results to statisticians at Icahn School of Medicine at Mount Sinai who didn't know which results came from which research group, according to *The New York Times*. The results showed that 60 of the 241 patients showed signs of consciousness similar to the healthy control group.

"We find that this kind of sharp dissociation of retained cognitive capabilities and no behavioral evidence of them is not uncommon," Schiff said in a press statement. "I think we now have an ethical obligation to engage with these patients, to try to help them connect to the world. What we need here is what we in our consortium have been trying to get started for twenty years: a sustained effort to benefit patients who have disorders of consciousness with systematic medical research, technology development, and better clinical infrastructure."

This growing awareness of the pervasive nature of cognitive motor dissociation along with continuing advancements in brain implants could help alleviate the trauma experienced by these patients. Because now that we know that "vegetative" patients could aware, it's a moral imperative to now help them live their best lives.

humans as biological containers, human bodies that hold souls. Souls are essentially a form of consciousness that are fractals from some primary consciousness. Maybe there's a Higher Self (the part connected to the primary) that has sub-souls which are playing out different versions of itself in different realities

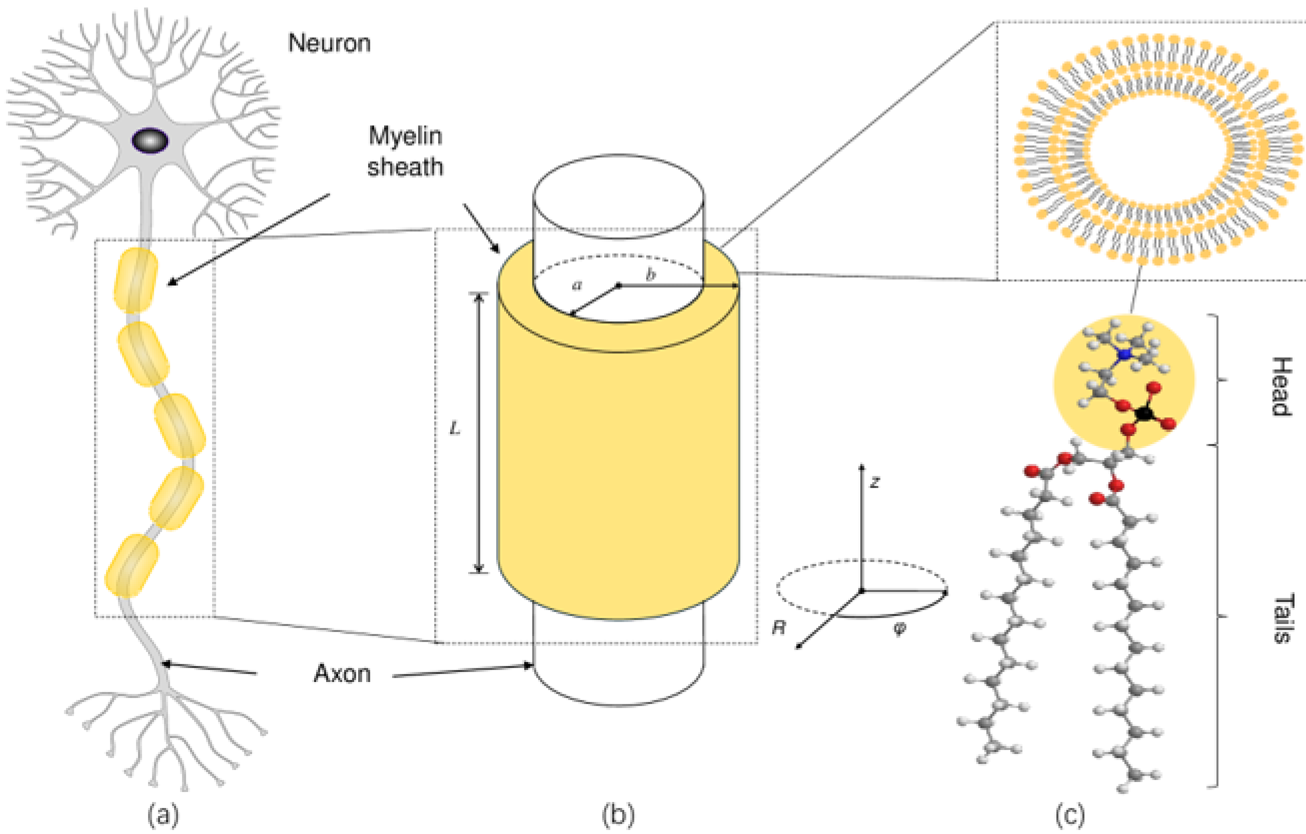
- For the past 30 years, scientists have investigated whether the human brain might require quantum processes to achieve cognition.
- A new study from Shanghai University uses mathematical models to suggest that certain fatty structures (which sheath the nerve cell's axon) could potentially produce quantum entangled biphoton pairs, potentially aiding in synchronization across neurons.
- However, scientists have long argued that the brain is too hot and messy for this type of phenomenon to occur, and detecting this phenomenon as it occurs in the brain would be an incredibly difficult task.

It has long been argued that the human brain is similar to a computer. But in reality, that's selling the brain pretty short. While comparing neurons and transistors is a convenient metaphor (and not *completely* out of left field), the brain is ultra-efficient, its energy is renewable, and it's capable of computational feats that even the most advanced computer can't pull off. In many ways, the inner workings of the human brain make up an unknown computational frontier.

Although your brain is superior to your laptop—or even the world's most advanced supercomputer—these machines run on classical physics. But there's another kind of a computer out there: a quantum one.

The idea that the human brain contains quantum properties isn't new. In fact, the British physicist Roger Penrose and the American anesthesiologist Stuart Hameroff first suggested the controversial concept back in the 90s, with their "orchestrated objective reduction" model of a consciousness. Since then, many pieces of evidence have at least hinted that, while the brain may not be a full-fledged quantum computer, some quantum properties may in fact help generate consciousness.

Now, a new study from Shanghai University submits yet another piece of evidence to the neurological court—that one particular process of the human brain exhibits behavior akin to quantum entanglement, a phenomenon when two particles (usually photons) become inextricably linked even across vast distances. This phenomenon confounded even the most brilliant of minds, including Albert Einstein, who called quantum entanglement "spooky action at a distance."



A closer look at myelin cylinders and its location along the neuron's axon.© Liu et al., Physical Review E, 2024

The study, published this month in the journal *Physics Review E*, suggests that a fatty material called myelin that surrounding the nerve cell's axon—the fiber that transmits electrical impulses to other nerves or body tissues—provides an environment in which the entanglement of photons is possible. This could potentially explain the rise of cognition, and especially synchronization, which is essential for information processing and rapid response.

"Consciousness within the brain hinges on the synchronized activities of millions of neurons, but the mechanism responsible for orchestrating such synchronization remains elusive," the paper reads. "The results indicate that the cylindrical cavity formed by a myelin sheath can facilitate spontaneous photon emission from the vibrational modes and generate a significant number of entangled photon pairs."

The team built mathematical models detailing how infrared photons could impact the myelin sheath and impart energy to chemical bonds—specifically, carbon-hydrogen bonds embedded in this fatty tissue. This, in turn, could spur biphoton generation with many pairs exhibiting entanglement, and serve as a type of "quantum communication resource" within the nervous system.

"When a brain is active, millions of neurons fire simultaneously," Yong-Cong Chen, a co-author of the study, told *New Scientist*. "If the power of evolution was looking for handy action over a distance, quantum entanglement would be [an] ideal candidate for this role."

If you're sensing some "woah, if true" quality to this research, you're not alone. For one, this phenomenon would need to be seen in a biological setting (likely in the brain of a mouse) before scientists get too excited about the brain's newfound "quantum communication resource." And that's a process that the authors readily admit would be difficult. Additionally, the idea of quantum entanglement playing a role in consciousness isn't a mainstream one—Hameroff, one the leading minds behind the idea that quantum phenomena could drive aspects of cognition, even told *New Scientist* months ago that "it was very popular to bash us" after the publication of their consciousness model.

But science is in the business of hypothesis and rigorous testing to discern the true nature of existence. And, as history has shown, what once seemed liked "spooky action a distance" can quickly become the cornerstone of the quantum world.

Scientists Have Developed a New Explanation for Consciousness

BY BOSTON UNIVERSITY SCHOOL OF MEDICINEOCTOBER 22, 2022120 COMMENTS3 MINS READ
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A recent study offers a new theory for consciousness.

According to a new theory, choices are formed unconsciously and become conscious around half a second later.

Consciousness is your awareness of yourself and your surroundings. This awareness is unique to you and subjective.

A new theory of consciousness has been developed by a researcher at Boston University's Chobanian & Avedisian School of Medicine, describing why it evolved, what it is useful for, which disorders influence it, and why it is so difficult to diet and resist other urges.

"In a nutshell, our theory is that consciousness developed as a memory system that is used by our unconscious brain to help us flexibly and creatively imagine the future and plan accordingly," explained corresponding author Andrew Budson, MD, professor of neurology. "What is completely new about this theory is that it suggests we don't perceive the world, make decisions, or perform actions directly. Instead, we do all these things unconsciously and then—about half a second later—consciously remember doing them."

In order to explain a number of phenomena that could not be readily explained by earlier theories of consciousness, Budson explained that he and his co-authors, psychologist Elizabeth Kensinger, Ph.D., from Boston College, and philosopher Kenneth Richman, Ph.D., at the Massachusetts College of Pharmacy and Health Sciences, developed this theory.

"We knew that conscious processes were simply too slow to be actively involved in music, sports, and other activities where split-second reflexes are required. But if consciousness is not involved in such processes, then a better explanation of what consciousness does was needed," said Budson, who also is Chief of Cognitive & Behavioral Neurology, Associate Chief of Staff for Education, and Director of the Center for Translational Cognitive Neuroscience at the Veterans Affairs (VA) Boston Healthcare System.

This theory, according to the researchers, is important because it clarifies how all of our choices and actions—which we mistakenly believe were made consciously—are actually made unconsciously. Therefore, since our conscious mind is not in charge of our actions, we may tell ourselves that we are just going to have one scoop of ice cream and then, the next thing we know, the container is empty.

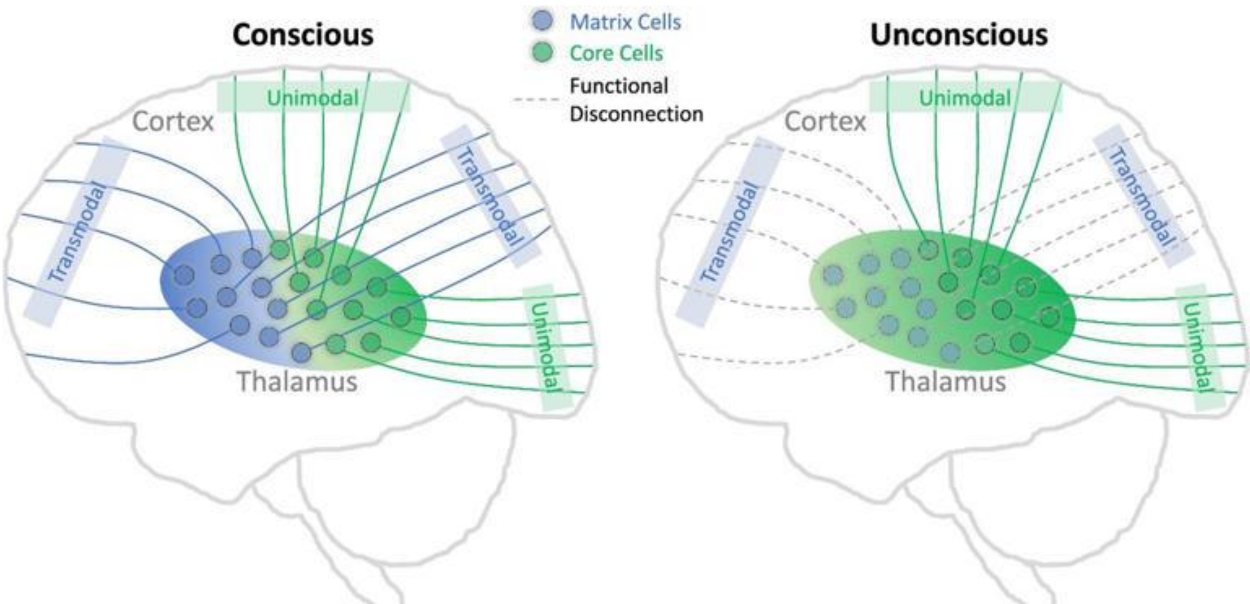
"Even our thoughts are not generally under our conscious control. This lack of control is why we may have difficulty stopping a stream of thoughts running through our head as we're trying to go to sleep, and also why mindfulness is hard," adds Budson.

Budson and his coauthors consider a number of neurologic, psychiatric, and developmental disorders to be disorders of consciousness including Alzheimer's disease and other dementias, delirium, migraine, schizophrenia, dissociative identity disorder, certain types of autism, and more.

Lastly, their paper provides a roadmap as to how clinicians, educators, and individuals can best improve behavior and gain knowledge, by using clinical and teaching methods that can be effective in shaping both the conscious mind and the unconscious brain. With further exploration, this work may allow patients to improve problem behaviors such as overeating, help us understand the ways in which brain structures support memory, and even provide insight into philosophical issues around free will and moral responsibility.

Reference: "Consciousness as a Memory System" by Andrew E. Budson, MD, Kenneth A. Richman, Ph.D., Elizabeth A. Kensinger, Ph.D., 3 October 2022, *Cognitive and Behavioral Neurology*.

How the brain's inner chamber governs our state of consciousness



Schematic illustration of the primary conclusion. Credit: Nature Communications (2024). DOI: 10.1038/s41467-024-51837-1

In hospital operating rooms and intensive care units, propofol is a drug of choice, widely used to sedate patients for their comfort or render them fully unconscious for invasive procedures.

Propofol works quickly and is tolerated well by most patients when administered by an anesthesiologist. But what is happening inside the brain when patients are put under and what does this reveal about consciousness itself?

Investigators at U-M who are studying the nature of consciousness have successfully used the drug to identify the intricate brain geometry behind the unconscious state, offering an unprecedented look at brain structures that have traditionally been difficult to study.

"Consciousness has been the subject of study from various perspectives and understanding the neurobiological foundations of consciousness carries major implications of multiple medical disciplines such as neurology, psychiatry and anesthesiology," said Zirui Huang, Ph.D., Research Assistant Professor in the Department of Anesthesiology at U-M Medical School.

To date, researchers have debated about how anesthetics suppress consciousness. Specifically, whether the site of action lies primarily in the thalamus, an egg-shaped structure deep within the brain, which receives information from what we see, touch and hear, or in the cerebral cortex, which processes that information in complex ways.

A study published in the journal *Nature Communications* and led by Huang, George Mashour, M.D., Ph.D. and Anthony G. Hudetz, Ph.D., of the U-M Center for Consciousness Science, outlines for the first time in humans how the connections among brain cells within those two important areas are modified by propofol. The paper is titled "Propofol Disrupts the Functional Core-Matrix Architecture of the Thalamus in Humans."

In healthy volunteers, they mapped changes in the brain's architecture before, during and after propofol sedation, guided by functional magnetic resonance imaging (fMRI). This enabled them to monitor blood flow to areas of the brain as the study participants entered and exited an unconscious state.

At baseline, explained Huang, the thalamus has a balanced level of activity of both specific nuclei (clusters of brain cells) that send sensory information to highly defined areas of the cortex—known as unimodal processing—and nonspecific nuclei that send information more diffusely throughout a higher layer of the cortex, known as transmodal processing.

The team found that, under deep sedation, the thalamus showed a drastic reduction in activity in clusters of brain cells responsible for transmodal processing, leading to a dominant unimodal pattern—suggesting that while sensory inputs are still received, there is no integration of those inputs.

"The field has been focusing on anesthetic effects in the thalamus and cortex for more than two decades—I believe this study significantly advances the neurobiology," said George Mashour, M.D., Ph.D., Professor of Anesthesiology and Pharmacology, and founder of the U-M Center for Consciousness Science.

Next, they discovered the specific cell types that played a role in the shift to an unconscious state and their relationship to the change in thalamic processing. The thalamus contains at least two distinct cell types, said Huang, core cells and matrix cells.

"We now have compelling evidence that the widespread connections of thalamic matrix cells with higher order cortex are critical for consciousness," says Hudetz, Professor of Anesthesiology at U-M and current director of the Center for Consciousness Science.

Imagining that the cortex is layered like an onion, core cells connect to lower layers while matrix cells connect to higher layers in a more spread-out manner.

By measuring mRNA expression signatures—like I.D. badges for the cells—they were able to see that a disruption in the activity of matrix cells played a greater role in the transition to unconsciousness than core cells. An additional surprise was that GABA, a major inhibitory transmitter in the brain usually thought to be key to propofol's actions, did not appear to play as prominent a role as expected.

"The results suggest that loss of consciousness during deep sedation is primarily associated with the functional disruption of matrix cells distributed throughout the thalamus," said Huang.

More information: Huang, Z., et al. Propofol disrupts the functional core-matrix architecture of the thalamus in humans. *Nature Communications* (2024). DOI: 10.1038/s41467-024-51837-1

Provided by University of Michigan

How to Induce Theta Brain Waves

Written by Taylor Patrick • Updated May 03, 2017

There are four types of brainwaves generated by humans. Beta waves are produced when we are highly engaged in mental activity, alpha waves are produced when we are in a more relaxed state, theta waves occur during daydreaming, and delta waves occur during sleep. A theta brainwave state is desirable because this is when we are at our most creative, generating new ideas effortlessly. This can occur spontaneously when we are on autopilot doing mindless activity such as running, taking a shower, or driving to work. However, you can also induce a theta state by meditating, with or without the aid of music designed to lower your brain frequencies.

Set a timer. If you are just starting to meditate, try 5 or 10 minutes to start. Gradually progress up to 30 minutes, an hour or more. By setting a timer you relieve yourself from the distraction of wondering how long you've been meditating and worrying about losing track of time.

Sit down in a comfortable position. You can sit cross-legged on the floor, on a meditation cushion or bench, or on a chair. It's important to be as comfortable as possible. You want to hold the position without distracting yourself by making adjustments while you're meditating. It's not recommended to lie down, as you may fall asleep unintentionally.

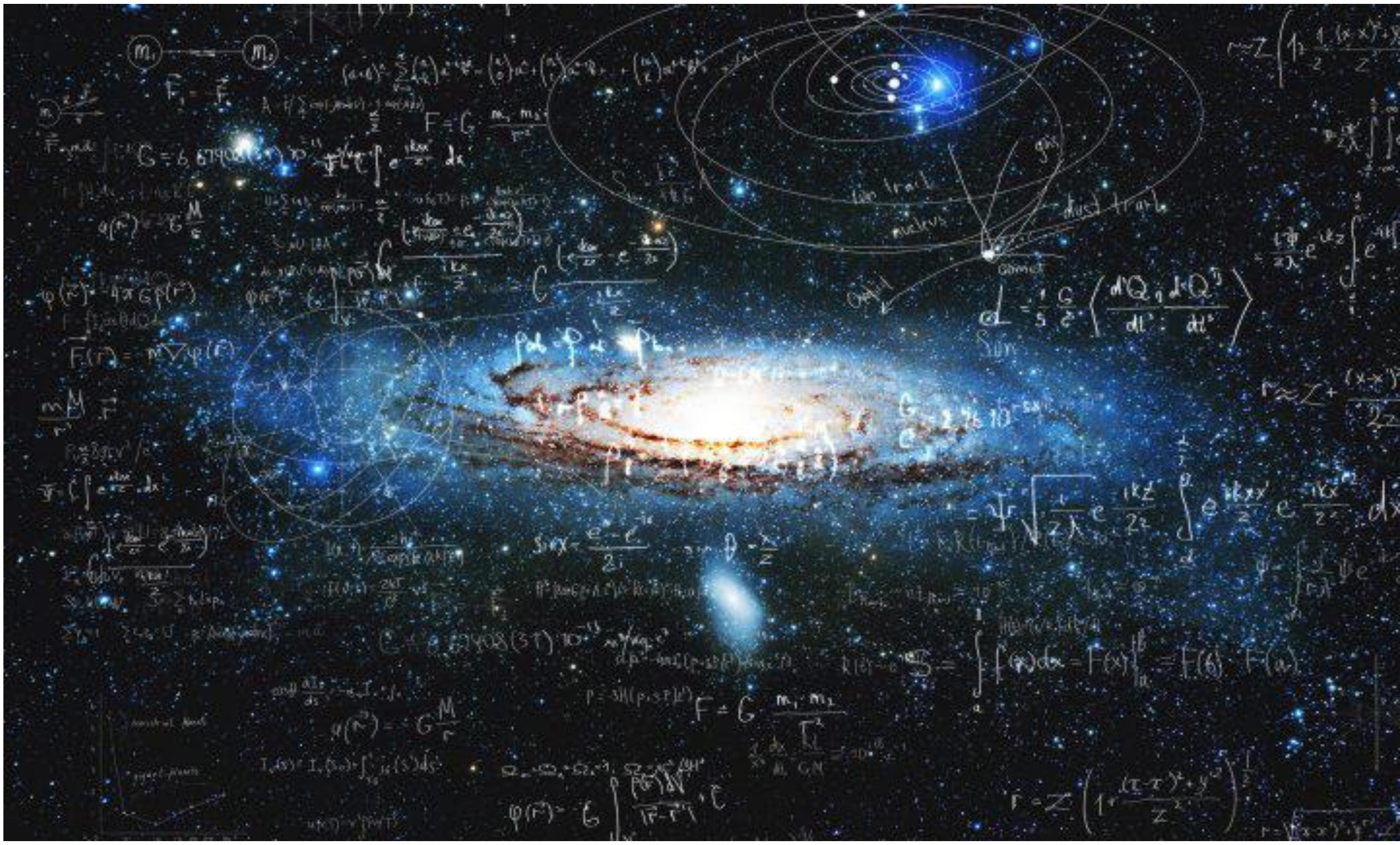
Close your eyes and focus on your breathing. Gently breathe slow and deep, following each breath as it flows in and out. Breathe in through your nose and breathe out through your mouth.

Count each full breath as it goes out, stopping your count when stray thoughts enter your mind. Try not to get attached to the thoughts--let them drift away and begin counting your breaths again, starting at one. The object is to notice when your thoughts wander and gently guide your mind back to the present, to your breath. Continue this until the timer goes off.

Tip

The more frequently and regularly you meditate, the easier it becomes and the more you can remain in a creative theta state for longer periods of time, even when you are not meditating.

There are many CDs with music that uses binaural beats, monaural beats, and isochronic tones to help induce a theta brainwave state during meditation

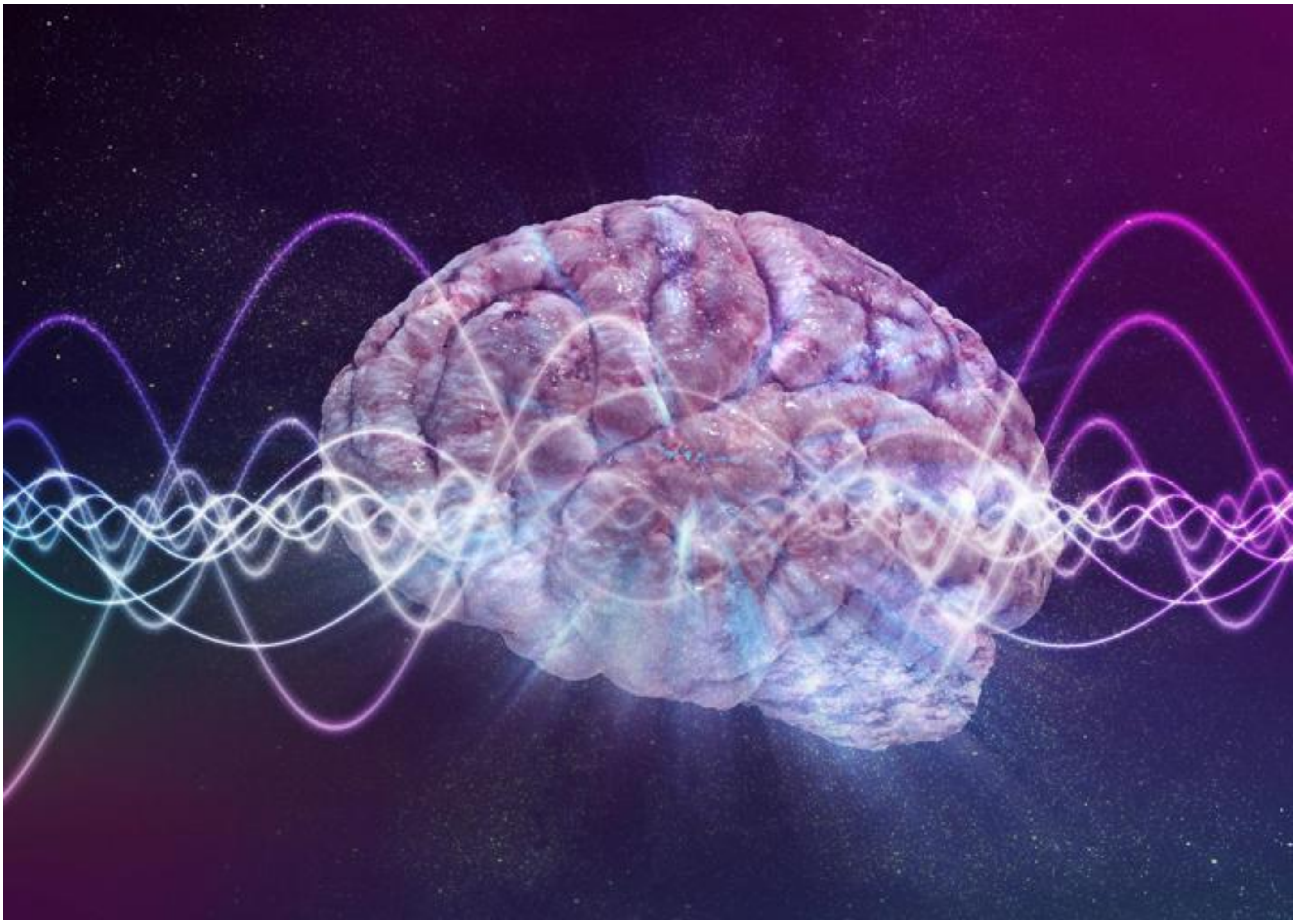


quantum physics questions, universe© Provided by BGR

What if everything in our world has a soul and mind? What if every desk, chair, and potted plant has a conscious stream of thoughts? That's the basic idea behind Panpsychism, a theory first put forward in the late 16th century by Francesco Patrizi. It's been a hundred years or so since science won out about this theory in the 1920s, but now it's regaining momentum.

To understand why this theory is regaining popularity requires us to look at one of the most difficult conundrums that human scientists have ever faced: where consciousness comes from. Scientists have been trying to solve this hard problem for over a hundred years, and while developments in neuroscience, psychology, and quantum physics have come far, we still don't have a definitive answer.

The argument is regaining momentum, though, thanks in part to the work of Italian neuroscientist and psychiatrist Giulio Tononi, who proposed the idea that there is widespread consciousness even found in the simplest of systems. Tononi and American neuroscientist Christof Koch argued that consciousness will follow where there are organized lumps of matter. Some even believe that the stars may be conscious.



brain waves© Provided by BGR

This basic idea, then, seems to suggest that grouped lumps of matter, like the very chair you're sitting in right now, may have a stream of consciousness. Of course, not everyone agrees with this. Many still take the stance that this is just an attempt to grasp at straws, if you will, in a bid to understand consciousness and how it comes to be.

You Are Much More Than You Think: A Universe Within You

The main idea behind Panpsychism seems to rely on the belief that if brains are not required for consciousness, then anything can be conscious of its existence, and thus, everything has different experiences. But there are more than just the believers and unbelievers here. There are actually some who believe that consciousness is all an illusion, which raises even more questions.

Keith Frankish, an honorary professor of philosophy at the University of Sheffield, told *Popular Mechanics* that he believes that consciousness is just an illusion of our own minds. Whether or not the very stars are conscious has yet to be proven, of course. And we're still a long way from understanding the brain and how it correlates to different things within our world.

This is still an area of science that draws a lot of big question marks from scientists. All you can really say for sure is what you believe. Are you conscious? Or is consciousness just an illusion that your brain has conjured up? It is certainly an interesting thought.

Integrated Information Theory of Consciousness

Integrated Information Theory (IIT) offers an explanation for the nature and source of consciousness. Initially proposed by Giulio Tononi in 2004, it claims that consciousness is identical to a certain kind of information, the realization of which requires physical, not merely functional, integration, and which can be measured mathematically according to the *phi* metric.

The theory attempts a balance between two different sets of convictions. On the one hand, it strives to preserve the Cartesian intuitions that experience is immediate, direct, and unified. This, according to IIT's proponents and its methodology, rules out accounts of consciousness such as functionalism that explain experience as a system operating in a certain way, as well as ruling out any eliminativist theories that deny the existence of consciousness. On the other hand, IIT takes neuroscientific descriptions of the brain as a starting point for understanding what must be true of a physical system in order for it to be conscious. (Most of IIT's developers and main proponents are neuroscientists.) IIT's methodology involves characterizing the fundamentally subjective nature of consciousness and positing the physical attributes necessary for a system to realize it.

In short, according to IIT, consciousness requires a grouping of elements within a system that have physical cause-effect power upon one another. This in turn implies that only reentrant architecture consisting of feedback loops, whether neural or computational, will realize consciousness. Such groupings make a difference to themselves, not just to outside observers. This constitutes integrated information. Of the various groupings within a system that possess such causal power, one will do so maximally. This local maximum of integrated information is identical to consciousness.

IIT claims that these predictions square with observations of the brain's physical realization of consciousness, and that, where the brain does not instantiate the necessary attributes, it does not generate consciousness. Bolstered by these apparent predictive successes, IIT generalizes its claims beyond human consciousness to animal and artificial consciousness. Because IIT identifies the subjective experience of consciousness with objectively measurable dynamics of a system, the degree of consciousness of a system is measurable in principle; IIT proposes the phi metric to quantify consciousness.

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1. The Main Argument

IIT takes certain features of consciousness to be unavoidably true. Rather than beginning with the neural correlates of consciousness (NCC) and attempting to explain what about these sustains consciousness, IIT begins with its characterization of experience itself, determines the physical properties necessary for realizing these characteristics, and only then puts forward a theoretical explanation of consciousness, as identical to a special case of information instantiated by those physical properties. "The theory provides a principled account of both the quantity and quality of an individual experience… and a calculus to evaluate whether a physical system is conscious" (Tononi and Koch, 2015).

a. Cartesian Commitments

IIT takes Descartes very seriously. Descartes located the bedrock of epistemology in the knowledge of our own existence given to us by our thought. "I think, therefore I am" reflects an unavoidable certainty: one cannot deny one's own existence as a thinker even if one's particular thoughts are in error. For IIT, the relevance of this insight lies in its application to consciousness. Whatever else one might claim about consciousness, one cannot deny its existence.

i. Axioms

IIT takes consciousness as primary. Before speculating on the origins or the necessary and sufficient conditions for consciousness, IIT gives a characterization of what consciousness means. The theory advances five axioms intended to capture just this. Each axiom articulates a dimension of experience that IIT regards as self-evident.

First, following from the fundamental Cartesian insight, is the axiom of existence. Consciousness is real and undeniable; moreover, a subject's consciousness has this reality intrinsically; it exists from its own perspective.

Second, consciousness has composition. In other words, each experience has structure. Color and shape, for example, structure visual experience. Such structure allows for various distinctions.

Third is the axiom of information: the way an experience is distinguishes it from other possible experiences. An experience specifies; it is specific to certain things, distinct from others.

Fourth, consciousness has the characteristic of integration. The elements of an experience are interdependent. For example, the particular colors and shapes that structure a visual conscious state are experienced together. As we read these words, we experience the font-shape and letter-color inseparably. We do not have isolated experiences of each and then add them together. This integration means that consciousness is irreducible to separate elements. Consciousness is unified.

Fifth, consciousness has the property of exclusion. Every experience has borders. Precisely because consciousness specifies certain things, it excludes others. Consciousness also flows at a particular speed.

ii. Postulates

In isolation, these axioms may seem trivial or overlapping. IIT labels them axioms precisely because it takes them to be obviously true. IIT does not present them in isolation. Rather, they motivate postulates. Sometimes the IIT literature refers to phenomenological axioms and ontological postulates. Each axiom leads to a corresponding postulate identifying a physical property. Any conscious system must possess these properties.

First, the existence of consciousness implies a system of mechanisms with a particular cause-effect power. IIT regards existence as inextricable from causality: for something to exist, it must be able to make a difference to other things, and vice versa. (What would it even mean for a thing to exist in the absence of any causal power whatsoever?) Because consciousness exists from its own perspective, the implied system of mechanisms must do more than simply have causal power; it must have cause-effect power upon itself.

Second, the compositional nature of consciousness implies that its system's mechanistic elements must have the capacity to combine, and that those combinations have cause-effect power.

Third, because consciousness is informative, it must specify, or distinguish one experience from others. IIT calls the cause-effect powers of any given mechanism within a system its cause-effect repertoire. The cause-effect repertoires of all the system's mechanistic elements taken together, it calls its cause-effect structure. This structure, at any given point, is in a particular state. In complex structures, the number of possible states is very high. For a structure to instantiate a particular state is for it to specify that state. The specified state is the particular way that the system is making a difference to itself.

Fourth, consciousness's integration into a unified whole implies that the system must be irreducible. In other words, its parts must be interdependent. This in turn implies that every mechanistic element must have the capacity to act as a cause on the rest of the system and to be affected by the rest of the system. If a system can be divided into two parts without affecting its cause-effect structure, it fails to satisfy the requirement of this postulate.

Fifth, the exclusivity of the borders of consciousness implies that the state of a conscious system must be definite. In physical terms, the various simultaneous subgroupings of mechanisms in a system have varying cause-effect structures. Of these, only one will have a maximally irreducible cause-effect structure. This is called the maximally irreducible conceptual structure, or MICS. Others will have smaller cause-effect structures, at least when reduced to non-redundant elements. Precisely this is the conscious state.

b. The Identity of Consciousness

IIT accepts the Cartesian conviction that consciousness has immediate, self-evident properties, and outlines the implications of these phenomenological axioms for conscious physical systems. This characterization does not exhaustively describe the theoretical ambition of IIT. The ontological postulates concerning physical systems do not merely articulate necessities, or even sufficiencies, for realizing consciousness. The claim is much stronger than this. IIT *identifies* consciousness with a system's having the physical features that the postulates describe. Each conscious state is a maximally irreducible conceptual structure, which just is and can only be a system of irreducibly interdependent physical parts whose causal interaction constitutes the integration of information.

An example may help to clarify the nature of IIT's explanation of consciousness. Our experience of a cue ball integrates its white color and spherical shape, such that these elements are inseparably fused. The fusion of these elements constitutes the structure of the experience: the experience is composed of them. The nature of the experience informs us about whiteness and spherical shape in a way that distinguishes it from other possible experiences, such as of a blue cube of chalk. This is just a description of the phenomenology of a simple experience (perhaps necessarily awkward, because it articulates the self-evident). Our brain generates the experience through neurons physically communicating with one another in systems linked by cause-effect power. IIT interprets this physical communication as the integration of information, according to the various constraints laid out in the postulates. The neurobiology and phenomenology converge.

Theories of consciousness need to account for what is sometimes termed the "binding problem." This concerns the unity of conscious experience. Even a simple experience like viewing a cue ball unites different elements such as color, shape, and size. Any theory of consciousness will need to make sense of how this happens. IIT's account of the integration of information may be understood as a response to this problem.

According to IIT, the physical state of any conscious system must converge with phenomenology; otherwise the kind of information generated could not realize the

axiomatic properties of consciousness. We can understand this by contrasting two kinds of information. First, there is Shannon information: When a digital camera takes a picture of a cue ball, the photodiodes operate in causal isolation from one another. This process does generate information; specifically, it generates observer-relative information. That is, the camera generates the information of an image of a cue ball for anyone looking at that photograph. The information that is the image of the cue ball is therefore relative to the observer; such information is called Shannon information. Because the elements of the system are causally isolated, the system does not make a difference to itself. Accordingly, although the camera gives information to an observer, it does not generate that information for itself. By contrast, consider what IIT refers to as *intrinsic* information: Unlike the digital camera's photodiodes, the brain's neurons do communicate with one another through physical cause and effect; the brain does not simply generate observer-relative information, it integrates *intrinsic* information. This information from its own perspective just is the conscious state of the brain. The physical nature of the digital camera does not conform to IIT's postulates and therefore does not have consciousness; the physical nature of the brain, at least in certain states, does conform to IIT's postulates, and therefore does have consciousness.
To identify consciousness with such physical integration of information constitutes an ontological claim. The physical postulates do not describe one way or even the best way to realize the phenomenology of consciousness; the phenomenology of consciousness is one and the same as a system having the properties described by the postulates. It is even too weak to say that such systems give rise to or generate consciousness. Consciousness is fundamental to these systems in the same way as mass or charge is basic to certain particles.

i. Some Predictions

IIT's conception of consciousness as mechanisms systematically integrating information through cause and effect lends itself to quantification. The more complex the MICS, the higher the level of consciousness: the corresponding metric is phi. Sometimes the IIT literature uses the term "prediction" to refer to implications of the theory whose falsifiability is a matter of controversy. This section will focus on more straightforward cases of prediction, where the evidence is consistent with IIT's claims. These cases provide corroborative evidence that enhance the plausibility of IIT.

Deep sleep states are less experientially rich than waking ones. IIT predicts, therefore, that such sleep states will have lower phi values than waking states. For this to be true, analysis of the brain during these contrasting states would have to show a disparity in the systematic complexity of non-redundant mechanisms. On IIT, this disparity of MICS complexity directly implies a disparity in the amount of conscious integrated information, because the MICS is identical to the conscious state. The neuroscientific findings bear out this prediction.

IIT cites similar evidence from the study of patients with brain damage. For example, we already know that among vegetative patients, there are some whose brain scans indicate that they can hear and process language: When researchers prompt such patients to think about playing tennis, the appropriate areas of the brain become activated. Other vegetative patients do not respond this way. Naturally, this suggests that the former have a richer degree of consciousness than the latter. When analyzed according to IIT's theory, the former have a higher phi metric than the latter; once again, IIT has made a prediction that receives empirical confirmation. IIT also claims that findings in the analysis of patients under anesthesia corroborate its claims.

In all these cases, one of two things happens. First, as consciousness fades, cortical activity may become less global. This reversion to local cortical activity constitutes a loss of integration: The system no longer is communicating across itself in as complex a way as it had. Second, as consciousness fades, cortical activity may remain global, but become stereotypical, consisting in numerous redundant cause-effect mechanisms, such that the informational achievement of the system is reduced: a loss of information. As information either becomes less integrated or becomes reduced, consciousness fades, which IIT takes as empirical support of its theory of consciousness as integrated information.

c. Characterizing the Argument

IIT combines Cartesian commitments with claims about engineering that it interprets, in part by citing corroborative neuroscientific evidence, as identifying the nature of consciousness. This borrows from recognizable traditions in the field of consciousness studies, but the structure of the argument is novel. While IIT's proponents strive for clarity in the exposition of their work by breaking it down into the simpler elements of axioms, propositions, and identity claims, the nature of the relations between these parts remains largely implicit in the IIT literature. To evaluate the explanatory success or failure of IIT, it should prove helpful to attempt an explication of these logical relations. This requires characterizing the relationship of the axioms with the postulates, and of the identity claims with the axioms, postulates, and supporting neuroscientific evidence.

The axioms, of course, count as premises. These premises seem to lead to the postulates: each postulate flows from a corresponding axiom. At the same time, IIT describes these postulates as unproven assumptions, which seems at odds with their being conclusions drawn from the axioms. Consider the first axiom and its postulate, concerning existence. The axiom states that consciousness exists, and more specifically, exists intrinsically; the postulate holds that this requires a conscious system to have cause-effect power, and more specifically, to have this power over itself. The link involves, in part, the claim that existence implies cause-effect power. This claim that for a thing to exist, it must be able to make a difference, is plausible, but not self-evident. Nor does the axiomatic premise alone deductively imply this postulate. Epiphenomenalists, for example, claim that conscious mental states, although existent and caused, do not cause further events; they do not make a difference. Epiphenomenalists certainly do not go on to identify consciousness with physically causal systems, as IIT does.

Tononi (2015) adopts the position that the move from the axioms to the postulates is one of inference to the best explanation, or abduction. On this line, while the axioms do not deductively imply the postulates, the postulates have more than mere statistical inductive support. For example, consider the observation that human brains, which on IIT are conscious systems, have cause-effect power over themselves. Minimally, this offers a piece of inductive support for describing conscious systems in general as having such a power. Tononi takes a stronger line, claiming that a system's property of having cause-effect power over itself most satisfyingly explains its intrinsic existence. So, what makes the brain a system at all, capable of having its own consciousness, is its ability to make a difference to itself. This illustrates the relation of postulates such as the first, concerning cause-effect power, to axioms such as the first axiom, concerning intrinsic existence, by appeal to something like explanatory fit, or satisfactoriness, which is to characterize that relation abductively.

In any case, IIT moves from the sub-conclusion about the postulates to a further conclusion, the identity claim: consciousness is identical to a system's having the physical properties laid out by the postulates, which realize the phenomenology described by the axioms. Here again, the abductive interpretation remains an option. On this interpretation, the *conjunction* of the physical features of the postulates provides the most satisfactory explanation for the identity of consciousness.
This breakdown of the argument reveals the separability of the two parts. A less ambitious version of IIT might have limited itself to the first part, claiming that the physical features described by the postulates are the actual and/or best ways of realizing consciousness, or more strongly that they are necessary and/or sufficient, without going on to say that consciousness is identical to a system having these properties. The foregoing paragraphs outlined the possible motivation for the identification claim as lying in the abductive interpretation.

The notion of best explanation is notoriously slippery, but also ubiquitous in science. From an intuitive point of view one might regard the content of the conjunction of the postulates as apt for accounting for the phenomenology, but one might, motivated by theoretical conservatism, stop short of describing this as an identity relation. One clue as to why IIT does not take this tack may lie in IIT's methodological goal of parsimony, something the literature mentions with some regularity. Perhaps the simplicity of identifying consciousness with a system's having certain intuitively apt physical properties outweighs the non-conservatism of the claim that consciousness is fundamental to such systems the way mass is fundamental to a particle.

2. The *Phi* Metric

a. The Main Idea

IIT strives, among other things, not just to claim the existence of a scale of complexity of consciousness, but to provide a theoretical approach to the precise quantification of the richness of experience for any conscious system. This requires calculating the maximal amount of integrated information in a system. IIT refers to this as the system's phi value, which can be expressed numerically, at least in principle.

Digital photography affords particularly apt illustrations of some of the basic principles involved in quantifying consciousness.

First, a photodiode exemplifies integrated information in the simplest way possible. A photodiode is a system of two elements, which together render it sensitive to two states only: light and dark. After initial input from the environment, the elements communicate input physically with one another, determining the output. So, the photodiode is a two-element system that integrates information. A photodiode not subsumed in another system of greater phi value is the simplest possible example of consciousness.

This consciousness, of course, is virtually negligible. The photodiode's experience of light and dark is not rich in the way that ours is. The level of information of a state depends upon its specifying that state as distinct from others. The repertoire of the photodiodes allows only for the most limited differentiation ("this" vs. "that"), whereas the repertoire of a complex system such as the brain allows for an enormous amount of differentiation. Even our most basic experience of darkness distinguishes it not only from light, but from shapes, colors, and so forth.

Second, a digital camera's photodiodes' causal arrangement neatly exemplifies the distinction between integrated and non-integrated information. Putting to one side that each individual photodiode integrates information as simply as possible, those photodiodes do not take input or give output to one another, so the information does not get integrated across the system. For this reason, the camera's image is informative to us, but not to itself.

Each isolated photodiode has integrated information in the most basic way, and would therefore have the lowest possible positive value of phi. The camera's photodiodes taken as a system do not integrate information and have a phi value of zero.

IIT attributes consciousness to certain systems, or networks. These can be understood abstractly as models. A computer's hardware may be modelled by logic circuits, which represent its elements and their connections as interconnected logic gates. The way a particular connection within this network mediates input and output determines what kind of logic gate it is. For example, consider a connection that takes two inputs, either which can be True or False, and then gives one output, True or False. The AND logic gate would give an output of True if both inputs were True or if both inputs were False. In other words, if both the one AND the other have the same value, the AND gate gives a True output. Such modelling captures the dynamics of binary systems, with "True" corresponding to 1 and "False" to 0. The arrangement of a network's various logic gates (which include not only AND, but also OR, NOT, XOR, among others) determines how any particular input to the system at time-step 1 will result in output at time-step 2, and so on for that system. The brain can be modelled this way too. Input can come from a prior brain state, or from other parts of the nervous system, through the senses. The input causes a change in brain state, depending on the organization of the particular brain, which can be articulated in abstract logic.

In order to measure the level of consciousness of a system, IIT must describe the amount of its integrated information. This is done by partitioning the system in various ways. If the digital camera's photodiodes are partitioned, say, by dividing the abstract model of its elements in half, no integrated information is lost, because all the photodiodes are in isolation from each other, and so the division does not break any connections. If no logically possible partition of the system results in a loss of connection, the conclusion is that the system does not make a difference to itself. So, in this case, the system has no phi.

Systems of interest to IIT will have connections that will be lost by some partitions and not by others. Some partitions will sever from the system elements that are comparatively low in original degree of connectivity to the system, in other words elements whose (de)activation has few causal consequences upon the (de)activation of other elements. A system where all or most elements have this property will have low phi. The lack of strong connectivity may be the result of relative isolation, or locality, an element not linking to many other elements, directly or indirectly. Or it could be from stereotypicality, where the element's causal connections overlap in a largely redundant way with the causal connection of other elements. A system whose elements are connected more globally and non-redundantly will have higher phi. A partition that not only separates all elements that do not make a difference to the rest of the system for reasons of either isolation or redundancy from those that do make a difference, but also separates those elements whose lower causal connectivity decreases the overall level of integration of the system from those that do not, will thereby have picked out the maximally irreducible conceptual structure (MICS), which according to IIT is conscious. The degree of that consciousness, its phi, depends upon its elements' level of causal connectivity. This is determined by how much information integration would be lost by the least costly further partition, or, in other words, how much the cause-effect structure of the system would be reduced by eliminating the least causally effective element within the MICS.

It is important to note that not every system with phi has consciousness. A sub- or super-system of an MICS may have phi but will not have consciousness.

If we were to take a non-MICS subsystem of a network, which in isolation still has causal power over itself, articulable as a logic circuit, then that would have phi. Were it indeed in isolation, it would have its own MICS, and its phi would correspond to that system's degree of consciousness. It is, however, not in isolation, but rather part of a larger system.

IIT interprets the exclusion axiom—that any conscious system is in one conscious state only, excluding all others—as implying a postulate that holds that, at the level of the physical system, there be no "double counting" of consciousness. So, although a system may have multiple subsystems with phi, only the MICS is conscious, and only the phi value of the MICS (sometimes called phi max) measures conscious degree. The other phi values measure degrees of non-conscious integrated information. So, for example, each of a person's visual cortices does not enjoy its own consciousness, but parts of each belong to a single MICS, which is the person's one unitary consciousness.

If we were to take a supersystem of an MICS, one that includes the MICS and also other associated elements with lower connectivity, we could again assign it a phi value, but this would not measure the local maximum of integrated information. The supersystem integrates information, but not maximally, and its phi is therefore not a measure of consciousness. This is probably best understood by example: a group of people in a discussion integrate information, but the connective degree among them is lower than the degree of connectivity within each individual. The group as such has no consciousness, but each individual person—or, more properly, the MICS of each—does. The individuals' MICSs are local maxima of integrated information and therefore conscious.

b. Some Issues of Application

The number of possible partitions of a system, called Bell's number, grows immensely as the number of elements increases. For example, the tiny nematode, a simple species of worm, has 302 neurons, "and the number of ways that this network can be cut into parts is the hyperastronomical 10 followed by 467 zeros" (Koch, 2012). Calculating phi precisely for much more complex systems such as brains eludes computation pragmatically, although not in principle. In the absence of precise phi computation, IIT employs mathematical "heuristics, shortcuts, and approximations" (ibid.). The IIT literature includes several different mathematical interpretations of phi calculation, each intended to replace the last; it is not yet clear that IIT has a settled account of it. Proponents of IIT hold that the mathematical details will enable the application, but not bear on the merits, of the deeper theoretical claims. At least one serious objection to IIT, however, attempts a *reductio ad absurdum* of those deeper claims via analysis of the mathematical implications.

It is clear that, whatever the mathematical details, the basic principles of phi imply that biological nervous systems such as the brain will be capable of having very high phi, because neurons often have thousands of connections to one another. On the other hand, a typical circuit in a standard CPU only makes a few connections to other circuits, limiting the potential phi value considerably. It is also clear that even simple systems will have at least some phi value, and that, provided they constitute local maxima, will have a corresponding measure of consciousness.

IIT does not intend phi as a measure of the quality of consciousness, only of its quantity. Two systems may have the same phi value but different MICS organizations. In this case, each would be conscious to the same degree, but the nature of the conscious experience would differ. The phi metric captures one dimension, the amount of integrated information, of a system. IIT does address the quality of consciousness abstractly, although not with phi. A system's model includes its elements and their connections, whose logic can be graphed as a constellation of (de)activated points with lines between them representing (de)activated connections. This is, precisely, its conceptual structure. Recall that the maximally irreducible conceptual structure, or MICS, is, on IIT, conscious. A graph of the MICS, according to IIT, captures its unique shape in quality space, the shape of that particular conscious state. In other words, this is the abstract form of the quality of the experience, or the experience's form "seen from the outside." The perspective "from the inside" is available only to the system itself, whose making differences to itself intrinsically, integrating information in one of many possible forms, just precisely is its experience. The phenomenological nature of the experience, its "qualia," are evident only from the perspective of the conscious system, but the logical graph of its structure is a complete representation of its qualitative properties.

3. Situating the Theory

a. Some Prehistory

IIT made its explicit debut in the literature in 2004, but has roots in earlier work. Giulio Tononi, the theory's founder and major proponent, worked for many years with Gerald Edelman. Their work rejected the notion that mental events such as consciousness will ever find full explanation by reference to the functioning of a system. Such functionalism, to them, ignores the crucial issue of the physical substrate itself. They especially emphasized the importance of re-entry. To them, only a system composed of feedback loops, where input may also serve as output, can integrate information. Feed-forward systems, then, do not integrate information. Even before the introduction of IIT, Tononi was claiming that integrated information was essential to the creation of a scene in primary consciousness.

Christof Koch, now a major proponent of IIT, collaborated for a long time with Francis Crick. Much of their earlier work focused on identifying the neural correlates of consciousness (NCC), especially in the visual system. While such research advances particular knowledge about the mechanisms of one set of conscious states, Crick and Koch came to see this work as failing to address the deeper problems of explaining consciousness generally. Koch also rejects the idea that identifying the functional dynamics of a system aptly treats what makes that system conscious. He came to regard information theory as the correct approach for explaining consciousness.

So, the two thinkers who became IIT's chief advocates arrived at that position after close neuroscientific research with Nobel Laureates who eschewed functional approaches to consciousness, favoring investigation of the relation of physical substrate to information generation.

b. IIT's Additional Support

As of 2016, Tononi, IIT's creator, runs the Center for Sleep and Consciousness at the University of Madison-Wisconsin. The Center has more than forty researchers, many of whom work in its IIT Theory Group. Koch, a major supporter of IIT, heads the prestigious Allen Institute for Brain Science. The Institute has links with the White House Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative, as well as the European Human Brain Project (HBP). IIT's body of literature continues to grow, often in the form of publications associated with the Center and the Institute. The public reputation of these organizations, as well as of Tononi and Koch's earlier work, lends a certain authority or celebrity to IIT. The theory has enjoyed ample attention in mainstream media. Nevertheless, IIT remains a minority position among neuroscientists and philosophers.

c. IIT as *Sui Generis*

IIT does not fit neatly into any other school of thought about consciousness; there are points of connection to and departures from many categories of consciousness theory.

IIT clearly endorses a Cartesian interpretation of consciousness as immediate; such an association is unusual for a self-described naturalistic or scientific theory of consciousness. Cartesian convictions do inform IIT's axioms and so motivate its overall methodological approach. To label IIT as a Cartesian theory generally, however, would be misleading. For one thing, like most modern theories of consciousness, it dissociates itself from the idea of a Cartesian theatre, or single point in the brain that is the seat of consciousness. Moreover, it is by no means clear how IIT stands in relation to dualism. Certainly, IIT does not advertise itself as positing a mental substance that is separate from the physical. At the same time, it draws an analogy between its identification of consciousness as a property of certain integrated information systems and physics' identification of mass or charge as a property of particles. One might interpret such introduction of immediate experience into the naturalistic ontology as having parallels with positing a new kind of mental substance. The literature will occasionally describe IIT as a form of materialism. It is true that IIT theorists do focus on the material substrate of informational systems, but again, one might challenge whether a theory that asserts direct experience as fundamental to substrates with particular architectural features is indeed limiting itself to reference to material in its explanation.

In describing the features of conscious systems, IIT will make reference to function, but IIT rejects functionalism outright. To IIT theorists, articulating the functional dynamics of a system alone will never do justice to the immediate nature of experience.

d. Relation to Panpsychism

The IIT literature, not only from Tononi but also from Koch and others, refers with some regularity to panpsychism—broadly put, any metaphysical system that attributes mental properties to basic elements of the world—as sharing important ground with IIT. Panpsychism comes in different forms, and the precise relationship between it and IIT has yet to be established. Both IIT and panpsychism strongly endorse Cartesian commitments concerning the immediate nature of experience. IIT, however, only attributes mental properties to re-entrant architectures, because it claims that only these will integrate information; this is inconsistent with any version of panpsychism that insists upon attributing mental properties to even more basic elements of the structure of existence.

i. Relation to David Chalmers

Of the various contemporary philosophical accounts of consciousness, IIT intersects perhaps most frequently with the work of David Chalmers. This makes sense, not only given Chalmers's panpsychist leanings, but also given the express commitment of both to a Cartesian acceptance of the immediacy of experience, and a corresponding rejection of functionalist attempts to explain consciousness.

Moreover, Chalmers's discussion of the relation of information to consciousness strongly anticipates IIT. Before the introduction of IIT, Chalmers had already endorsed the view of information as involving specification, or reduction of uncertainty. IIT often echoes this, especially in connection with the third axiom and postulate. Chalmers also characterizes information as making a difference, which relates to IIT's first postulate especially. These notions of specification and difference-making are familiar from the standard Shannon account of information, but the point is that both Chalmers and IIT choose to understand consciousness partly by reference to these concepts rather than to information *about* something.

A major theme in Chalmers's work involves addressing the problem of the precise nature of the connection between physical systems and consciousness. Before IIT, Chalmers speculated that information seems to be the connection between the two. If this is the case, then phenomenology is the realization of information. Chalmers suggests that information itself may be primitive in the way that mass or charge is. Now, this does not directly align with IIT's later claims of how consciousness is fundamental to certain informational systems in the same way that mass or charge is fundamental to particles, but the parallels are clear enough. Similarly, Chalmers's description of a "minimally sufficient neural system" as the neural correlate of consciousness resembles IIT's discussion of the MICS. Both also use the term "core" in this context. It comes as no surprise that IIT and Chalmers have intersected when we read Chalmers's earlier claims: "Perhaps, then, the intrinsic nature required to ground the information states is closely related to the intrinsic nature present in phenomenology. Perhaps one is even constitutive of the other" (Chalmers, 1996).

Still, the relationship between Chalmers's work and IIT is not one of simple alliance. Despite the apparent similarity of their positions on what is fundamental, there is an important disagreement. Chalmers takes the physical to derive from the informational, and grounds the realization of phenomenal space—the instantiation of conscious experience—not upon causal "differences that make a difference," but upon the intrinsic qualities of and structural relations among experiences. IIT regards consciousness as being intrinsic to certain causal structures, which might be read as the reverse of Chalmers's claim. In describing his path to IIT, Koch endorses Chalmers as "a philosophical defender of information theory's potential for understanding consciousness" while faulting Chalmers's work for not addressing the internal organization of conscious systems (Koch, 2012). To Koch, treating the architecture is necessary because consciousness does not alter in simple covariance with change in amounts of bits of information. Because IIT addresses the physical organization, it struck Koch as superior.

There has been some amount of cross-reference between IIT and Chalmers in the literature, although important differences are apparent. For example, Chalmers famously discusses the possibility of a zombie, or operating physical match of a human that does not have experience. On IIT, functional zombies are possible, but not zombies whose nervous connections duplicate our own. In other words, if a machine were built to imitate the behavior of a human perfectly, but whose hardware involved feed-forward circuits, then it would generate possibly no phi, or more likely low, local phi, rather than the high phi of human consciousness. But if we posit that the machine replicates the connections of the human down to the level of the hardware, then it would follow that the system would integrate the same level of phi and would be equally conscious.

Chalmers (2016) writes that IIT "can be construed as a form of emergent panpsychism," which is true in a sense, but requires qualification. By "emergent panpsychism" Chalmers means that IIT posits consciousness as fundamental not to the merest elements of existence but to certain structures that emerge at the level of particles' relations to one another. This is a fair assessment, whether or not IIT's advocates choose to label the theory this way. But in the difference between emergent and non-emergent lies the substance of IIT: what precisely makes one structure "emerge" conscious and another not is what IIT hopes to explain. Non-emergent panpsychism of the sort associated with Chalmers by definition pitches its explanation at a different level. Indeed, it does not necessarily grant the premise that there exist non-conscious elements, let alone structures, in the first place. Despite the similarities between IIT and some of Chalmers's work, the two should not be confused.

4. Implications

a. The Spectrum of Consciousness

It is widely accepted that humans experience varying degrees of consciousness. In sleep, for example, the richness of experience diminishes, and sometimes we do not experience at all. IIT implies that brain activity during this time will generate either less information or less integrated information, and interprets experimental results as bearing this out. On IIT, the complexity of physical connections in the MICS corresponds to the level of consciousness. By contrast, the cerebellum, which has many neurons, but neurons that are not complexly interconnected and so do not belong to the MICS, does not generate consciousness.

There does not exist a widely accepted position on non-human consciousness. IIT counts among its merits that the principles it uses to characterize human consciousness can apply to non-human cases.

On IIT, consciousness happens when a system makes a difference to itself at a physical level: elements causally connected to one another in a re-entrant architecture integrate information, and the subset of these with maximal causal power is conscious. The human brain offers an excellent example of re-entrant architecture integrating information, capable of sustaining highly complex MICSs, but nothing in IIT limits the attribution of consciousness to human brains only.

Mammalian brains share similarities in neural and synaptic structure: the human case is not obviously exceptional. Other, non-mammalian species demonstrate behavior associated in humans with consciousness. These considerations suggest that humans are not the only species capable of consciousness. IIT makes a point of remaining open to the possibility that many other species may possess at least some degree of consciousness. At the same time, further study of non-human neuroanatomy is required to determine whether and how this in facts holds true. As mentioned above, even the human cerebellum does not have the correct architecture to generate consciousness, and it is possible that other species have neural organizations that facilitate complex behavior without generating high phi. The IIT research program offers a way to establish whether these other systems are more like the cerebellum or the cerebral cortex in humans. Of course, consciousness levels will not correspond completely to species alone. Within conscious species, there will be a range of phi levels, and even within a conscious phenotype, consciousness will not remain constant from infancy to death, wakefulness to sleep, and so forth.

IIT claims that its principles are consistent with the existence of cases of dual consciousness within split-brain patients. In such instances, on IIT, two local maxima of integrated information exist separately from one another, generating separate consciousness. IIT does not hold that a system need have only one local maximum, although this may be true of normal brains; in split-brain patients, the re-entrant architecture has been severed so as to create two. IIT also takes its identification of MICSs through quantification of phi as a potential tool for assessing other actual or possible cases of multiple consciousness within one brain.

Such claims also allow IIT to rule out instances of aggregate consciousness. The exclusion principle forbids double-counting of consciousness. A system will have various subsystems with phi value, but only the local maxima of phi within the system can be conscious. A normal waking human brain has only one conscious MICS, and even a split-brain patient's conscious systems do not overlap but rather are separate. One's conscious experience is precisely what it is and nothing else. All this implies that, for example, the United States of America has no superordinate consciousness in addition to the consciousness of its individuals. The local maxima of integrated information reside within the skulls of those individuals; the phi value of the connections among them is much lower.

Although IIT allows for a potentially very wide range of degrees of consciousness and conscious entities, this has its limits. Some versions of panpsychism attribute mental properties to even the most basic elements of the structure of the world, but the simplest conscious entity admitted on IIT to be conscious would have to be a system of at least two elements that have cause-effect power over one another. Otherwise no integrated information exists. Objects such as rocks and grains of sand have no phi, whether in isolation or heaped into an aggregate, and so no consciousness.

IIT's criteria for consciousness are consistent with the existence of artificial consciousness. The photodiode, because it integrates information, has a phi value; if not subsumed into a system of higher phi, this will count as local maximum: the simplest possible MICS or conscious system. Many or most instances of phi and consciousness may be the result of evolution in nature, independent of human technology, but this is a contingent fact. Often technological systems involve feed-forward architecture that lowers or possibly eliminates phi, but if the system is physically re-entrant and satisfies the other criteria laid out by IIT, it may be conscious. In fact, according to IIT, we may build artificial systems with a greater degree of consciousness than humans.

b. IIT and Physics

IIT has garnered some attention in the physics literature. Even if one accepts the basic principles of IIT, it still remains open to offer a different account of the physical particulars. Tononi and the other proponents of IIT coming from neuroscientific backgrounds tend to offer description at a classical grain. They frame integrated information by reference to neurons and synapses in the case of brains, and to re-entrant hardware architecture in the case of artificial systems. Such descriptions stay within the classical physics paradigm. This does not exhaust the theoretical problem space for characterizing integrated information.

One alternative (Barrett, 2014) proposes that consciousness comes from the integration of information intrinsic to fundamental fields. This account calls for reconceiving the phi metric, which in its 2016 form applies only to discrete systems, and not to electromagnetic fields. Another account (Tegmark, 2015) also proposes non-classical physical description of conscious, integrated information. This generalizes beyond neural or neural-type systems to quantum systems, suggesting that consciousness is a state of matter, whimsically labelled "perceptronium."

c. Artificial Consciousness

IIT's basic arguments imply, and the IIT literature often explicitly claims, certain important constraints upon artificial conscious systems.

i. Constraints on Structure/Architecture

At the level of hardware, computation may process information with either feed-forward or re-entrant architecture. In feed-forward systems, information gets processed in only one direction, taking input and giving output. In re-entrant systems, which consist of feedback loops, signals are not confined to movement in one direction only; output may operate as input also.

IIT interprets the integration axiom (the fourth axiom, which says that each experience's phenomenological elements are interdependent) as entailing the fourth postulate, which claims that each mechanism of a conscious system must have the potential to relate causally to the other mechanisms of that system. By definition, in a feed-forward system, mechanisms cannot act as causes upon those parts of the system from which they take input. A purely feed-forward system would have no phi, because although it would process information, it would not integrate that information at the physical level.

One implication for artificial consciousness is immediately clear: Feed-forward architectures will not be conscious. Even a feed-forward system that perfectly replicated the behavior of a conscious system would only *simulate* consciousness. Artificial systems would need to have re-entrant structure to generate consciousness.

Furthermore, re-entrant systems may still generate very low levels of phi. Conventional CPUs have transistors that only communicate with several others. By contrast, each neuron of the conscious network of the brain connects with thousands of others, a far more complex re-entrant structure, making a difference to itself at the physical level in such a way as to generate much higher phi value. For this reason, brains are capable of realizing much richer consciousness than conventional computers. The field of artificial consciousness, therefore, would do well to emulate the neural connectivity of the brain.

Still another constraint applies, this one associated with the fifth postulate, the postulate of exclusion. A system may have numerous phi-generating subsystems, but according to IIT, only the network of elements with the greatest cause-effect power to integrate information—the maximally irreducible conceptual structure, or MICS—is conscious. Re-entrant systems may have local maxima of phi, and therefore small pockets of consciousness. Those attempting to engineer high degrees of artificial consciousness need to focus their design on creating a large MICS, not simply small, non-overlapping MICSs.

If IIT is correct in placing such constraints upon artificial consciousness, deep convolutional networks such as GooGleNet and advanced projects like Blue Brain may be unable to realize high levels of consciousness.

ii. Relation to "Silent Neurons"

IIT's third postulate has a somewhat counterintuitive implication. The third axiom claims that each conscious experience is precisely what it is; that is, it is distinct from other experiences. The third postulate claims that, in order to realize this feature of consciousness, a system must have a range of possible states, describable by reference to the cause-effect repertoires of its mechanistic elements. The system realizes a specific conscious state by instantiating one of those particular physical arrangements.

An essential component of the phenomenology of a conscious state is the degree of specificity: a photodiode that registers light specifies one of only two possible states. IIT accepts that such a simple mechanism, if not subsumed under a larger MICS, must be conscious, but only to a negligible degree. On the other hand, when a human brain registers light, it distinguishes it from countless other states; not only from dark, but from different shades of color, from sound, and so forth. The brain state is correspondingly more *informative* than the photodiode state.

This means that not only active neuronal firing, but also neuronal silence, determines the nature of a conscious state. Inactive parts of the complex, as well as active ones, contribute to the specification at the physical level, which IIT takes as the realization of the conscious state.

It is important not to conflate silent, or inactive, neurons of this kind with de-activated neurons. Only neurons that genuinely fall within the cause-effect repertoires of the mechanistic elements of the system count as contributing to specification, and this applies to inactive as well as to active ones. If a neuron was incapable all along of having causal power within the MICS, its inactivity plays no role in generating phenomenology.

Likewise, IIT predicts that should neurons otherwise belonging to cause-effect repertoires of the system be rendered incapable of such causation (for example, by optogenetics), their inactivity would not contribute to phenomenology.

5. Objections

a. The Functionalist Alternative

According to functionalism, mental states, including states of consciousness, find explanation by appeal to function. The nature of a certain function may limit the possibilities for its physical instantiation, but the function, and not the material details, is of primary relevance. IIT differs from functionalism on this basic issue: on IIT, the conscious state is identified with the way in which a system embodies the physical features that IIT's postulates describe.

Their opposing views concerning constraints upon artificial consciousness nicely illustrate the contrast between functionalism and IIT. For the functionalist, any system that functions identically to, for example, a conscious human, will by definition have consciousness. Whether the artificial system uses re-entrant or feed-forward architecture is a pragmatic matter. It may turn out that re-entrant circuitry more efficiently realizes the function, but even if the system incorporates feed-forward engineering, so long as the function is achieved, the system is conscious. IIT, on the other hand, expressly claims that a system that performed in a way completely identical to a conscious human, but that employed feed-forward architecture, would only simulate, but not realize consciousness. Put simply, such a system would operate as if it were integrating information, but because its networks would not take output as input, would not actually integrate information at the physical level. The difference would not be visible to an observer, but the artificial system would have no conscious experience.

i. Rejecting Cartesian Commitments

Those who find functionalism unsatisfactory often take it as an inadequate account of phenomenology: no amount of description of functional dynamics seems to capture, for example, our experience of the whiteness of a cue ball. Indeed, IIT entertains even broader suspicions. Beginning with descriptions of physical systems may never lead to explanations of consciousness. Rather, IIT's approach begins with what it takes to be the fundamental features of consciousness. These self-evident, Cartesian descriptors of phenomenology then lead to postulates concerning their physical realization; only then does IIT connect experience to the physical.

This methodological respect for Cartesian intuitions has a clear appeal, and the IIT literature largely takes this move for granted, rather than offering outright justification for it. In previous work with Edelman (2000), Tononi discusses machine-state functionalism, an early form of functionalism that identified a mental state entirely with its internal, "machine" state, describable in functional terms. Noting that Putnam, machine-state functionalism's first advocate, came to abandon the theory because meanings are not sufficiently fixed by internal states alone, Tononi rejects functionalism generally. More recently, Koch (2012) describes much work in consciousness as "models that describe the mind as a number of functional boxes" where one box is "magically endowed with phenomenal awareness." Koch confesses to being guilty of this in some of his earlier work. He then points to IIT as an exception.

Functionalism is not receiving a full or fair hearing in these instances. Machine-state functionalism is a straw man: contemporary versions of functionalism do not commit to an entirely internal explanation meaning, and not all functionalist accounts are subject to the charge of arbitrarily attributing consciousness to one part of a system. The success or failure of functionalism turns on its treatment of the Cartesian intuitions we all have that consciousness is immediate, unitary, and so on. Rather than taking these intuitions as evidence of the unavoidable truth of what IIT describes in its axioms, functionalism offers a subtle alternative. Consciousness indeed seems to us direct and immediate, but functionalists argue that this "seeming" can be adequately accounted for without positing a substantive phenomenality beyond function. Functionalists claim that the seeming immediacy of consciousness receives sufficient explanation as a set of beliefs and dispositions to believe that consciousness is immediate. The challenge lies in giving a functionalist account of such beliefs: no mean feat, but not the deep mystery that non-functionalists construe consciousness as posing. If functionalism is correct in this characterization of consciousness, it undercuts the very premises of IIT.

ii. Case Study: Access *vs.* Phenomenal Consciousness

Function may be understood in terms of access. If a conscious system has cognitive access to an association or belief, then that association or belief is conscious. In humans, access is often taken to be demonstrated by verbal reporting, although other behaviors may indicate cognitive access. Functionalists hold that cognitive access exhaustively describes consciousness (Cohen and Dennett, 2012). Others hold that subjects may be phenomenally conscious of stimuli without cognitively accessing them.

Interpretation of the relevant empirical studies is a matter of controversy. The phenomenon known as "change blindness" occurs when a subject fails to notice subtle differences between two pictures, even while reporting thoroughly perceiving each. Dennett's version of functionalism, at least, interprets this as the subject not having cognitive access to the details that have changed, and moreover as not being conscious of them. The subject overestimates the richness of his or her conscious perception. Certain non-functionalists claim that the subject does indeed have the reported rich conscious phenomenology, even though cognitive access to that phenomenal experience is incomplete. Block (2011), for instance, holds this interpretation, claiming that "perceptual consciousness overflows cognitive access." On this account, phenomenal consciousness may occur even in the absence of access consciousness.

IIT's treatment of the role of silent neurons aligns with the non-functionalist interpretation. On IIT, a system's consciousness grows in complexity and richness as the number of elements that could potentially relate causally within the MICS grows. Such elements, even when inactive, contribute to the specification of the integrated information, and so help to fix the phenomenal nature of the experience. In biological systems, this means that silent but potentially active neurons matter to consciousness.

Such silent neurons are not accessed by the system. These non-accessed neurons still contribute to consciousness. As in Block's non-functionalism, access is not necessary for consciousness. On IIT, it is crucial that these neurons could potentially be active, so they must be accessible to the system. Block's account is consistent with this in that he claims that the non-accessed phenomenal content need not be inaccessible. (Koch, separately from his support of IIT, takes the non-functionalist side of this argument (Koch and Tsuchiya, 2007); so do Fahrenfort and Lamme (2012); for a functionalist response to the latter, see Cohen and Dennett (2011, 2012).)

Non-functionalist accounts that argue for phenomenal consciousness without access make sense given a rejection of the functionalist claim that phenomenality may be understood as a set of beliefs and associations, rather than a Cartesian, immediate phenomenology beyond such things.

iii. Challenging IIT's Augmentation of Naturalistic Ontology

Any account of consciousness that maintains that phenomenal experience is immediately first-personal stands in tension with naturalistic ontology, which holds that even experience in principle will receive explanation without appeal to anything beyond objective, or third-personal, physical features. Among theories of consciousness, those versions of panpsychism that attribute mental properties to basic structural elements depart perhaps most obviously from the standard scientific position. Because IIT limits its attribution of consciousness to particular physical systems, rather than to, for example, particles, it constitutes a somewhat more conservative position than panpsychism. Nevertheless, IIT's claims amount to a radical reconception of the ontology of the physical world.

IIT's allegiance to a Cartesian interpretation of experience from the outset lends itself to a non-naturalistic interpretation, although not every step in IIT's argumentation implies a break from standard scientific ontology. IIT counts among its innovations the elucidation of integrated information, achieved when a system's parts make a difference intrinsically, to the system itself. This differs from observer-relative, or Shannon, information, but by itself stays within the confines of naturalism: for example, IIT could have argued that integrated information constitutes an efficient functional route to realizing states of awareness.

Instead, IIT makes the much stronger claim that such integrated information, provided it is locally maximal, is *identical* to consciousness. The IIT literature is quite explicit on this point, routinely offering analogies to other fundamental physical properties. Consciousness is fundamental to integrated information in the same way as it is fundamental to mass that space-time bends around it. The degree and nature of any given phenomenal feeling follow basically from the particular conceptual structure that is the integrated information of the system. Consciousness is not a brute property of physical

structure *per se*, as it is in some versions of panpsychism, but it is inextricable from physical systems with certain properties, just as mass or charge is inextricable from some particles. So, IIT is proposing an addition to what science admits into its ontology.
The extraordinary nature of the claim does not necessarily undermine it, but it may be cause for reservation. One line of objection to IIT might claim that this augmentation of naturalistic ontology is non-explanatory, or even *ad hoc*. We might accept that biological conscious systems possess neurology that physically integrates information in a way that converges with phenomenology (as outlined in the relation of the postulates to the axioms) without taking this as sufficient evidence for an identity relation between integrated information and consciousness. In response, IIT advocates might claim that the theory's postulates give better ontological ground than functionalism for picking out systems in the first place.

b. Aaronson's *Reductio ad Absurdum*

The computer scientist Scott Aaronson (on his blog *Shtetl-Optimized*; see Horgan (2015) for an overview) has compelled IIT to admit a counterintuitive implication. Certain systems, which are computationally simple and seem implausible candidates for consciousness, may have values of phi higher even than those of human brains, and would count as conscious on IIT. Aaronson's argument is intended as a *reductio ad absurdum*; the IIT response has been to accept its conclusion, but to deny the charge of absurdity. Aaronson's basic claim involves applying phi calculation. Advocates of IIT have not questioned Aaronson's mathematics, so the philosophical relevance lies in the aftermath. IIT refers to richly complex systems such as human brains or hypothetical artificial systems in order to illustrate high phi value. Aaronson points out that systems that strike us as much simpler and less interesting will sometimes yield a high phi value. The physical realization of an expander graph (his example) could have a higher phi value than a human brain. A graph has points that connect to one another, making the points vertices and the connections edges. This may be thought of as modelling communication between points. Expander graphs are "sparse" – having not very many points – but those points are highly connected, and this connectivity means that the points have strong communication with one another. In short, such graphs have the right properties for generating high phi values. Because it is absurd to accept that a physical model of an expander graph could have a higher degree of consciousness than a human being, the theory that leads to this conclusion, IIT, must be false.

Tononi (2014) responds directly to this argument, conceding that Aaronson has drawn out the implications of IIT and phi fairly, even ceding further ground: a two-dimensional grid of logic gates, even simpler than an expander graph, would have a high phi value and would, according to IIT, have a high degree of consciousness. Tononi has already argued that a photodiode has minimal consciousness; to him, accepting where Aaronson's reasoning leads is just another case of the theory producing surprising results. After all, science must be open to theoretical innovation.

Aaronson's rejoinder challenges IIT by arguing that it implicitly holds inconsistent views on the role of intuition. In his response to Aaronson's original claims, Tononi disparages intuitions regarding when a system is conscious: Aaronson should not be as confident as he is that expander graphs are not conscious. Indeed, the open-mindedness here suggested seems in line with the proper scientific attitude. Aaronson employs a thought-experiment to draw out what he takes to be the problem. Imagine that a scientist announces that he has discovered a superior definition of temperature and has constructed a new thermometer that reflects this advance. It so happens that the new thermometer reads ice as being warmer than boiling water. According to Aaronson, even if there is merit to the underlying scientific work, it is a mistake for the scientist to use the terms "temperature" or "heat" in this way, because it violates what we mean by those terms in the first place: "heat" means, partly, what ice has less of than boiling water. So, while IIT's phi metric may have some merit, it is not in measuring consciousness degree, because "consciousness" means, partly, what humans have and expander graphs and logic gates do not have.

One might, in defense of IIT, respond by claiming that the cases are not as similar as they seem, that the definition of heat necessitates that ice has less of it than boiling water and that the definition of consciousness does not compel us to draw conclusions about expander graphs' non-consciousness, strange as that might seem. Aaronson's argument goes further, however, and it is here that the charge of inconsistency comes into play. Tononi's answer to Aaronson's original reductio argument partly relies upon claiming that facts such as that the cerebellum is not conscious are totally well-established and uncontroversial. (IIT predicts this because the wiring of the cerebellum yields a low phi and is not part of the conscious MICS of the brain.) Here, argues Aaronson, Tononi is depending upon intuition, but it is possible that although the cerebellum might not produce our consciousness, it may have one of its own. Aaronson is not arguing for the consciousness of the cerebellum, but rather pointing out an apparent logical contradiction. Tononi rejects Aaronson's claim that expander graphs are not conscious because it relies on intuition, but here Tononi himself is relying upon intuition. Nor can Tononi here appeal to common sense, because IIT's acceptance of expander graphs and logic gates as conscious flies in the face of common sense.

It is possible that IIT might respond to this serious charge by arguing that almost everyone agrees that the brain is conscious, and that IIT has more success than any other theory in accounting for this while preserving many of our other intuitions (that animals, infants, certain patients with brain-damage, and sleeping adults all have dimmer consciousness than adult waking humans, to give several examples). Because this would accept a certain role for intuitions, it would require walking back the gloss on intuition that Tononi has offered in response to Aaronson's reductio. Moreover, Aaronson's arguments show that such a defense of the overall intuitive plausibility of IIT will face difficult challenges.

c. Searle's Objection

In one of very few published discussions of IIT by a philosopher, John Searle (2013a) has come out against it, criticizing its emphasis on information as a departure from the more promising "biological approach." His objections may be divided into two parts; Koch and Tononi (2013) have offered a response.

First, Searle claims that in identifying consciousness with a certain kind of information, it has abandoned causal explanation. Appeal to cause should be the proper route for scientific explanation, and Searle maintains, as he has throughout his career, that solving the mystery of consciousness will depend upon the explication of the causal powers special to the brain that give rise to experience. Information fails aptly to address the problem because it is observer-relative; indeed, it is relative to the conscious observer. A book or computer, to take typical examples of objects associated with information, does not contain information except insofar as it is endowed by the conscious subject. Information is in the eye of the beholder. The notion of information presupposes consciousness, rather than explaining it.

Second, according to Searle, IIT leads to an absurdity, namely panpsychism, which is sufficient reason to reject it. He interprets IIT as imputing consciousness to all systems with causal relations, and so it follows on IIT that consciousness is "spread over the universe like a thin veneer of jam." A successful theory of consciousness will have to appreciate that consciousness "comes in units" and give a principled account of how and why this is the case.

Koch and Tononi's response (2013) addresses both strands of Searle's argument. First, they agree that Shannonian information is observer-relative, but point out that integrated information is non-Shannonian. IIT defines integrated information as necessarily existing with respect to itself, which they understand in expressly causal terms, as a system whose parts make a difference to that system. Integrated information systems therefore exist intrinsically, rather than relative to observers. Not only does IIT attend to the observer-relativity point, then, but also does so in a way that, contrary to Searle's characterization, crucially incorporates causality.

Second, they deny that IIT implies the kind of panpsychism that Searle rejects as absurd. As they point out, IIT only attributes consciousness to local maxima of integrated information (MICS), and although that implies that some simple systems such as the isolated photodiode have a minimal degree of consciousness, it provides a principle to determine which "units" are conscious, and which are not. As Tononi had already put it, before Searle's charges: "How close is this position to panpsychism, which holds that everything in the universe has some kind of consciousness? Certainly, the IIT implies that many entities, as long as they include some functional mechanisms that can make choices between alternatives, have some degree of consciousness. Unlike traditional panpsychism, however, the IIT does not attribute consciousness indiscriminately to all things. For example, if there are no interactions, there is no consciousness whatsoever. For the IIT, a camera sensor as such is completely unconscious…" (Tononi, 2008).

Although Searle offers a rejoinder (2013b) to Tononi and Koch's response, it largely rehearses the original claims. Regardless of whether IIT is true, Tononi and Koch have given good reason to read it as addressing precisely the concerns that Searle raises. Arguably, then, Searle might have reason to embrace IIT as a theory of consciousness that at least attempts a principled articulation of the special casual powers of the brain, which Searle has regarded for many years as the proper domain for explaining consciousness.

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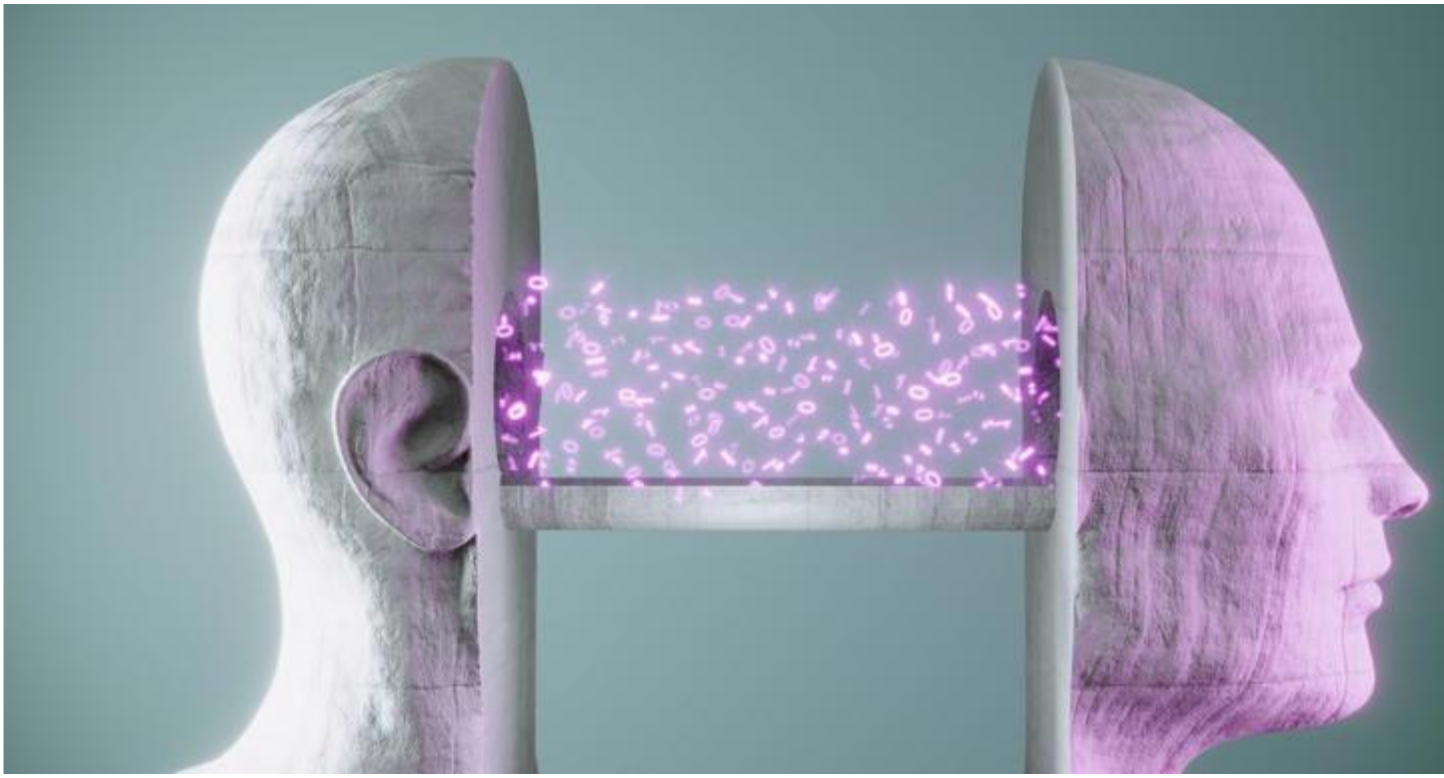


A dream team of European neuroscientists is advancing toward a unified theory of consciousness, potentially unlocking the mysteries of the mind.© Eoneren - Getty Images

- An EU team of neuroscientists asked their peers: “Can’t we all just get along?”
- They analyzed how five major theories of consciousness overlap in both fundamentals and details.
- Ultimately, consciousness is not well understood at all—everyone could be right *and* wrong.

In newly published research, a full baseball team worth of neuroscientists from around Europe have combined their theories of the mechanics of consciousness. By breaking theories into pieces and comparing like with like, the scientists realized that certain kinds of experimentation can answer several questions at once across the different theories. Why reinvent the wheel, or better yet, reinvent the science grant-funded experiment? In the journal *Neuron*, the group laid out their new, collaborative approach to brain science.

These researchers (hailing from universities in Netherlands, German, Italy, Estonia, and more) have come together from the Human Brain Project—a European Union-created committee of scientists from many disciplines who all collaborated towards the goal of accelerating research on the human brain. The project lasted from 2013 to 2023, so it's not surprising that two high-profile neuroscience papers have come from this larger group in the first half of 2024. The other is a position paper in the MIT journal *Imaging Neurosience* that was coauthored by dozens of scientists and supported by many more.

Even outsiders can see there are some workplace and industry politics rumbling below these two papers. Someone writing a manifesto or pushing a new model of collaboration is speaking against a status quo in some way. Indeed, while some areas of scientific research are more collaborative in a public way (like nuclear fusion research facilities around the world that trade top-tier scientists like ace pitchers), others (like many human sciences and national defense) become proprietary as companies, governments, and universities seek to patent their work.

Many Worlds Theory_ You're in a Parallel Universe _ Can You Visit Your Other Lives

"Historically, most researchers have emphasized the development and validation of their preferred theoretical framework in isolation," the researchers wrote. "[W]e show that many aspects of the various theories of consciousness do not necessarily contradict each other, as sometimes claimed; instead, theories often try to explain different aspects of consciousness and tend to converge on fundamental neuronal mechanisms and processes."

In other words, researchers are agreeing on many of their findings—at least, as far as physical observations inside the brain and its cells go. It's only in the subsequent steps, where scientists form theories to explain what they're seeing, that differences begin to seem insurmountable. To study this in more depth, this paper's authors chose five major working theories of consciousness. These cover three of the four suggested types of models laid out by two influential neuroscientists.

All five theories, according to the researchers, share two major underpinnings: recurrent processing and integration. There are also nitty-gritty qualities that subgroups share, like the main role of the brain's posterior cortex or the importance of localized feedback within the brain's microcircuitry. Overall, they say, there are some interesting convergences on each level of granularity. And that could be a key first step to building a unified theory of consciousness.

Perhaps more importantly, the researchers explained, the wide spread of theories "has even led to accusations of illegitimacy between competing theories"—something that could stop with more understanding. After all, there's still an enormous amount we don't know about consciousness or the physical structures of the brain.

At the end of the day (or century!), just one theory will prove to be entirely correct. When that happens, there will be a lot of excitement—and a lot of humble pie.

Quantum Physics Shows Us a Different Perspective on Death

Quantum physics challenges our understanding of death. Dr. Robert Lanza's biocentrism theory suggests consciousness shapes reality.

The double-slit experiment shows particles behave differently when observed. Could our perception of death be fundamentally flawed?

Consciousness: The Universe's Hidden Architect

Biocentrism argues consciousness creates space and time. This theory explains why the universe appears fine-tuned for life.

95% of the universe consists of dark matter and energy we can't directly observe. Are we missing a crucial piece of the cosmic puzzle.

Heisenberg's Uncertainty: Reality or Illusion

Heisenberg's principle limits our ability to measure particles. We can't simultaneously know a particle's exact location and momentum.

This principle applies to objects as large as 2,000 atoms. Does this uncertainty extend to our concept of death?

Entanglement: Defying Space and Time

Quantum entanglement allows instant communication between particles. Einstein called this "spooky action at a distance".

Entanglement has been observed over distances of 1,200 kilometers. Could this phenomenon transcend death itself?

Many-Worlds: Are We Already Immortal

The many-worlds interpretation suggests infinite parallel universes. Every possible outcome occurs simultaneously in different realities.

This theory implies we're always alive somewhere. Are we experiencing just one slice of eternal existence?

Terror Management: Why We Fear Death

Terror management theory explains our existential dread. Humans develop beliefs to transcend mortality.

75% of people believe in some form of afterlife. Is our fear of death blocking a deeper understanding of reality?

Biocentrism: Bridging Science and Philosophy

Dr. Lanza's biocentrism blends biology and physics. Critics argue it lacks mathematical foundation.

The theory has sparked debate among 30% of physicists. Can this controversial idea revolutionize our understanding of existence?

Observer Effect: Do We Create Reality

The observer effect suggests we influence quantum outcomes. This phenomenon has been demonstrated in labs worldwide.

It challenges the notion of an objective reality. Are we unwittingly shaping our own afterlife?

Einstein's Legacy: Time as an Illusion

Einstein proposed time is a stubborn illusion. His theories have been confirmed by atomic clocks on satellites.

Time dilation effects are measurable at speeds of 20 miles per hour. Does our limited perception of time blind us to eternal existence?

Beyond Death: A New Scientific Frontier

Quantum theories are reshaping our view of death. Research in this field has doubled in the last decade.

65% of Americans believe science will explain the afterlife. Are we on the brink of a paradigm shift in understanding mortality?

Non-locality Principle Suggests Consciousness Beyond Body

Quantum non-locality implies instant connections across space. This principle could apply to consciousness as well.

It suggests our awareness might extend beyond our physical bodies. This concept aligns with some spiritual beliefs about the afterlife.

Observer Effect: Consciousness Shapes Physical Reality

Quantum physics emphasizes the role of the observer. Measurements can affect quantum outcomes.

This implies consciousness plays a role in shaping reality. It suggests our awareness might influence existence beyond death.

Information Theory: Consciousness as Preserved Data

Quantum information theory suggests information is never lost. This could apply to the information that constitutes our consciousness.

Physicist Leonard Susskind supports this idea. It implies our essence might be preserved after death.

Biocentrism: Life and Consciousness Create Universe

Biocentric theory proposes life creates the universe. This reverses the traditional view of a lifeless cosmos.

Developed by Robert Lanza, it suggests consciousness is fundamental. In this view, death might be a transition, not an end.

Quantum Archaeology: Future Tech to Reconstruct Past Today

Quantum archaeology is a speculative future technology. It proposes using advanced computing to reconstruct past events.

This could theoretically "resurrect" consciousness from the past. While highly theoretical, it offers a unique perspective on death and memory.

Through quantum physics, our understanding of the universe has been transformed as it challenges traditional concepts of reality. One of its most intriguing propositions is that death might not be the end but an illusion. So, is our comprehension of this final chapter fundamentally flawed? Could it be that death, as we perceive it, is merely an illusion crafted by our limited human perspective?

What is Quantum Physics

The study of the smallest particles in the universe, like atoms and photons, is called quantum physics. It reveals that these tiny particles can behave in strange and unpredictable ways, such as being in multiple places at once or instantly affecting each other even when far apart. These unusual behaviors show that the universe operates on principles different from the everyday world's.

Consciousness is Beyond the Physical Body

New theories of quantum physics suggest that consciousness goes beyond the physical brain. Some theorists say that consciousness is a fundamental universe property, existing independently of matter. If this is true, it could explain near-death occurrences, out-of-body experiences, and even survival of consciousness after the physical body ceases to function.

The Illusion of Time and Space

We usually think of time as a straight line, moving from the past to the future. However, time and space are flexible and connected unexpectedly in the quantum world. It questions our belief that death is a final stop in a straightforward timeline. Instead, it suggests that death might not end but a shift to a different state or dimension.

Quantum Immortality

Building on these ideas, some scientists have proposed the concept of quantum immortality. The theory suggests that consciousness, a quantum phenomenon, might exist in multiple possibilities even after physical death. In this view, death becomes a branching point, with different versions of consciousness exploring different realities. While this concept remains highly speculative, it offers a fascinating perspective on the nature of mortality.

Role of Near-Death Experiences

Near-death experiences (NDEs) have fascinated people for centuries. Often involving feelings of peace, detachment from the body, and encounters with light or deceased loved ones, NDEs have been reported by people from diverse cultures and backgrounds. Some researchers believe it could be evidence of consciousness existing independently of the physical brain, aligning with the quantum perspective on death.

Quantum Entanglement

It is a phenomenon where two particles become interconnected, regardless of distance. Actions performed on one particle instantaneously affect the other as if they were one. A few theorists propose a connection between quantum entanglement and consciousness, suggesting that our minds might be entangled with the universe. It could explain the sense of interconnectedness often reported in near-death encounters and meditative states.

The Holographic Universe Theory

Another concept related to quantum physics is the holographic principle. This theory proposes that the entire universe can be described as a two-dimensional information field projected onto a three-dimensional space. If our reality is indeed a hologram, it raises questions about the nature of consciousness and the potential for its persistence beyond physical death.

Challenges and Criticism

It's important to note that the idea of death as an illusion is highly speculative and faces significant issues. Many scientists are skeptical of the claims made by quantum physicists and consciousness researchers. Critics argue that there's insufficient evidence to support the notion of consciousness surviving physical death and that neurological or psychological factors can explain near-death encounters.

The Power of Belief

Regardless of the scientific evidence, the concept of death as an illusion has profound implications for our knowledge of life and our place in the universe. It offers a sense of hope and possibility, suggesting that our consciousness might continue to exist in some form beyond the physical realm.

Exploring Consciousness

One of science's most complex challenges is understanding consciousness and the nature of reality. As technology advances, we can expect to make groundbreaking discoveries that will shed new light on these age-old questions. Whether or not death is ultimately proven to be an illusion, the exploration of consciousness is a journey of great human significance.

Embracing The Unknown

Ultimately, the question of whether death exists or not remains unanswered. Nonetheless, contemplating this possibility can lead to a deeper appreciation for life and wonder about the universe. By embracing the unknown and exploring the frontiers of human knowledge, we can expand our knowledge of ourselves and our place in the cosmos.

The Role of Spirituality and Philosophy

While science offers valuable insights into the nature of reality, spirituality and philosophy have long explored questions of life, death, and consciousness. These disciplines can provide complementary perspectives and offer frameworks for understanding our encounters. Incorporating insights from both science and spirituality can enrich our perception of the human condition.

Death as a Catalyst for Personal Growth

Even if death is not the end, it is a powerful motivator for living a meaningful life. The awareness of our mortality can inspire us to pursue our passions, connect with others, and positively impact the world. By embracing the impermanence of life, we can live with greater purpose and fulfillment.

Ethical Implications

The idea of death as an illusion raises ethical questions. If consciousness can potentially survive physical death, how does this impact our apprehension of concepts like euthanasia, organ donation, and end-of-life care? These complex issues require careful consideration and societal dialogue.

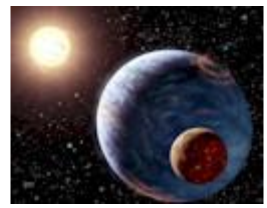
The Future of Death Research

Advancements in quantum biology and neuroscience are opening new avenues for understanding consciousness and its relationship to physical reality. While we're far from conclusively answering questions about death, these fields promise exciting discoveries. As physicist Michio Kaku puts it, "The next revolution in our perception of consciousness may come from the quantum world."

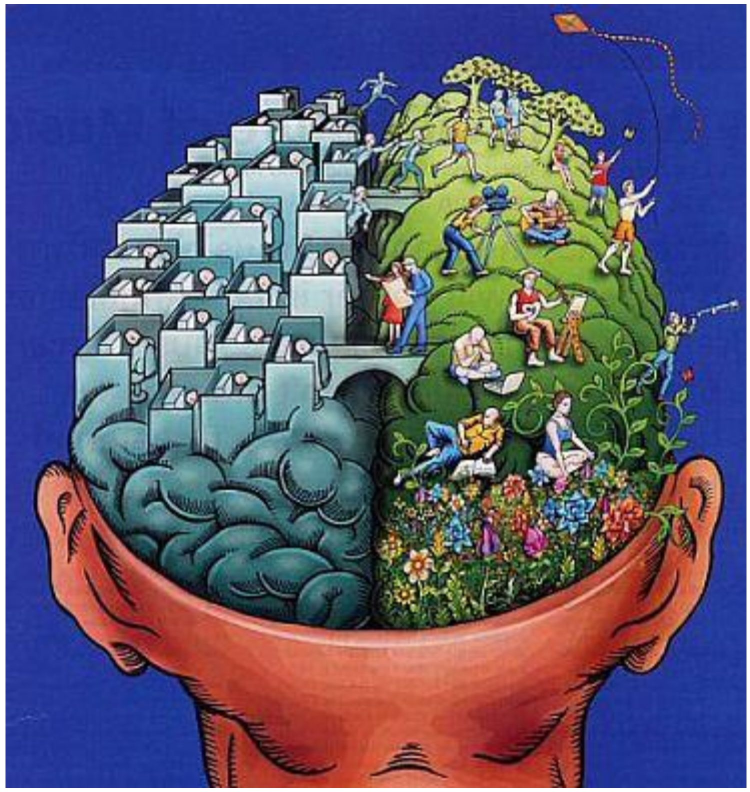
Altered States

Freedom From The Known

Altered States of Consciousness



A state of consciousness that differs significantly from baseline or normal consciousness often identified with a brain state that differs significantly from the brain state at baseline or normal consciousness.



The left and Right Brain

Paul Maclean discovered in his research on the human brain that by far, most of Western Society never escapes the trap of the Left Brain and its Ego. Consequently, all types of illnesses result because of the lack of contact with the Right Brain, which contains the Self. Because of the polarity between the Left Brain and the Right Brain techniques must be used to make contact between them and begin the Integration process**.**

Left and Right Brain

LEFT BRAIN	***RIGHT BRAIN***
Logical - responsible for logic functions such as mathematics, computations, logical deductions	*Imaginative - responsible for imagination, visualisation and 'open ended' creative thinking.*
Analytic - examines things part by part, and relates to small details	*Synthetic - arranges the parts to form the whole; can perceive the whole*

Computational - uses sums and computations to reach estimates

Intuitional - uses intuition to sense or get a feeling of a situation,(including hunches)

Sequential - does things one at a time

Holistic - does differenmt tasks at once

Factual - deals with details, items, particulars, features of a thing

things Visual /visuo-spatial - uses imagery, colours; perceives shape and dimension

Insular - works within the parameters of the individual's existent data

'Open-ended' - in touch with, and can tap into, unlimited 'collective consciousnesses'

MIND STATES

By connecting a subject to an Electroencephalograph (EEG), his/her brain waves can be measured in cycles per second (c.p.s.). This is not so much a quantitative measure of mental activity as it is of a state of mind. There are essentially four states - beta, alpha, theta and delta. Although these have only been scientifically studied with the advent of modern equipment, I was intrigued to unearth mention of these four states in ancient eastern texts. It seems that some ancient societies have long known how to exploit the mind's unlimited potential. But whereas in the past such knowledge was limited to a privileged few, today it has been made more accessible, and streamlined with modern scientific knowledge.

At an average of 20 c.p.s., the beta state is the normal, everyday waking state. In this state we are predominantly engaged in left brain activity. Lowering the brain wave frequency to around 15 c.p.s. brings us into the alpha state, and it is here that right brain activity is engaged. Lower still are theta and delta, but these do not concern us as they are really only accessed during sleep. Lowering frequency simply means cutting out unnecessary stress and brain 'chit-chat'. Besides engaging creative abilities, this makes the individual more alert,allows clearer thinking and enables mental faculties which the beta level does not. Although we talk of lowering frequency, the effect is more of an altered state.

We are particularly interested in the alpha state, as this is where right brain activity can be actively engaged. This state brings into play our imaginative and creative faculties, as well as our intuitive mind. It is the state at which ideas will flow more readily. In everyday life, we go through alpha at least twice a day - in the evening as we drift off to sleep, and in the morning when we wake up. This explains why many top inventions were conceived early in the morning, or during a state of relaxation. Einstein came up with the theory of relativity not in his laboratory but while sunbathing on a hillside. Although mathematics is predominantly a left brain activity, he allocated time to relaxing his mind, and advised his students to do likewise. Nikola Tesla, Thomas Edison, Wolfgang Mozart, Einstien and other successful thinkers and geniuses employed similar techniques. Our aim naturally, is to produce alpha frequencies while fully alert. A state of alpha does not put one to sleep, on the contrary, it confers a whole spectrum of benefits.

THE BENEFITS

The following are some of the principal benefits of right brain activity towards personal effectiveness of human resources:

1. Enhanced creativity and imagination

The right brain can be thought of being connected directly to the source of creativity, and the alpha state is hence more conducive to innovative thinking and generation of new ideas.

2. Problem-solving and trouble-shooting

With the mind in a more relaxed state and access to its immense creative resources, it is naturally better disposed to deal with crisis and solve problems constructively.

3. Less stress

The alpha state has a built-in fringe benefit in that it actually releases accumulated stress and tension from both body and mind. In our hectic lifestyles, this makes for more harmonious working conditions on both micro and macro levels, with resultant improved teamwork, drops in absenteeism, improved well being and other long-term benefits

4. Heightened intuition

Studies at Harvard revealed that the majority of presidents and managers of multi-national companies attributed up to 80% of their success to intuition. Intuition - the legendary hunches and gut feelings of the seasoned businessperson - can indeed be a very important element in business. Yet because it defies tangible description, intuition is hardly ever mentioned in conventional training programmes, with the exception of a few mind dynamics systems. Open-minded, right brain thinking is highly conducive to intuition, particularly in deep states of alpha.

5. Easier implementation of personal change

The quest towards personal effectiveness often involves effecting changes in disposition or attitude, enhancing constructive traits and eliminating unconstructive ones, as described earlier. The alpha state very much facilitates these processes. During powerful workshops that promote change, I often find it useful to induce states of alpha in order to catalyse new awareness at deeper subconscious levels of synthesis.

6. Enhanced study / learning abilities, and memory retention

Another important benefit of right brain patterns is that they greatly facilitate learning and study, as well as memory retention. This explains the effectiveness of accelerated learning methods.

7. Better rapport and negotiation skills

Establishing rapport with others during meetings and negotiations can mean the difference between agreement or non-agreement, deal or no deal. Even the most powerful NLP rapport skills work better if one has accessed a state of alpha. The subject can then be 'paced and led' to follow suit, creating a resonant state of mind which makes for better bilateral agreement.

8. Other mind skills

Possibly the most outstanding applications of right brain methodology lie in the use of specialised techniques which present new, often astonishing possibilities. Examples of applications are the gaining of new mental information, establishing non-localised rapport, boosting goal achievement through visualisation, solo brainstorming and mental 'market-testing' of concepts. These are some of the applications reportedly experienced around the world from ces users. The advantage of these CES TOOLS is, that they enable onewith practice to access a peak performance state at will, a state which is then gradually integrated into daily life.

You can encourage the Brain to peak performance

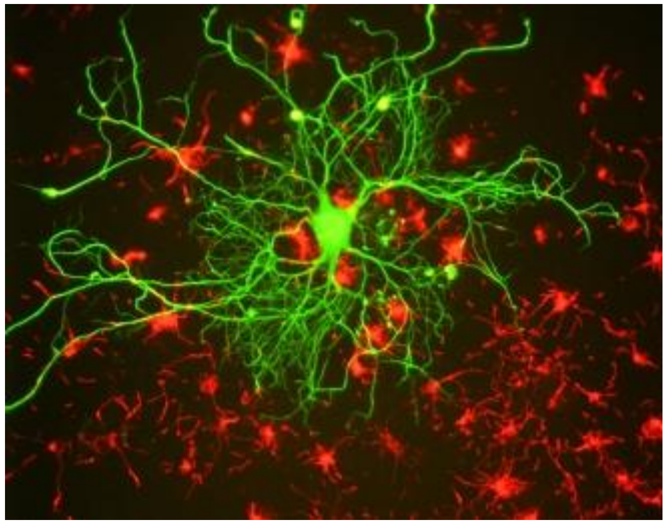
By far the best way of inducing right brain activity and high performance, is through specialised tools such as CES (Cranial electro stim) systems

CES (Cranial electro stim) has been shown to be particularly effective in Raising the right brain parameters over the left, by which it then can be accessed, at will, for various applications. Similar techniques are employed in the mental training programmes of athletes.

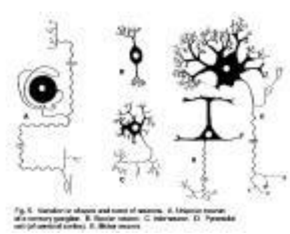
For both sports , business and Altered States of Consciousness, the objective is the same, to attain peak performance**.**

Stimulating the Brain and Mind

Human performance in all areas can be deliberately improved through environmental, biochemical, and psychophysiological manipulation of the brain and mind. One way this takes place is by using machines designed by researchers to stimulate the human neocortex through exposure to experiences which are changing, and challenging, and which provide the brain and mind an opportunity to exercise itself by means of self-observation and self-transformation.



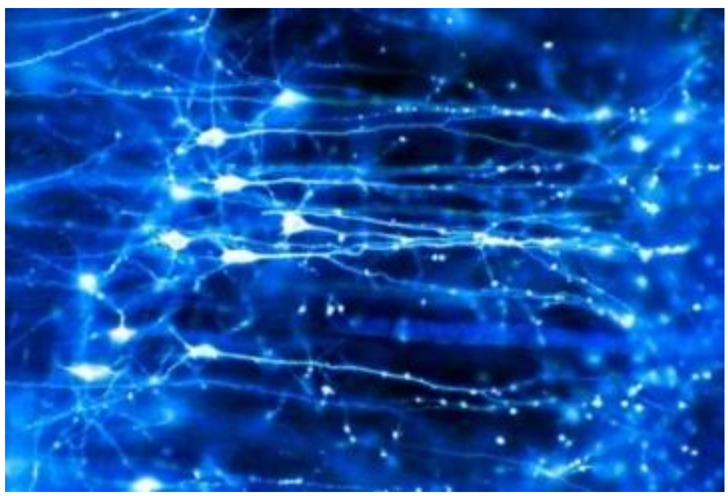
The brain is an electrically powered and electricity- generating organ. Composed of an estimated one hundred billion neurons, each neuron produces and transmits electrical impulses which travel from the cell body down long fibers called axons until they reach a junction, or synapse, with another neuron. At the junction point the electrical impulses fire chemical messengers, called neurotransmitters, across the synaptic gap to receptors on the next cell. Having received the message, that neuron then generates its own electrical impulse and sends it to other neurons to which it is connected. Each neuron can be connected to thousands of other neurons, each simultaneously sending and receiving impulses to and from thousands of other neurons--so one neuron can electrically alter millions of other neurons.



*An increase in neuron size, thicker cerebral size, and more neuron-neuron connection are all examples of the plasticity of the brain. In one study designed to show the effects of rats in a rich and stimulating environment, found that the rats brain weight increased by about **7-10% after 60 days, with synaptic connections increasing by about 20%** (4). It has also been experimentally shown that new and novel experiences increase the number of excitatory synapses per neuron and decreases the number of inhibitory ones in the visual cortex (4). The modification of the excitatory and inhibitory balance is a direct result of the plasticity factor in action. Also, the plasticity factor can increase or decrease* *the number of neurons depending on the richness or depravity of the experience. The neuronal increase was approximately 35-40% more neurons in the olfactory region (4). During human development, connections are being built at the speed of about 3 billion a second, reaching 1,000 trillion connections in the whole brain. All of these many neurons, connections, and maintenance thereof do not exist to remain dormant.*

PaShawnda Briley

To get an idea of how complex this electrical system is, the National Academy of Sciences estimates that "a single human brain has a greater number of possible connections among its nerve cells than the total number of atomic particles in the universe."



The OLD View

Humans lose approximately 100,000 neurons each day after age 30 and the cortex loses about 30% of its neurons between adulthood and age 90

But GOOD News

The longstanding belief that the adult brains do not produce new neurons is being challenged by current research. Adults may indeed be able to generate new neurons, in a process called neurogenesis, throughout life and at the rate of thousands per day.

Recent advances by two neuroscientists, Fred H. Gage of the Salk Institute in San Diego and Peter S. Eriksson of the Göteborg University Institute of Clinical Neuroscience, indicate that the old belief
(they've always believed that the more complex and highly evolved human brain, after reaching maturity, cannot produce new neurons)
is wrong. Gage and Eriksson collected the first convincing evidence that the brains of adult humans, even elderly people, regularly regenerate neurons in the hippocampus. Why is the hippocampus of interest? It appears to control which experiences are filed away into long-term memory and which pass into oblivion. It is not only where memories are stored, but it also controls which bits of information become memories. Simply put, it is the control panel for learning.

A 1997 study revealed that adult mice in enriched living conditions grew

60% more neurons than did genetically identical control animals, and they did better on a learning tasks. These results held even for elderly mice, which typically produce new neurons at a much lower rate than younger mice

In addition to environmental enrichment, animal studies in the last several years have identified other factors that influence neurogenesis. Stress has shown signs of being an inhibitor, while exercise tends to increase new nerve cell production. However, these links are still being investigated and are quite preliminary. The truth is that there are many steps to neurogenesis, and there are multiple factors that affect it at any stage of the game.
http://www.linezine.com/3.3/themes/bgsbftad.htm

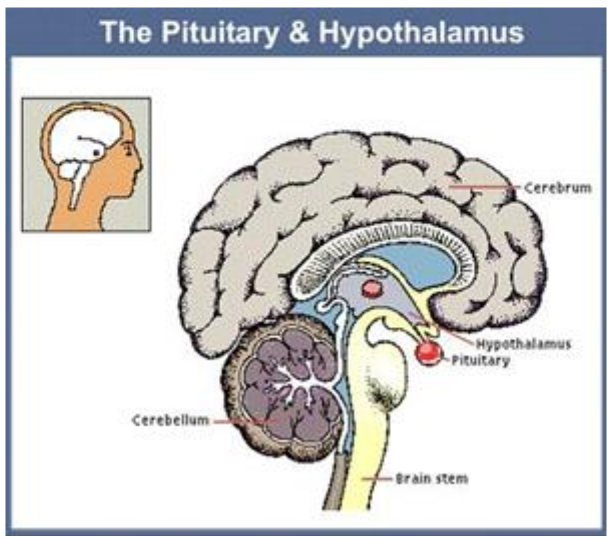
Can CES (Cranial electro stim)Help produce Altered states

CES (Cranial electro stim) use intense programs of pulsed frequencies in multi-sensory stimuli to encourage the brain to grow new neural pathways. It is also likely that they encourages the growth of new neurons and to have these neurons migrate to the parts of the brain where they are most needed for overcoming the conditions commonly known as Attention Deficit Disorder, dyslexia ,memory and other cognitive issues.

Out of body experiences

Electronic Meditation is Amazing

*HGH: As we get older, decreasing quantities of HGH results in many aging symptoms including loss of muscle tone, increased weight gain, loss of stamina, sagging skin and muscles, wrinkled skin that lacks good tone and texture and flagging memory and many diseases associated with aging. HGH is produced naturally by the pituitary gland in the center of our brain.



Conclusions: Both 0.5 and 100 Hz CES provide frequency distribution shifts that suggest beneficial changes in mental state. However, compared to 0.5 Hz CES, 100 Hz CES effected a greater overall change. [Source]

When we are in deep, meditative state in the delta level the pituitary is stimulated to produce more HGH which is why we feel refreshed and replensished when we get a good nights sleep. The anti-aging properties of deep meditation come from the release of HGH when reaching the delta level during meditation.

Frequencies
4.5 Hz Deep Shamanic Experience
7.83Hz Meditation,Deeply relaxed focased awareness

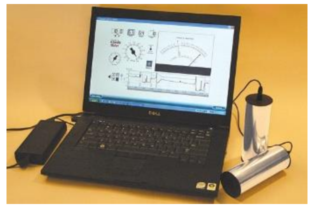
Biofeedback

Biofeedback is the use of mechanical means to amplify certain internal cues, make us aware of them, and make it possible to control mental and brain states. Extensive research has shown that what were thought to be "involuntary" psychophysiological states, such as blood pressure, body temperature, etc., are in fact controllable through the use of biofeedback.

"Biofeedback means getting immediate ongoing infomation about one's own biological processes or conditions, such as heart behavior, temperature, brain-wave activity, blood pressure, or muscle tension. Information is usually fed back by a meter, by a light or sound, or subjects simply watch the physiological record as it emerges from the monitoring equipment. Biofeedback training means using the information to change and control voluntarily the specific process or response being monitored."
Elmer Green, Beyond Biofeedback

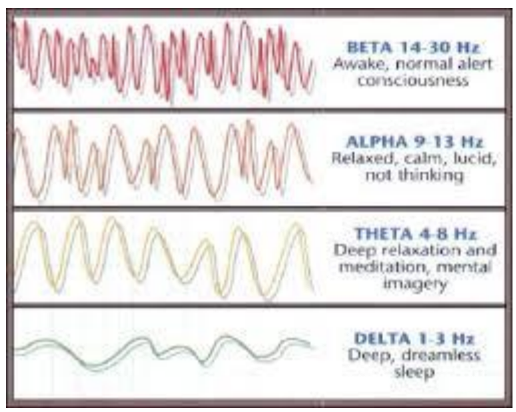
One of the early researchers, Elmer Green of the Menninger Clinic in Kansas, used biofeedback instruments to study Eastern yogis. He discovered that certain yogis could control their internal states merely through meditation and thought.

Maurice "Barry" Sterman, a professor emeritus in the departments of Neurobiology and Psychiatry at UCLA, began an experiment in 1965 on brain wave states in cats. He accidentally discovered a specific EEG rhythm state during which the cat, waiting for a reward of food, became absolutely still, though extremely alert. Sterman named this frequency "sensorimotor rhythm" (SMR). He isolated the 12 to 15 hertz frequencies (SMR) in the EEG of the experimental cats and operantly conditioned them to create this state. Sterman then worked with a human subject, a young lady who suffered from epileptic seizures two or more times per month. Epilepsy is accompanied by an invasion of unwanted theta wave frequency in the brain. The subject was connected to the EEG equipment and was tasked with keeping a green light on (presence of SMR) and a red light off (presence of theta waves). The subject was able to create SMR for long periods and her seizures reduced in number and intensity. She remained seizure-free after the experiment for a number of months**.**



"Occassionally I had heard half-joking remarks about researchers in biofeedback sounding like snake-oil salesmen. It didn't bother me until one of our own doctors cautioned against the concept of biofeedback as a panacea. Then I gave it serious thought. Why did biofeedback prove helpful in the treatment of so many and varied disorders? **Suddenly I realized that it isn't biofeedback that is the 'panacea'--it is the power within the human being to self-regulate, self-heal, re-balance.** Biofeedback does nothing to the person; it is a tool for releasing that potential." Alyce Green, Beyond Biofeedback

Brain Waves



In our ordinary waking state, we primarily experience beta brain waves (which vibrate at a frequency ranging from about 13 to 30 hertz or cycles per second). During deep relaxation, we move to alpha waves (8-13 Hz) and we ordinarily only experience theta waves (4-7 Hz) in those brief moments between waking and sleeping. The ultraslow delta waves (0.5-4 Hz) occur during sleep.

Scientists have found that when meditators reach a state of deep awareness and internal mental serenity the two hemispheres of their brain--which ordinarily generate brain waves of different frequencies and amplitudes--become synchronized, both hemispheres generating the same brain waves.

Higher States

Dr. Gerald Oster, a biophysicist at Mount Sinai School of Medicine in New York City discovered that pulsations called binaural beats occurred in the brain when tones of different frequency were presented separately to each ear.

> *We have a finely woven, intricate interrelationship of brainwavefrequencies that delicately determines our state of consciousness.Being able to intentionally alter this combination of brainwavefrequencies is an intrinsic part of developing the self-mastery that leads to a high-performance mind - one that can enter thestate of consciousness that is most beneficial or desirable for any given circumstance.*
> *Anna Wise*

Robert Monroe developed tapes which send signals separately to each ear--signals of 400 and 404 hertz, for example--resulting in the sounds blending inside the brain and setting up a binaural beat frequency of 4 Hz (theta waves), producing a state of brain hemisphere equilibrium and altered states.

The optimum brainwave pattern

The optimum brainwave pattern for creativity, healing, insight and all forms of high performance combines the intuitive, empathetic radar of delta waves, the creative inspiration, personal insight, and spiritual awareness of theta waves, the bridging capacity and relaxed, detached, awareness of alpha waves, and the external attention and ability to consciously process thought of beta waves, all at the same time. Originally discovered in yogis, swamis and those in higher states of consciousness by C. Maxwell Cade, this awakened mind pattern can also be found during the "ah-ha" experience and all forms of peak performance, regardless of activity, content, intention, philosophy or theology.

> ***"One of the most basic human experiences, one that is genuinely universal and unites -- or, more precisely, could unite -- all of humanity, is the experience of transcendence in the broadest sense of the word." -- Václav Havel, President, Czech Republic***

Altered states of Consciousness

Altered states of consciousness generally include alterations in both the content and functioning of the consciousness, usually experienced by an individual and somtimes observed by others watching him. The term "state" is not to be trivialized but denotes the states or stages of behavior through which the individual progresses. Frequently persons in these states appear to be in a sleeplike condition commonly referred to as a trance.

Among the long term effects are the radical shifts in the perception in one's self and environment that result in a semi-permanent redefinition of one's self, world, and values. Frequently altered states of consciousness either are induced personally or by others which may or may not produce lasting effects. Some religious groups do seek to induce such altered states in persons so they may derive spiritual insight and value changes from them. The most dramatic examples of these states are mystical experiences.

The experience of being united with God or nature is called a mystical experience. Such experiences may be of a religious or nonreligious nature. The nonreligious experiences derive much of their content from nature; although many religious mystics have been lead to God or the Absolute through nature. However, not all transcendental experiences with nature are mystical, but just render feelings of overwhelming joy or ecstasy.

Causes other than religious beliefs, such as illnesses and accidents, can result in altered states of consciousness or mystical experiences.

Emanuel Swedenborg (1688-1772)

Emanuel Swedenborg (1688-1772), the Swedish scientist and scholar, also claimed to have experienced mystical experiences in the form of dreams. These episodes began at the age of fifty-six. In these dreams he traveled to spiritual planes such as heaven and hell where he claimed to have spoken with Jesus, and God, and spirits of the dead which he referred to as angels. Also, he claimed to have seen the order of the universe. He continued spending most of the remainder of his life taking these spiritual journeys usually in a light sleep or trance which sometimes lasted as long as three days. As a result of these trips his spiritual views differed greatly from orthodox Christianity. His views were published in several books.

Edgar Cayce (1877-1945)

Edgar Cayce (1877-1945) sometimes called the "sleeping prophet" gave prophetic, healing, and karmic readings in a light-sleep state similar to that of Swedenborg. Cayce put himself into a hypnotic trance while lying down and then gave personal readings. He helped heal many persons this way by describing their ailments and then prescribing what the person should do in the form of treatment. He gave many karmic readings telling about the lost continent of Atlantis and other ancient places. Frequently when giving solitary readings Cayce would have the person taking down his reading tap him to prevent him from going into a deeper sleep.

> *"These ideas have been created by the poets. But the truth is, you can call it empty mind or you can call it empty heart; it is the same. Emptiness – you are just a watcher and all around there is nothing with which you are identified, there is nothing to which you are clinging. This non-clinging watchfulness is the empty mind, no-mind, or empty heart. These are simply words. The real thing is emptiness – of all thoughts, feelings, sentiments, emotions. Only a single point of witnessing remains."*
>
> *Osho*

Shamanism

Also within shamanism altered states of consciousness are employed. They are often self-induced by the shaman and called the shamanic state of consciousness. This is a state can vary from a light sleep to a coma which enables the shaman to see and do things in a nonordinary reality which he cannot do in the ordinary reality of a waking state. It is in this nonordinary reality the shaman can perform cures with the help of guardian spirits and spirit helpers and do shape shifting

Shamanic Frequency 4.5 hz

Samadhi Resonance 7.82

"Nothing in current science can account for consciousness, yet consciousness is the one thing we cannot deny. The exploration of this final frontier has now become imperative. It is clear that most of the problems we face today — global, social, and personal — stem from human thinking, perception, and values. The crisis is, at its roots, a crisis of consciousness. Now, more than ever, we need to understand our own minds, and how to liberate ourselves from the limiting egocentric modes of thinking so that we can achieve our true inner potential." ~Peter Russell

The awakened mind brainwave pattern combines the intuitive,empathetic radar of the delta waves, the creative inspiration, personal insight, and spiritual awareness of the theta waves, the bridging capacity and relaxed, detached, awareness of the alphawaves, and the external attention and ability to consciously process thought of beta waves, all at the same time. This brainwave pattern can be found during "peak experience" or "peak performance", regardless of the content or intention, in all forms of creativity and high performance. The awakened mind is also the"ah-ha", appearing at the exact instant of solving the problem, or getting the insight**.**

> *I have no doubt whatever that most people live, whether physically, intellectually, or morally, in a very restricted circle of their potential being . . . the so-called "normal man" of commerce, so to speak, the healthy Philistine, is a mere extract from the potentially realizable individual he represents, and we all have reservoirs of life to draw upon of which we do not dream. (O'Brien, 1964, p. 155)*

Enlightenment or the Fully Awakened mind has been given many names. Buddha means "the enlightened one;" Christ and Messiah also mean that. St. Paul called it "the peace of God that passeth under-standing" and Richard Maurice Bucke named it "cosmic consciousness." In Zen it is satori, in yoga it is samadhi or moksha, in Sufism it is fana, in Taoism it is wu or The Ultimate Tao. Jurdjieff labeled it "objective consciousness," Sri Aurobindo spoke of the Supermind, mystery schools and occult paths speak of "illumination," "liberation," and "self-realization." Likewise, enlightenment has been symbolized by many images; the thousand-petaled lotus of

Hinduism, the Holy Grail of Christianity, the clear mirror of Buddhism, Judaism's Star of David, the yin-yang circle of Taoism, the mountaintop, the swan, the still lake, the mystic rose, the eternal flame. (p. xvi)

The perennial belief in the existence of an uninterrupted intuition of Oneness is rooted in the recurring notion that humankind is uniquely situated to simultaneously experience the finite and the infinite

It has been called a sacred
hunger,
the quest for truth, the longing for
God,
the search for fulfillment.
In the space between two thoughts.
An inexplicable occurrence of
perfect
peace in the depths of Chaos

Can CES help!

CES systems **like the BTPRO use VERY GENTLE ELETRO PULSES CES (frequencies)to encourage Hemispheric balancing.**

It has been estimated that the average person has sixty thousand separate thoughts each and every day. The problem with this is that we have the same sixty thousand thoughts today that we had yesterday, and we'll repeat them again tomorrow. Our minds are filled with the same chatter day in and day out. Learning to be quiet and meditate involves figuring out a way to enter the spaces between your thoughts; or the gap, as I call it. In this silent empty space between your thoughts, you can find a sense of total peace' in a realm that is ordinarily unknowable. Here, any illusion of your separateness is shattered. However, if you have sixty thousand separate thoughts in a day, there is literally no time available to enter the space between your thoughts, because there is no space!

Most of us have minds that race full-speed day and night. Our thoughts are a hodgepodge of continuous dialogue about schedules, money worries, sexual fantasies, grocery lists, drapery problems, concern about the children, vacation plans, and on and on like a merry-go-round that never stops. Those sixty thousand thoughts are usually about ordinary daily activities and create a mental pattern that leaves no space for silence.

The mind is like a pond. On the surface you see all the disturbances, yet the surface is only a fraction of the pond. It is in the depth below the surface, where there is stillness, that you will come to know the true essence of the pond, as well as your own mind.

By going below the surface, you come to the spaces between thoughts, where you are able to enter the gap. The gap is total emptiness or silence, and it is indivisible. No matter how many times you cut silence in half, you still get silence. This is what is meant by now. Perhaps it is the essence of God, that which cannot be divided from the oneness.

CES Systems have helped many experience this space, this gap.

Silence is in the heart of all things. We cannot hear silence, we become silence. To become silence, we have to find our way through the narrow gap between two thoughts. Silence also begins in that place where the breath, as it enters us, comes to rest, and from where the breath, as it leaves us, comes from.
Innerpulse with breath pacing

There, in the space between two thoughts, the trough of the brainwave, the pause between exhalation and inhalation, is the true altered state: the presence of the peace-bestowing, ever tranquil, ever fertile void.

"Man has his future within him dynamically alive at this present moment".
Abraham Maslow, Psychologist

Credit: Pixabay/CC0 Public Domain© Provided by Phys.org

The progress of science in the last 400 years is mind blowing. Who would have thought we'd be able to trace the history of our universe to its origins 14 billion years ago? Science has increased the length and the quality of our lives, and the technology that is commonplace in the modern world would have seemed like magic to our ancestors.

For all of these reasons and more, science is rightly celebrated and revered. However, a healthy pro-science attitude is not the same thing as "scientism," which is the view that the scientific method is the only way to establish truth. As the problem of consciousness is revealing, there may be a limit to what we can learn through science alone.

Perhaps the most worked out form of scientism was the early 20th-century movement known as logical positivism. The logical positivists signed up to the "verification principle," according to which a sentence whose truth can't be tested through observation and experiments was either logically trivial or meaningless gibberish. With this weapon, they hoped to dismiss all metaphysical questions as not merely false but nonsense.

These days, logical positivism is almost universally rejected by philosophers. For one thing, logical positivism is self-defeating, as the verification principle itself cannot be scientifically tested, and so can be true only if it's meaningless. Indeed, something like this problem haunts all unqualified forms of scientism. There is no scientific experiment we could do to prove that scientism is true; and hence if scientism is true, then its truth cannot be established.

Related video: What is Quantum Mechanics? (Dailymotion)

In spite of all of these deep problems, much of society assumes scientism to be true. Most people in the UK are totally unaware that "metaphysics" goes on in almost every philosophy department in the country. By metaphysics, philosophers don't mean anything spooky or supernatural; this is just the technical term for philosophical, as opposed to scientific, enquiry into the nature of reality.

Truth without science

How is it possible to find out about reality without doing science? The distinguishing feature of philosophical theories is that they are "empirically equivalent," which means you can't decide between them with an experiment.

Take the example of my area of research: the philosophy of consciousness. Some philosophers think that consciousness emerges from physical processes in the brain—this is the "physicalist" position. Others think it's the other way around:

consciousness is primary, and the physical world emerges from consciousness. A version of this is the "panpsychist" view that consciousness goes all the way down to the fundamental building blocks of reality, with the word deriving from the two Greek words pan (all) and psyche (soul or mind).

Still others think that both consciousness and the physical world are fundamental but radically different—this is the view of the "dualist." Crucially, you can't distinguish between these views with an experiment, because, for any scientific data, each of the views will interpret that data in their own terms.

For example, suppose we discover scientifically that a certain form of brain activity is correlated with the conscious experience of an organism. The physicalist will interpret this as the form of organization which turns non-conscious physical processes—such as electrical signals between brain cells—into conscious experience, whereas the panpsychist will interpret it as the form of organization which unifies individual conscious particles into one larger conscious system. Thus we find two very different philosophical interpretations of the same scientific data.

If we can't work out which view is right with an experiment, how can we choose between them? In fact, the selection process is not so dissimilar from what we find in science. As well as appealing to experimental data, scientists also appeal to the theoretical virtues of a theory, for example how simple, elegant and unified it is.

Philosophers too can appeal to theoretical virtues in justifying their favored position. For example, considerations of simplicity seems to count against the dualist theory of consciousness, which is less simple than its rivals in so far as it posits two kinds of fundamental stuff—physical stuff and consciousness—whereas physicalism and panpsychism are equally simple in positing just one kind of fundamental stuff (either physical stuff or consciousness).

It could also be that some theories are incoherent, but in subtle ways that require careful analysis to uncover. For example, I have argued that physicalist views of consciousness are incoherent (although—like much in philosophy—this is controversial).

There is no guarantee that these methods will yield a clear a winner. It could be that on certain philosophical issues, there are multiple, coherent, and equally simple rival theories, in which case we should be agnostic about which is correct. This would in itself be a significant philosophical finding concerning the limits of human knowledge.

Philosophy can be frustrating because there is so much disagreement. However, this is also true in many areas of science, such as history or economics. And there are some questions on which there is a modest consensus, for example, on the topic of free will.

A tendency to mix up philosophy with a growing anti-science movement undermines the united front against the real and harmful opposition to science we find in climate change denial and anti-vax conspiracies.

Like it or not, we can't avoid philosophy. When we try to do so, all that happens is we end up with bad philosophy. The first line of Stephen Hawking and Leonard Mlodinow's book "The Grand Design" boldly declared: "Philosophy is dead." The book then went on to indulge in some incredibly crude philosophical discussions of free will and objectivity.

If I wrote a book making controversial pronouncements on particle physics, it'd be rightly ridiculed, as I haven't been trained in the relevant skills, haven't read the literature, and haven't had my views in this area subject to peer scrutiny. And yet there are many examples of scientists lacking any philosophical training publishing very poor books on philosophical topics without it impacting their credibility.

This might be sounding bitter. But I genuinely believe society would be deeply enriched by becoming more informed about philosophy. I have hope that we will one day move on from this "scientistic" period of history, and understand the crucial role both science and philosophy have to play in the noble project of finding out what reality is like.

- For the past 30 years, scientists have investigated whether the human brain might require quantum processes to achieve cognition.

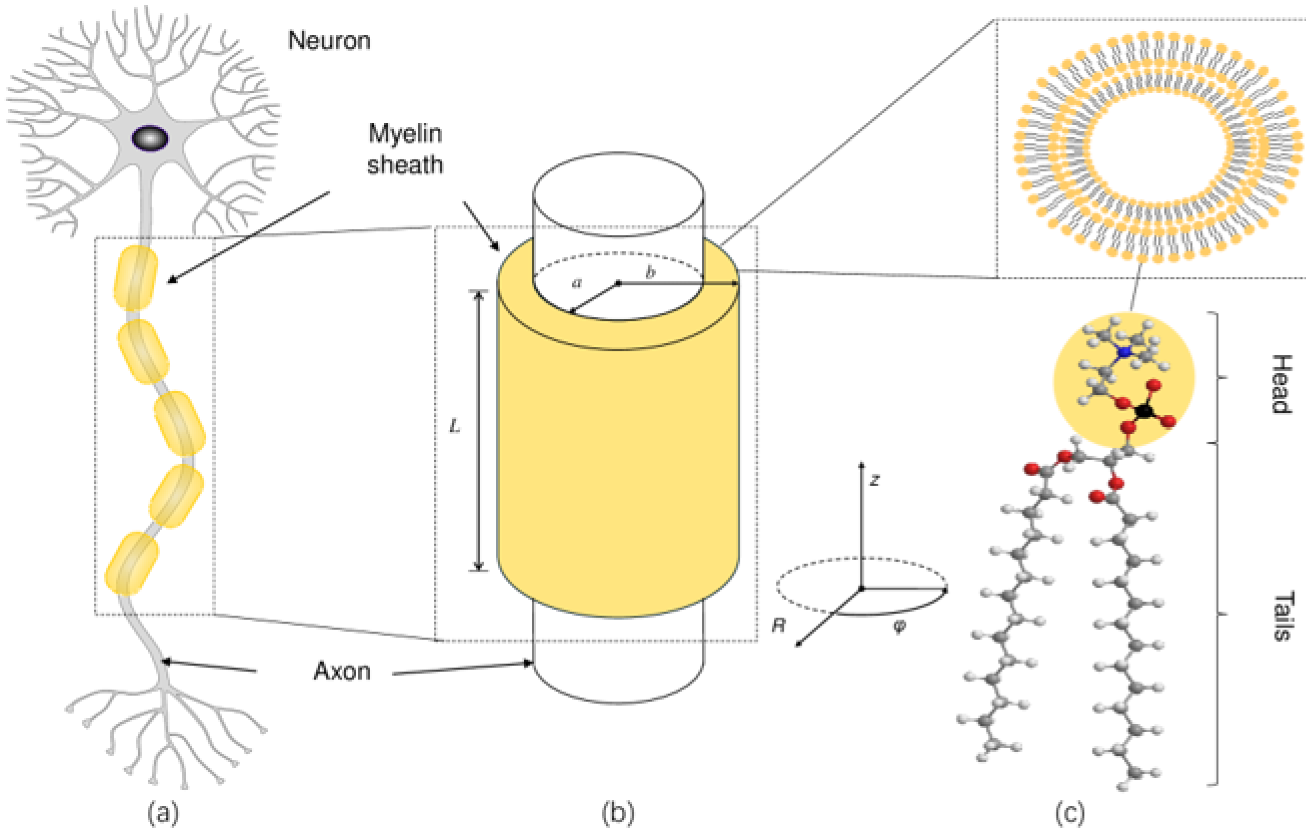
- A new study from Shanghai University uses mathematical models to suggest that certain fatty structures (which sheath the nerve cell's axon) could potentially produce quantum entangled biphoton pairs, potentially aiding in synchronization across neurons.
- However, scientists have long argued that the brain is too hot and messy for this type of phenomenon to occur, and detecting this phenomenon as it occurs in the brain would be an incredibly difficult task.

It has long been argued that the human brain is similar to a computer. But in reality, that's selling the brain pretty short. While comparing neurons and transistors is a convenient metaphor (and not *completely* out of left field), the brain is ultra-efficient, its energy is renewable, and it's capable of computational feats that even the most advanced computer can't pull off. In many ways, the inner workings of the human brain make up an unknown computational frontier.

Although your brain is superior to your laptop—or even the world's most advanced supercomputer—these machines run on classical physics. But there's another kind of a computer out there: a quantum one.

The idea that the human brain contains quantum properties isn't new. In fact, the British physicist Roger Penrose and the American anesthesiologist Stuart Hameroff first suggested the controversial concept back in the 90s, with their "orchestrated objective reduction" model of a consciousness. Since then, many pieces of evidence have at least hinted that, while the brain may not be a full-fledged quantum computer, some quantum properties may in fact help generate consciousness.

Now, a new study from Shanghai University submits yet another piece of evidence to the neurological court—that one particular process of the human brain exhibits behavior akin to quantum entanglement, a phenomenon when two particles (usually photons) become inextricably linked even across vast distances. This phenomenon confounded even the most brilliant of minds, including Albert Einstein, who called quantum entanglement "spooky action at a distance."



A closer look at myelin cylinders and its location along the neuron's axon.© Liu et al., Physical Review E, 2024

The study, published this month in the journal *Physics Review E*, suggests that a fatty material called myelin that surrounding the nerve cell's axon—the fiber that transmits electrical impulses to other nerves or body tissues—provides an environment in which the entanglement of photons is possible. This could potentially explain the rise of cognition, and especially synchronization, which is essential for information processing and rapid response.

"Consciousness within the brain hinges on the synchronized activities of millions of neurons, but the mechanism responsible for orchestrating such synchronization remains elusive," the paper reads. "The results indicate that the cylindrical cavity formed by a myelin sheath can facilitate spontaneous photon emission from the vibrational modes and generate a significant number of entangled photon pairs."

The team built mathematical models detailing how infrared photons could impact the myelin sheath and impart energy to chemical bonds—specifically, carbon-hydrogen bonds embedded in this fatty tissue. This, in turn, could spur biphoton generation with many pairs exhibiting entanglement, and serve as a type of "quantum communication resource" within the nervous system.

"When a brain is active, millions of neurons fire simultaneously," Yong-Cong Chen, a co-author of the study, told *New Scientist*. "If the power of evolution was looking for handy action over a distance, quantum entanglement would be [an] ideal candidate for this role."

If you're sensing some "woah, if true" quality to this research, you're not alone. For one, this phenomenon would need to be seen in a biological setting (likely in the brain of a mouse) before scientists get too excited about the brain's newfound "quantum communication resource." And that's a process that the authors readily admit would be difficult. Additionally, the idea of quantum entanglement playing a role in consciousness isn't a mainstream one—Hameroff, one the leading minds behind the idea that quantum phenomena could drive aspects of cognition, even told *New Scientist* months ago that "it was very popular to bash us" after the publication of their consciousness model.

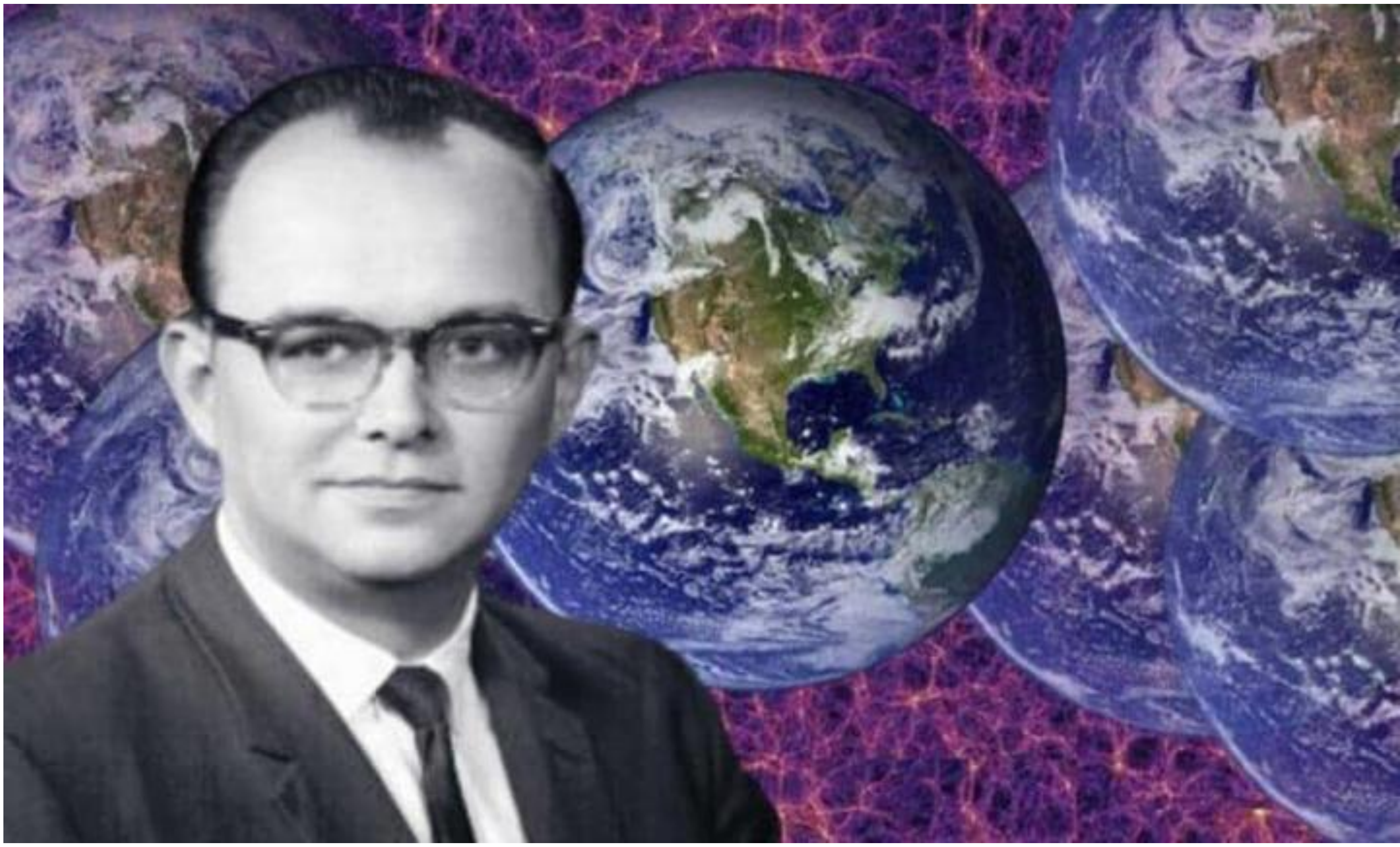
But science is in the business of hypothesis and rigorous testing to discern the true nature of existence. And, as history has shown, what once seemed liked "spooky action a distance" can quickly become the cornerstone of the quantum world.

Hugh Everett III is famous as the man who devised the many-worlds interpretation of quantum physics.

Everett's theory concerns a mysterious puzzle that lies at the heart of quantum physics and suggests that measurement causes the universe to branch out into infinite different versions, all with the tiniest of differences. This may sound like pure science fiction, but the idea is supported by the mathematics of quantum mechanics.

The rejection of the concept would lead Everett to leave physics to pursue mathematics in the military and industry. A heavy drinker and smoker, he passed away at just 51 years of age.

Despite the fact it is not the consensus, many physicists still prefer the many-worlds interpretation of quantum physics over alternatives. Everett would not live to see the respect earned by his fellow physicists for the idea of "many worlds" or the incredible success that the idea would have in popular fiction.



Hugh Everett III whose many-worlds interpretation of quantum physics inspired physics and writers of science fiction alike for decades. (Robert Lea)© ZME Science

Everett's Journey Into Physics

Everett was born in 1930 and was raised around Washington D.C. initially by his mother, and then later by his father Hugh Everett Jr, and his stepmother. He attended St. John's College High School before moving to the Catholic University of America graduating in 1953 with a degree in chemical engineering.

After Everett received a National Science Foundation fellowship, the budding mathematician continued his studies at Princeton. It was here in 1953 that Everett took his first introductory course in quantum mechanics.

In a 2007 article for *Scientific American*, Peter Bryne says that Everett's journey to many worlds was kick-started in 1954 as he drank sherry with Charles Misner, a fellow Princeton student. The two began to discuss the counter-intuitive nature of quantum physics, and the young physicist began to consider the idea of many worlds as a solution to a lingering problem.

What is the Many Worlds Interpretation of Quantum Physics?

Ever since the inception of quantum physics in the 1920s, the so-called collapse of superposition–when a quantum system can be described as existing in potentially contradictory states–has troubled researchers.

The states of a system describe the possible values it can take. So if a coin is considered a physical system it can take two states–heads or tails.

In quantum physics, these states are described by wave mathematics. Because waves can overlap in what is known as a wavefunction, it means that a quantum system can theoretically exist in a superposition of multiple states simultaneously.

This affects subatomic particles like electrons and photons and describes qualities such as their velocity or spin. It isn't seen on a macroscopic or "everyday" scale. But, a macroscopic hypothetical example is perhaps the easiest way to think about it.

A good way of picturing this is with Erwin Schrödinger's infamous Schrödinger's cat thought experiment. This sees a cat placed in a box with a diabolical device–a lethal poison that is released only if an atom within the device decays.

The box is sealed for an hour, enough time for the atom to possibly decay. But, because atomic decay is a quantum process, and thus completely random, there is no way to tell if the poison has been released.

This means that, if we treat the cat, box, and device as a quantum system it is possible to describe it as a superposition of states. And in this case, those states are "dead" and "alive."

Its contradictory state is only resolved when the experimenter opens the bow–analogous to taking a measurement on the system. This causes the superposition to collapse–a process also called decoherence–and resolve into a single state.

But, quite what it is about measurement that causes this collapse has remained a mystery. This would come to be known as the “measurement problem.”

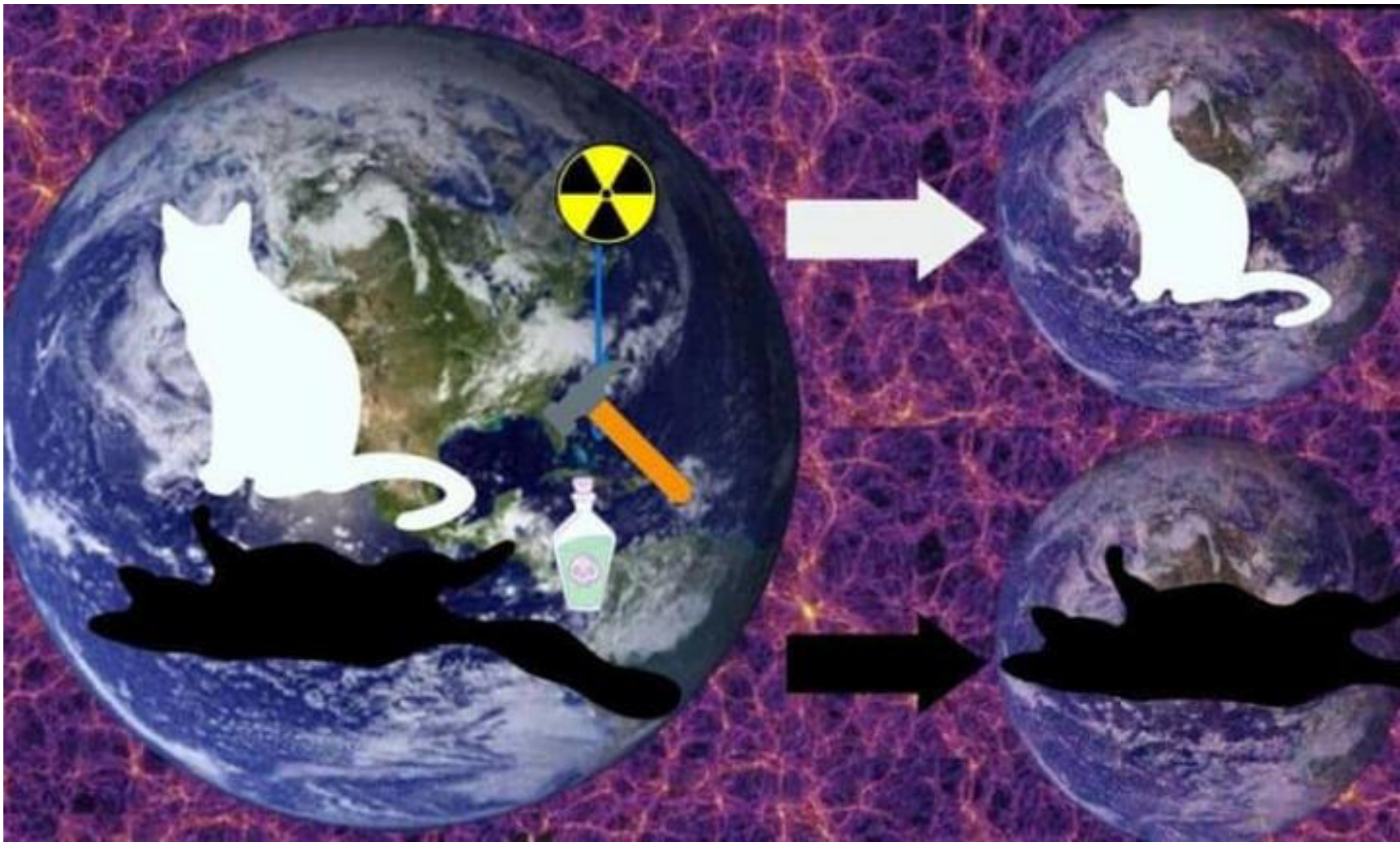
Everett’s suggestion of “many worlds” takes a very different approach. It posits the idea that the wavefunction doesn’t collapse at all.

Instead, when a measurement is made on a quantum system, the wavefunction grows to envelop the measurement equipment, the experimenter and eventually the entire Universe.

In effect, this means framing the many-worlds interpretation of quantum physics with the Schrödinger’s cat thought experiment there is no wavefunction collapse.

Each possible state of a quantum system exists in its own universe, separated from the rest.

“From the viewpoint of the theory, all elements of a superposition (all ‘branches’) are ‘actual,’ none any more ‘real’ than the rest,” Everett wrote in a thesis produced on the interpretation.


The many-worlds interpretation of quantum physics suggests that wavefunctions do not collapse at all but branch out and create a new universe for each possible state (Robert Lea)© ZME Science

Instead of opening the box and resolving a state in which the cat is dead or alive, the experimenter opens the box to discover if she is in a universe in which the cat survived or a universe in which it died. Thus, Everett solves the measurement problem by doing away with decoherence altogether.

There is of course a consequence to this. Quantum systems are not large systems like cats in boxes, they actually concern particles on a subatomic level. This means every particle interaction creates a nearly unfathomable amount of worlds.

Consider the act of flicking on a light for instance. To emit 60 Joules a second a light bulb must blast out about 1.8 x 10 photons per second.

Each of these photons would have billions of possible paths, each of which would have its own universe. Just considering the possible combinations in this situation suggests an unfathomably large number of worlds born in this one very mundane act.

Considering every possible quantum event in the Universe this quickly swells the number of created worlds to something approaching infinity. This is troubling to physicists and is perhaps the reason the many-worlds concept has never trumped the wavefunction collapse idea of quantum physics suggested by the widely accepted Copenhagen interpretation.

Indeed, when released in 1957, Everett's paper on the many-worlds interpretation was met with almost complete indifference from the physics community.

Early quantum theorist and Everett's academic adviser at Princeton John Wheeler had many discussions with the physicist about his theory. In a 2006 interview, Wheeler remarked: "[Everett] was disappointed, perhaps bitter, at the nonreaction to his theory. How I wish that I had kept up the sessions with Everett. The questions that he brought up were important."

Everett would meet with Niels Bohr, another prominent quantum physicist in 1959 several times over a period of six weeks. He would also perfect a technique to search for optimum solutions to complex problems–the Everett algorithm. But, despite this, Everett was done with quantum physics research for good.

He didn't even return to research in the 1970s when his concept finally began to gain traction. This doesn't mean Everett rested on his laurels, however.

After Many Worlds

Hugh Everett framed by a nuclear explosion. After leaving quantum physics research Everett's work on the effects of nuclear weapons may have ensured pre-emptive strikes were not an option. (Robert Lea)© ZME Science

Everett would earn his doctorate from Princeton in 1957, a year after he had begun to work for the Pentagon. This employment saw him conduct important work such as the calculation of mortality rates that could potentially arise as a consequence of radioactive fallout resulting from a nuclear war.

He would advise officials in both the Eisenhower and Kennedy administrations regarding the selection of hydrogen bomb targets and the development of delivering a nuclear strike via missiles, submarines and planes.

Everett's work and its terrifying implications may well have persuaded world leaders that a nuclear war would result in "mutually assured destruction." Perhaps it even swayed officials who were considering preemptive strikes an option, that instead, a perpetual stand-off was a preferable approach to nuclear conflict.

Everett would go on to found several companies, including, in 1964, Lambda Corporation, which developed mathematical models for anti-ballistic missile systems and nuclear wargames.

In 1971 he devised a Bayesian computer program capable of learning from experience to assess possible outcomes which would be used to develop strategies for tracking incoming ballistic missiles.

As the years progressed, Everett's heavy drinking and smoking began to take their toll. He was an unsympathetic character to colleagues, one of whom later recalled that Everett was cold and logical but had no time for human concepts like civil rights.

Most damningly perhaps, was the fact that Everett barely knew his children Elizabeth and Mark. As a teenager, the latter would find Everett dead in his bed on July 19, 1982, at the age of 51.

Mark, who would go on to become the lead singer for the band the Eels, believes that the discovery of his father's lifeless body was the first time he had touched him.

Everett's daughter, Elizabeth, would go on to take her own life in 1996. After her death as the result of an overdose, a note was discovered in her purse which said she had gone to join her father in another universe.

Many Worlds in Popular Culture

It isn't just physicists that have embraced the idea of many worlds. Storytellers across a range of mediums have adopted the concept as a powerful storytelling device.

At the end of 2021, *Spider-Man: No Way Home* would use the many-worlds idea–albeit labelling it as a "multiverse" which is quite a different concept in science–to allow Tom Holland's Peter Parker to meet previous incumbents of the role, Tobey Maguire and Andrew Garfield, and team up to tackle some familiar villains.

The film would go on to become the fifth highest-grossing film of all time and its themes have been given a horrific twist in the Sam Raimi-directed *Doctor Strange in the Multiverse of Madness* earlier this year.

Also on the silver screen this year, many-worlds was given an irreverent twist in the Michelle Yeoh starring *Everything Everywhere All at Once*. In the movie, an unlikely action hero accesses the skills of her counterparts from alternative universes to combat a multiversal foe with familial connections.

No medium of fiction has embraced the concept of many worlds quite as wholeheartedly as comic books, however. Veteran comic book writer Mark Waid who has written characters for DC Comics and Marvel including the *Justice League*, *Spider-Man*, *The Avengers,* and *The Flash*, explained to *ZME Science* why comic book fans have fallen in love with the idea of "many worlds."

"They provide new ideas. After eighty years of stories largely featuring the same heroes, it's insanely difficult to find ideas that have not been done before," Waid says. "There have been, and this is true, more stories told about Batman than about any other fictional hero in human history. Multiverse versions of Batman allow for new, fresh stories."

One of the original concepts of many worlds in comics came about in 1961 in the pages of the DC Comics published Flash issue 123 in which Barry Allen vibrated from his own world–Earth 1–to one in which his predecessor Jay Garrick still operated as the Flash. Jay's world was dismissively labelled "Earth-2."

This introduced to DC comics the concept of "infinite Earths" which would be popular throughout the 60s, 70s, and 80s, with meetings between the Justice League and their Earth-2 counterparts the Justice Society occurring every year. The characters were even able to journey to a world occupied by their writers in which they were simply comic book characters.

This was until 1986 and an event called "Crisis on Infinite Earths" by Marv Wolfman and George Perez, which rolled all these Earths into one. In the early 2000s, Waid who currently writes Superman/Batman: World's Finest for DC Comics was part of a move to bring back "infinite Earths" albeit under a new moniker–Hypertime.

“From Crisis on Infinite Earths on through the 1990s, every single DC ‘event’ story made the DC Universe smaller by creating more restrictions and rules. No more parallel worlds. No more easy time travel. Everyone’s superpowers had the same origins. Stuff like this. And it made me nuts,” Waid explains. “Superhero comics aren’t about rules, they’re about flying. Hypertime was an attempt to open some doors rather than close them.

“I will always love DC’s Earth-One/Earth-Two dichotomy. Simple, easy to explain, DC’s ‘many worlds’ kicked off of the whole concept.”

In his 2010 biography of Hugh Everett III, Peter Byrne describes the physicist’s affection for science fiction. Byrne speculates that the idea of parallel worlds likely intrigued Everett long before he formalised his interpretation of quantum physics.

It’s a testament to Everett’s legacy that just as early sci-fi inspired real science, his scientific theory has inspired sci-fi tales for subsequent decades. Thus, millions of science fiction fans, cinema-goers, and comic book readers have thrilled at the concept pioneered by Everett, likely without even knowing his name.

This article originally appeared in 2022 and was republished with some small updates.

What are dreams?

Dreams combine verbal, visual, and emotional stimuli into a broken and nonsensical, yet entertaining storyline. Dreams can include people you know or people you’ve never met, as well as places you are familiar with or places you’ve never even heard of. Sometimes dreams are simply a recall of events throughout the day, while other times they reveal some of our deepest and darkest fears, secrets, and fantasies.

What happens in our brains when we dream?

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There are five sleep stages that occur while we sleep. Our brain activity gradually slows down during the first four stages until we experience delta brain waves, which are the slowest brain waves and part of the deepest level of sleep. After the fourth stage, we enter REM sleep where most dreaming occurs. During REM sleep cycle, our bodies are paralyzed until we leave it, to ensure we don't act out our dreams. We go through these stages several times and have more REM sleep as the night goes on.

Why can't we always remember dreams?

©Provided by AskThis

It is said that just five minutes after we wake up, we have already forgotten at least 50% of our dream's content. And just ten minutes later, we've forgotten 90%. There are many theories about why we have trouble remembering dreams, such as Freud's theory that we forget our dreams because they contain repressed thoughts and wishes that we don't care to remember. Other dream researchers simply believe that because humans tend to think ahead rather than backwards, we can't remember because other things get in the way and make it more difficult.

How do you control your dreams?

©Provided by AskThis

There is currently research being done in dream control, specifically in the areas of lucid dreaming and dream incubation. These are both learned methods that allow you to control the events that occur in your dreams, but both take a lot of training and practice in order to be successful. Read on for more information about these methods and how you can learn to control your own dreams.

What is lucid dreaming?

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Lucid dreaming is a method of dream control that occurs when you realize you are dreaming while you are still dreaming and are then able to control what happens in your dreams. Less than 20% of people in the United States are able to have lucid dreams once a month or more. There are many different techniques and approaches for learning how to have lucid dreams, but all take a great deal of training and practice to effectively accomplish. While lucid dreaming is generally just a cool concept, there are also practical applications for this practice as well, such as aiding in personal development, enhancing self-confidence, overcoming nightmares, and improving mental health.

What is dream incubation?

Less complex than lucid dreaming, dream incubation is a technique for controlling your dreams that involves learning to plant a seed for a specific dream topic to occur. If you believe that dreams aid in problem solving, this technique is useful for directing your dreams to include a specific problem that you are attempting to address.

What is sleep paralysis?

During hypnagogia, the transitional state from wakefulness to sleep, many mental phenomena can occur during this time, including sleep paralysis. This causes a person to temporarily be unable to move, speak, or react, and it is often accompanied by terrifying hallucinations and physical experiences. This can include seeing a person walk into your room and being unable to react or feeling a strong current running through your upper body.

These experiences are known as waking dreams, and they can feel like your nightmares are literally coming to life. One theory for why sleep paralysis occurs is that it is the result of disrupted REM sleep, since your body becomes paralyzed while in REM. Sleep paralysis is sometimes a symptom of disorders such as narcolepsy, migraines, anxiety, and sleep apnea.

Why do we have recurring dreams?

A recurring dream means having the same or similar dream many times, either over a short period of time or sometimes even over your entire lifetime. According to some theorists, having a recurring dream usually means there is some underlying problem in your life that is causing you stress that you are ignoring. The reason the dream repeats is because you have yet to correct the problem.

What are nightmares?

Nightmares are dreams that are so distressing they usually wake us up in the middle of the night. Though they can occur at any age, nightmares are usually seen in children with the most frequency. Traumatic events can cause nightmares to occur, as can certain medications. If you have recurring nightmares, getting treatment for the problem will vary depending on who you ask. Psychologists will usually recommend beginning with trying to interpret what the dream is about and why you are having it. Then you are expected to address the problem or problems that are causing the nightmare to occur. Another method for stopping nightmares is to learn lucid dreaming, which allows you to confront your attacker in the dream and therefore end the nightmares.

Can we learn from our dreams?

While most scientists see dreams as merely nonsense that the brain creates from fragments of images and memories, there are dream interpreters dedicated to examining the symbolic messages encoded in our dreams. However, dream interpretation should be taken with a grain of salt, as systems of interpretation are not supported by science.

Credit: Pixabay/CC0 Public Domain

People have pondered whether dreams have a purpose throughout human history. Modern scientists are fascinated with this question too.

For a long time, the science of dreams has oscillated between fringe research and the mainstream. But creative study designs and new technology are transforming it into an exciting and serious research niche.

Here are four recent breakthroughs that may pave the way for a greater understanding of dreaming.

Lucid dreams

In 2021 an international study showed that two-way communication between a lucid dreamer and a researcher in the lab was possible. In 2024, another study built on this by training lucid dreamers to control a virtual car from within their dreams.

The 12 dreamers in the experiment made slight muscle twitches, which sent a signal to a computer to make the virtual vehicle move forwards or turn. Signals were sent back to the dreamer to inform them of obstacles to try and avoid. Some could move the car well, but others, no matter how hard they tried, could not.

While fascinating, it is still unknown how such technology could be used in everyday life. And the small sample of this study, in part owing to the rarity of skilled lucid dreamers, limit the conclusions we can take from it. But the findings suggest that it may be possible (at least with practice) for some people to make decisions from inside a dream and communicate them.

Why do we dream?

Sleep and dreams researcher Mark Blagrove from Swansea University thinks dreams were meant to be shared socially and evolved in humans to enhance emotional intelligence and empathy.

Since 2016, Blagrove has collaborated with artist Julia Lockheart in a dream discussion and illustration group. An audience member is invited to share a recent dream. Blagrove leads the discussion, while Lockheart sketches an interpretation of the dream onto the pages of Sigmund Freud's book "The Interpretation of Dreams."

His 2019 research paper showed that discussing a dream in this way can lead to increased empathy between dream sharer and listeners. Blagrove argues this could have been valuable to ancestral survival in forming significant connections with others.

Other theories about why we dream have begun to emerge in recent years too, and some were discussed at a panel in June 2024 at the International Association for the Study of Dreams (IASD) annual conference. For example, the embodied cognition theory of dreaming, which proposes that dreams prepare us for the cognitive actions of ordinary waking life.

It hasn't been tested yet but shows a growing scientific interest in the adaptive purpose of dreams.

Insights from long dream series

Michael Schredl of the University of Mannheim in Germany is arguably the most prolific dream researcher today, having published hundreds of articles and books since his career began in the 1990s. He has been keeping a dream journal since the early 1980s. At the IASD conference, he gave a keynote talk analyzing more than 12,000 of his dreams.

Overall, the patterns seemed to support the continuity hypothesis of dreaming—that our dreams are influenced by events and concerns that are happening in our waking lives.

Schredl believes he is one of the first people to look at weather patterns in dreams. He noticed a steady decline over the years of ice, snow and hail in his dreams. Interestingly, this was similar to the documented declining number of "ice days" (days when the temperature was below 0°C for 24 hours) in Germany since he has been keeping a dream journal. He joked that perhaps the global warming effects are showing up in dreams too, but this could also be influenced by waking concerns about such things.

Another interesting pattern was references to money in dreams. When the Deutsche Mark was the prevailing currency, it occasionally showed up in his dreams over the years, but when the German currency changed to the Euro in 2002, the number of Deutsche Mark references were replaced by references to the Euro.

Long dream series such as this are rare, but they can show how us how intertwined dream content is with our waking lives.

Dream recall

Some people are better at remembering their dreams than others, recalling dreams more frequently and in more detail. For a long time, researchers have tried to determine the reasons and mechanisms for this difference. They've looked into factors including personality and attitude towards dreams, general memory ability, and the small physiological signals that happen during certain sleep stages. So far, one of the most consistent predictors of more frequent dream recall has been a positive attitude towards dreaming; if you think dreams are important, you're probably more motivated to try and remember them more often.

In 2022 French researcher Salomé Blain and their colleagues investigated the role of attention in dream recall, a cognitive skill which is closely connected to memory.

While their participants' ability to recall dreams did not seem linked to working memory—which temporarily holds information for immediate use—participants with low dream recall were better at ignoring distracting stimuli, and vice versa.

They compared low and high dream recallers in their ability to distinguish whether two melodies (which were both played in the same ear) were different, while a distracting melody was played in the opposite ear.

This suggests that people who are good at remembering dreams may be worse at filtering out irrelevant and distracting information, hence they may notice more of what's happening in their mind while sleeping.

However, dream recall is a learnable skill. For example, keeping a dream journal can significantly improve dream recall, especially for people who already have quite low dream recollection.

Are dreams truly a gateway to the subconscious?

Do dreams send us important messages from our deepest selves? Why do some dreams stay with us, vivid as day, while others slip away? Neuroscientists and psychologists have endeavored to answer these questions for decades, with fascinating results.

From the historical and cultural tapestries that have shaped our understanding of dreams to the cutting-edge scientific discoveries revealing what happens in our brains at night, this gallery is a journey through the night's most profound mystery.

Are you ready to explore the hidden corridors of your own mind? Click through to unravel the secrets that await in the world of dreams.

Historical perspectives on dreams

Historically, dreams were seen as divine messages or omens. This evolution from ancient beliefs to today's scientific understanding reflects our growing knowledge of brain science and psychology.

The physiology of dreaming

During REM sleep, the brain becomes highly active, similar to when awake. This stage is critical for dreaming, involving areas like the amygdala for emotions and the hippocampus for memories.

The REM cycle and Its importance in dreaming

REM sleep, a cycle occurring every 90 minutes during sleep, is crucial for consolidating memories and processing emotions, often resulting in intense dreaming.

Why do we dream? Theories and insights

Scientific theories suggest dreams aid in emotional regulation, problem-solving, and consolidating learning and memories. Psychologists propose they reflect our unconscious mind and inner conflicts.

Dreams and the subconscious mind

Dreams are a gateway to our subconscious, revealing hidden fears, desires, and conflicts. This connection highlights how dreams can be a tool for psychological insight and self-awareness.

The role of dreams in memory consolidation

Dreams play a critical role in solidifying memories. During sleep, the brain reorganizes and integrates new information with existing knowledge, a process vividly reflected in our dreams.

Neurological mechanisms behind dreaming

Dreaming involves various brain regions, including the prefrontal cortex, which is less active, leading to illogical dream scenarios. Neurotransmitters like serotonin and norepinephrine are also at play.

The link between dreams and emotional processing

Dreams are essential for emotional health, allowing the brain to process and interpret emotions experienced during waking hours, often leading to psychological resolution and understanding.

Dreams in different cultures and their interpretations

Across cultures, dreams have been interpreted differently, from prophetic visions to messages from ancestors. This diversity reflects the universal, yet culturally unique, nature of dreaming.

Why some remember dreams and others don't

Dream recall varies; some remember vividly while others can barely recall any details. This difference is influenced by factors like sleep quality, stress levels, and even genetic predispositions.

Understanding nightmares and their causes

Nightmares, often stress or trauma-induced, are a brain mechanism to process and cope with fears. They can also result from sleep disorders or medications.

Vivid dreams: what makes them different

Vivid dreams are marked by intense, lifelike experiences. Factors like stress, sleep deprivation, and certain medications can trigger these extraordinarily clear dreams.

Dreams and mental health

The content and nature of dreams can reflect one's mental health. Recurrent themes or disturbing dreams might signal underlying psychological issues.

Lucid dreaming: gaining control within dreams

Lucid dreaming is a state where the dreamer is aware they're dreaming and can sometimes control the narrative. This phenomenon illustrates the brain's remarkable capability for self-awareness during sleep.

Interpreting common dream themes and symbols

Common dreams, like falling or flying, carry universal symbols but can have unique meanings based on the individual's experiences and emotions.

Impact of external stimuli on dream content

External noises or sensations can infiltrate our dreams, demonstrating how our sleeping brain processes real-time environmental cues.

Dreams in children vs. adults

Children's dreams often feature imaginative content and evolve as they age, reflecting their developing brains and cognitive abilities.

Sleep disorders and their effect on dreaming

Disorders like insomnia or sleep apnea can significantly impact dream patterns and quality, often leading to less REM sleep and fewer remembered dreams.

Dreams and creativity

Dreams can be a source of creative inspiration, providing unique, uninhibited perspectives that have influenced artists, writers, and inventors throughout history.

Technology in dream research

Advances in neuroimaging and AI have revolutionized dream research, allowing deeper insights into the dreaming brain and its functions.

The role of dreams in problem-solving and decision-making

Dreams can contribute to problem-solving by providing creative solutions or new perspectives, often leading to 'eureka' moments upon waking.

Dreams and their role in cultural mythology

Across various cultures, dreams have been revered as prophetic tools or spiritual guides, deeply embedded in mythologies and religious practices.

Exploring the mysteries of sleep paralysis

Sleep paralysis, a state of being conscious but unable to move, is often accompanied by vivid hallucinations. This phenomenon highlights the complex relationship between sleep stages and brain activity.

The future of dream research and potential discoveries

As research progresses, we anticipate new discoveries about dream functions, their impact on mental health, and potential therapeutic uses.

Comparing dream theories: Freud vs. Jung

Freud's and Jung's theories offer contrasting views. Freud's emphasize unconscious desires and Jung's focus on archetypes and the collective unconscious.

The effects of medication and substances on dreaming

Certain medications and substances can alter dream patterns, intensify dreams, or even suppress REM sleep, showing the chemical influence on dreaming.

Dreams and predictions: separating myth from science

While some cultures believe in prophetic dreams, science views them as reflections of the mind's inner workings rather than predictors of the future.

Personal dream journals: tools for self-discovery

Keeping a dream journal can aid in understanding recurring patterns, themes, and emotional undercurrents, offering personal insights and self-awareness.

The ever-evolving understanding of dreams

As research continues, our understanding of dreams grows, revealing more about this fascinating intersection of science, psychology, and culture.

Sources: (Scientific American) (Knowable Magazine)

I'm Obsessed With This Theory Behind Why We Dream© Provided by HuffPost UK

Dreaming is something all of us do, to different extents. Some of us have vivid dreams that we can recall perfectly the next morning and the rest of us find ourselves trying to remember more than vague details of what happened during our slumber.

Why we do this is still not something that scientists can agree wholeheartedly on, and, while there isn't a conclusive answer at this point, a new theory that was published this year might just be the answer we've been looking for.

Dreams could be serving as a function

Writing for the British Psychological Society, Mark Blagrove said that while there are theories as to what happens when we dream, the purpose of them could actually be far more related to our waking life.

This is especially true when it comes to telling others about our dreams.

Blagrove said: “Dream-sharing may increase empathy because the dream acts as a piece of fiction, which is explored by the dreamer and others as part of the sharing process.

“Dreams would thus be like literary fiction, which has itself been shown to elicit empathy towards the characters that the fiction describes.”

Blagrove and his team have found that sharing what happens in our dreams opens the door for being more vulnerable and open with people. He said: “We suggest that the function of dreams thus resides in their waking use, and that dreams are like blushing, a way for self-disclosure to be supported, for the benefit of the group, even if such self-disclosure can sometimes be uncomfortable for the individual.”

This makes sense to me. There have been times that I’ve described particularly overwhelming dreams to loved ones just to later disclose that I was likely dreaming about such disturbing things because I was struggling with the pressures and stresses of my waking life.

This is just a theory for now but hopefully we’ll learn more from Blagrove and his team soon.

Can you imagine hearing yourself speak? A voice inside your head — perhaps reciting a shopping list or a phone number? What would life be like if you couldn't?

Some people, including me, cannot have imagined visual experiences. We cannot close our eyes and conjure an experience of seeing a loved one's face, or imagine our lounge room layout — to consider if a new piece of furniture might fit in it. This is called "aphantasia", from a Greek phrase where the "a" means without, and "phantasia" refers to an image. Colloquially, people like myself are often referred to as having a "blind mind."

While most attention has been given to the inability to have imagined visual sensations, aphantasics can lack other imagined experiences. We might be unable to experience imagined tastes or smells. Some people cannot imagine hearing themselves speak.

A recent study has advanced our understanding of people who cannot imagine hearing their own internal monologue. Importantly, the authors have identified some tasks that such people are more likely to find challenging.

What the study found

Researchers at the University of Copenhagen in Denmark and at the University of Wisconsin-Madison in the United States recruited 93 volunteers. They included 46 adults who reported low levels of inner speech and 47 who reported high levels.

Both groups were given challenging tasks: judging if the names of objects they had seen would rhyme and recalling words. The group without an inner monologue performed worse. But differences disappeared when everyone could say words aloud.

Doing this will change your life - How to never feel lonely again #psychology

Importantly, people who reported less inner speech were not worse at all tasks. They could recall similar numbers of words when the words had a different appearance to one another. This negates any suggestion that aphants (people with aphantasia) simply weren't trying or were less capable.

Hearing our own imagined voice may play an important role in word processing. (Image credit: sutadimages/Shutterstock)© Provided by Live Science

A welcome validation

The study provides some welcome evidence for the lived experiences of some aphants, who are still often told their experiences are not different, but rather that they cannot describe their imagined experiences. Some people feel anxiety when they realise other people can have imagined experiences that they cannot. These feelings may be deepened when others assert they are merely confused or inarticulate.

In my own aphantasia research I have often quizzed crowds of people on their capacity to have imagined experiences.

Questions about the capacity to have imagined visual or audio sensations tend to be excitedly endorsed by a vast majority, but questions about imagined experiences of taste or smell seem to cause more confusion. Some people are adamant they can do this, including a colleague who says he can imagine what combinations of ingredients will taste like when cooked together. But other responses suggest subtypes of aphantasia may prove to be more common than we realise.

The authors of the recent study suggest the inability to imagine hearing yourself speak should be referred to as "anendophasia," meaning without inner speech. Other authors had suggested anauralia (meaning without auditory imagery). Still other researchers have referred to all types of imagined sensation as being different types of "imagery."

Having consistent names is important. It can help scientists "talk" to one another to compare findings. If different authors use different names, important evidence can be missed.

We're starting to broaden our understanding of the senses and how we imagine them. Provided by Live Science

We have more than 5 senses

Debate continues about how many senses humans have, but some scientists reasonably argue for a number greater than 20.

In addition to the five senses of sight, smell, taste, touch and hearing, lesser known senses include thermoception (our sense of heat) and proprioception (awareness of the positions of our body parts). Thanks to proprioception, most of us can close our eyes and touch the tip of our index finger to our nose. Thanks to our vestibular sense, we typically have a good idea of which way is up and can maintain balance.

It may be tempting to give a new name to each inability to have a given type of imagined sensation. But this could lead to confusion. Another approach would be to adapt phrases that are already widely used. People who are unable to have imagined sensations commonly refer to ourselves as "aphants." This could be adapted with a prefix, such as "audio aphant." Time will tell which approach is adopted by most researchers.

Why we should keep investigating

Regardless of the names we use, the study of multiple types of inability to have an imagined sensation is important. These investigations could reveal the essential processes in human brains that bring about a conscious experience of an imagined sensation.

In time, this will not only lead to a better understanding of the diversity of humans, but may help uncover how human brains can create any conscious sensation. This question — how and where our conscious feelings are generated — remains one of the great mysteries of science.

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— Antonio Veloz / 500px/500px/Getty Images© Provided by Inverse

The Universe is big, as Douglas Adams would say.

The most distant light we can see is the cosmic microwave background (CMB), which has taken more than 13 billion years to reach us. This marks the edge of the observable Universe, and while you might think that means the Universe is 26 billion light-years across, thanks to cosmic expansion, it is now closer to 46 billion light-years across. By any measure, this is pretty darn big. But most cosmologists think the Universe is much larger than our observable corner of it. What we can see is a small part of an unimaginably vast, if not infinite, creation. However, a new paper argues that the observable Universe is mostly all there is.

In other words, on a cosmic scale, the Universe is quite small.

There are several reasons why cosmologists think the Universe is large. One is the distribution of galaxy clusters. If the Universe didn't extend beyond what we see, the most distant galaxies would feel a gravitational pull toward our region of the cosmos but not away from us, leading to asymmetrical clustering since galaxies cluster at around the same scale throughout the visible Universe. In other words, the observable Universe is homogenous and isotropic.

The second point is that spacetime is flat. If spacetime weren't flat, our view of distant galaxies would be distorted, making them appear much larger or smaller than they actually are. Distant galaxies do appear slightly larger due to cosmic expansion, but not in a way that implies an overall curvature to spacetime. Based on the limits of our observations, the flatness of the cosmos implies it is at least 400 times larger than the observable Universe.

Dark Energy: The Mysterious Force Filling the Void of the Universe!

Then, there is the fact that the cosmic microwave background is almost a perfect blackbody. There are small fluctuations in its temperature, but it is much more uniform than it should be. To account for this, astronomers have proposed a period of tremendous expansion just after the Big Bang, known as early cosmic inflation. We have not observed any direct evidence of it, but the model solves so many cosmological problems that it's widely accepted. If the model is accurate, then the Universe is on the order of 1026 times larger than the observable Universe.

So, given all of this theoretical and observational evidence, how could anyone argue that the Universe is small? It has to do with string theory and the swamplands.

Although string theory is often presented as a physical theory, it's actually a collection of mathematical methods. It can be used in the development of complex physical models, but it can also just be mathematics for its own sake. One of the problems with connecting the mathematics of string theory to physical models is that the effects would only be seen in the most extreme situations, and we don't have enough observational data to rule out various models. However, some string theory models appear much more promising than others. For example, some models are compatible with quantum gravity, and others are not. So often, theorists will define a "swampland" of theories that aren't promising.

When you separate the promising theoretical lands from the swamp, what you are left with are theories where early cosmic inflation isn't an option. Most of the inflationary string theory models are in the swampland. This leads one to ask whether you could construct a model cosmology that matches observation without early inflation, which brings us to this new study.

One way to get around early cosmic inflation is to look at higher-dimensional structures. Classic general relativity relies upon four physical dimensions, three of space and one of time, or 3+1. Mathematically, you could imagine a 3+2 universe or 4+1, where the global structure can be embedded into an effective 3+1 structure. This is a common approach in string theory since it isn't limited to the standard structure of general relativity. The authors demonstrate that under just the right conditions, you could construct a higher-dimensional structure within string theory that matches observation and avoids the swampland. Based on their toy models, the Universe may only be a hundred or a thousand times larger than the observed Universe. It's still big but downright tiny when compared to the early inflation models.

All of this is pretty speculative, but in a way, so is early cosmic inflation. If early cosmic inflation is true, we should be able to observe its effect through gravitational waves in the somewhat near future. If that fails, it might be worth looking more closely at string theory models that keep us out of the theoretical swamp.

This article was originally published on Universe Today by Brian Koberlein.


Quantum connection behind brain signals and human consciousness

What truly defines our consciousness? How does it arise from mere biological processes? These questions have sparked countless debates and studies. Some fascinating new research in the quantum realm might bring a glimmer of light into this abyss of questions, potentially unraveling the enigma that is human consciousness.

The mystery of consciousness has tied us in knots for centuries, captivating philosophers, scientists, and thinkers alike. We marvel at the brilliance of our own minds, exploring the depth of our thoughts, emotions, and experiences, only to find it equally baffling and elusive.

Through neuroscience, psychology, and philosophy, we can begin to piece together the puzzle of what it means to be aware and alive.

Meet Yong-Cong Chen, an esteemed professor from Shanghai University and the Shanghai Center for Quantitative Life Sciences. Chen is dedicated to unraveling those mind-bending questions that keep us awake at night.

The consciousness conundrum

The greatest challenge in understanding consciousness lies in its inherent complexity.

How do our brains, composed solely of biological tissue, manage to generate intricate processes such as thoughts, emotions, and the remarkable phenomenon of self-awareness?

This perplexing question has intrigued philosophers and scientists for centuries.

While intriguing theories like neural synchronization -- which posits that various regions of the brain collaborate seamlessly -- and neurotransmitter interactions influencing mood and behavior provide valuable insights, they do not offer a comprehensive explanation.

The synchronous firing of millions of neurons that creates the rich tapestry of human experience remains a mystery.

Some researchers even speculate that quantum mechanics might hold the key to unraveling the secrets of consciousness. In particular, the fascinating notion of instantaneous communication between particles across vast distances known as quantum entanglement.

Exploring quantum consciousness theories

Striding into this relatively unexplored territory, Chen and his team speculated that quantum mechanics, specifically quantum entanglement, could have a role in brain communication.

They have zoomed in on the myelin sheath, a protective layer encasing nerve fibers, which seems to play a huge role in neuron synchronization.

The myelin sheath, our neural bodyguard, not only shields axons (neuron transmitters) but also boosts neural transmission speed.

However, the puzzle remains unsolved as the neural signals tend to travel slower than sound, prompting us to ask, how do our brains synchronize countless neurons efficiently? Chen and his crew believe quantum entanglement could hold the answer.

Studying consciousness in the quantum realm

Chen's team, in their pursuit of answers, treated photons and their surrounding electromagnetic fields in the myelin sheath as quantum entities.

They unearthed that the myelin sheath traps energy within, acting as an electromagnetic cavity, producing highly entangled photons.

These entangled photons defy the basic principles of classical physics where changing the state of one photon, would instantly affect the other, regardless of the distance between them.

"We showed that the two photons can indeed have a higher rate of being entangled under certain conditions," Chen explained.

This intriguing discovery implies that our brains might be using quantum mechanics to promote faster neuron communication, potentially rewriting our understanding of neural communication, and ultimately, consciousness.

Real-world implications

Imagine if we unraveled the mystery of consciousness. It would change the way we understand not only our minds but perhaps offer profound insights into brain diseases, improve brain-machine interfaces, and maybe even advance artificial intelligence. The potential applications of these findings are vast.

Consider the possibility of this photon entanglement extending to potassium ion channels in neurons. This could mean a quantum effect on neuron firing, opening up new perspectives on brain signaling.

Chen highlights, "at this early stage, our primary goal is to identify possible mechanisms of neural synchronization, which affects numerous neurobiological processes."

His work is a testament to the boundless mysteries that our brains hold and the extent of our efforts to understand it.

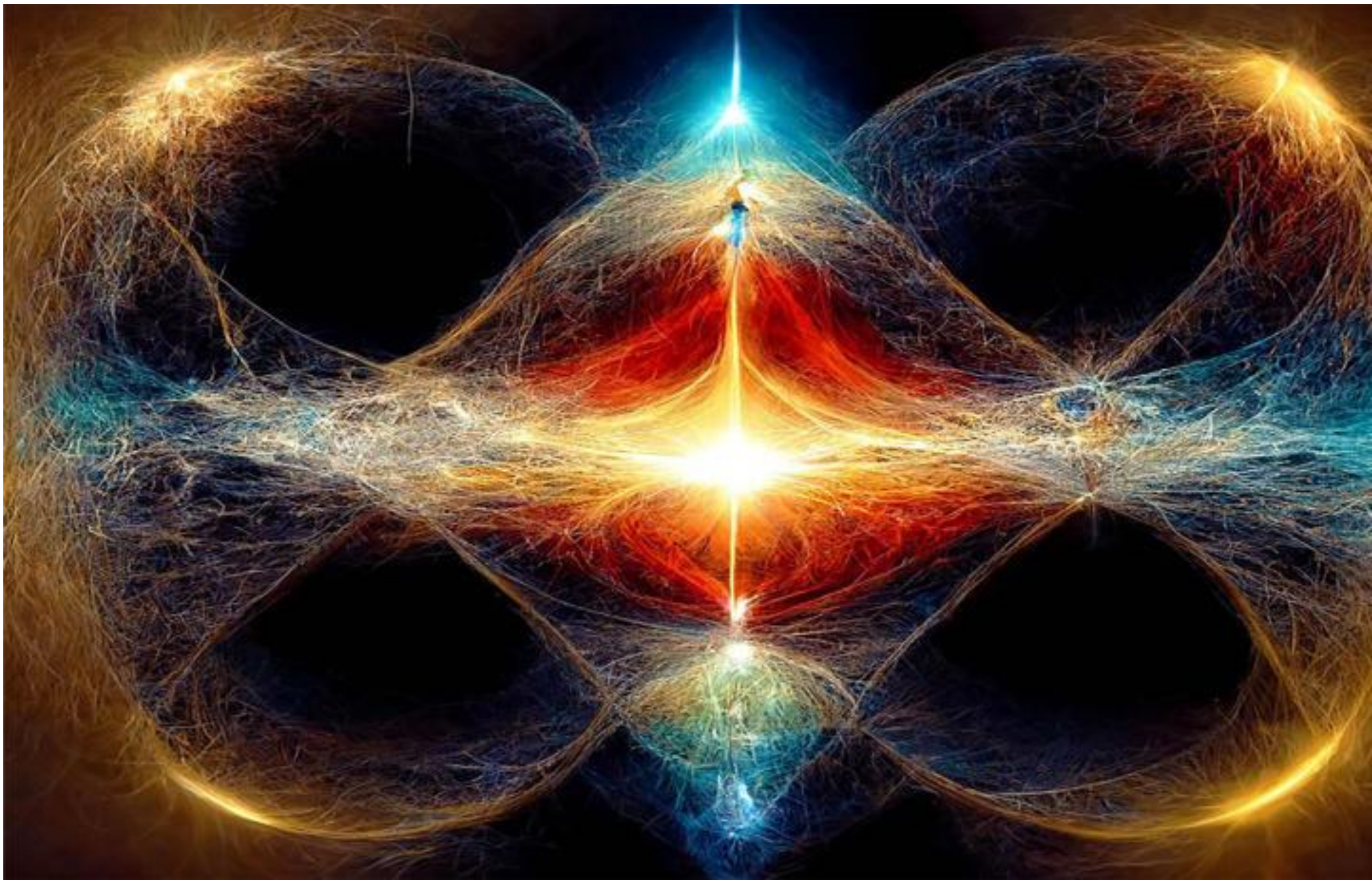
Future of quantum consciousness research

Our brains, the most complex organs in our bodies, continue to amaze and challenge us. Chen's research offers a new lens to view these wonders, suggesting that quantum mechanics might be a silent player in our brain communication.

As we grapple with consciousness's intricacies, mind-bending research like Chen's reminds us of the limitless possibilities that stretch before us.

Could quantum mechanics and the human brain be entwined in ways we never imagined? The story of the origin and emergence of consciousness is only just beginning.

The full study was published in the journal *Physical Review E*.


What if all things have consciousness? This idea is called panpsychism© Provided by Earth

Have you ever wondered if consciousness is a fundamental feature of the universe, present in all matter to some degree? This intriguing idea, known as panpsychism, has captivated philosophers and scientists for centuries.

From ancient philosophical musings to contemporary debates, panpsychism offers a unique perspective on the nature of consciousness.

Ancient roots of panpsychism

The concept of panpsychism can be traced back to ancient philosophical traditions. In ancient Greece, philosophers like Thales of

Miletus and Anaxagoras proposed that all things are imbued with a form of life or soul.

Thales believed that even magnets and other objects had souls because they could move and influence other objects, while Anaxagoras suggested that everything contains a portion of mind.

The Stoics, another influential group in ancient philosophy, believed that the universe is a living, rational organism imbued with a divine, animating principle called the "logos." This principle was thought to permeate all matter, giving rise to the interconnectedness of all things.

Panpsychism in pre-modern times

During the medieval period, panpsychism found resonance in the works of various scholars and mystics. The Neoplatonists, influenced by Plato's teachings, embraced the idea that the cosmos is a living being with a soul.

Plotinus, a prominent Neoplatonist philosopher, argued that the universe is an emanation of the One, and every part of it participates in the divine intellect.

You Are Much More Than You Think: A Universe Within You #Shorts

The Renaissance brought a revival of interest in ancient philosophies, and with it, a resurgence of panpsychistic ideas.

Philosophers like Giordano Bruno championed the idea that the universe is infinite and populated with innumerable living beings, each possessing a soul.

Bruno's cosmological views, which included elements of panpsychism, challenged the prevailing Aristotelian cosmology and contributed to the scientific revolution.

Challenges and revivals in the enlightenment

The Enlightenment period, with its emphasis on reason and scientific inquiry, brought new challenges to panpsychism.

Mechanistic views of the universe, as proposed by thinkers like René Descartes and Isaac Newton, dominated the intellectual landscape.

Descartes' dualism separated mind and body, relegating consciousness to the realm of the immaterial soul, distinct from the physical world.

However, not all Enlightenment thinkers rejected panpsychism. Gottfried Wilhelm Leibniz proposed a metaphysical system that included panpsychistic elements.

His concept of monads -- simple, indivisible substances that make up the universe -- suggested that each monad has a form of perception or consciousness.

In the 19th and 20th centuries, panpsychism experienced a revival as philosophers and scientists began to grapple with the implications of Darwin's theory of evolution and the nature of consciousness.

Thinkers like William James, Alfred North Whitehead, and Gustav Fechner explored panpsychistic ideas in their work, suggesting that consciousness could be a fundamental feature of the universe.

Contemporary perspectives on panpsychism

In recent years, panpsychism has gained traction among some neuroscientists and physicists as a potential framework for understanding consciousness.

The limitations of reductive physicalism, which attempts to explain consciousness solely in terms of neural processes, have led some researchers to consider alternative approaches.

The most prominent theories in the modern age are Integrated Information Theory (IIT) and Orchestrated Objective Reduction (Orch-OR) theory.

Emergence of Integrated Information Theory (IIT)

Integrated Information Theory (IIT) is a scientific theory that aims to explain what consciousness is, how it works, and why it exists.

Developed by neuroscientist Giulio Tononi in 2004, IIT proposes that consciousness arises from the integration of information within a system, and the amount of integrated information (denoted as Φ, pronounced "phi") determines the level of consciousness.

Key principles of IIT:

- Consciousness is a fundamental property of certain systems that integrate information.
- The amount of integrated information (Φ) in a system determines the degree of consciousness.
- A system with a high Φ value will have a more complex and unified conscious experience.
- Consciousness is intrinsic and independent of external observers or functions.
- Any system, whether biological or artificial, can be conscious if it has a sufficiently high Φ value.

According to IIT, a system generates consciousness when it integrates information in a way that is irreducible to its individual parts.

This means that the information processed by the system is more than just the sum of its parts; it is integrated and unified in a way that creates a coherent, subjective experience.

IIT also proposes that the quality and content of a conscious experience are determined by the specific way information is integrated within the system. Different patterns of integrated information give rise to different qualia, or subjective experiences.

Implications and criticisms

One of the implications of IIT is that consciousness is not limited to biological systems like the human brain.

In principle, any system that integrates information, such as a sufficiently complex artificial neural network, could be conscious. This aligns with the panpsychist view that consciousness is a fundamental feature of the universe.

However, IIT also faces challenges and criticisms. Some argue that the theory is too abstract and difficult to test empirically. Others question whether the mathematical formalism used to calculate Φ truly captures the essence of consciousness.

Orch-OR theory: Consciousness at the quantum realm

The Orchestrated Objective Reduction (Orch-OR) theory, proposed by physicist Roger Penrose and anesthesiologist Stuart Hameroff, suggests that consciousness arises from quantum processes in the brain, specifically within the microtubules of neurons.

Penrose and Hameroff argue that the brain is not merely a classical computer, but rather a quantum computer that harnesses the strange properties of quantum mechanics to process information and generate consciousness.

Microtubules as the key to quantum consciousness?

According to Orch-OR, microtubules, the tiny protein scaffolds that provide structure and support within neurons, are the site of these quantum computations.

The theory proposes that microtubules contain quantum bits (qubits) that can exist in multiple states simultaneously, a property known as superposition.

These qubits interact and become entangled, forming a quantum system that can perform complex computations.

Orchestration of objective reduction

Penrose and Hameroff suggest that when enough microtubules become entangled and reach a critical threshold, an "objective reduction" occurs, collapsing the quantum state and giving rise to a moment of conscious experience.

The theory also proposes that the objective reduction is orchestrated by the fundamental geometry of spacetime, which Penrose calls "quantum gravity."

This connection between quantum processes in the brain and the structure of the universe itself is what gives the theory its "orchestrated" qualifier.

Quantum mechanics and consciousness

One of the appealing aspects of Orch-OR is that it attempts to bridge the gap between the abstract, mathematical world of quantum mechanics and the subjective, experiential nature of consciousness.

It offers a potential explanation for how the strange, non-intuitive properties of quantum systems might give rise to the unified, coherent experience of consciousness.

Ongoing developments and future prospects

However, Orch-OR has faced significant criticism from both the scientific and philosophical communities. Many experts argue that the brain is too warm, wet, and noisy for sustained quantum coherence to occur, and that microtubules are not suitable candidates for quantum computation.

Others question the lack of empirical evidence supporting the theory and the difficulty in testing its claims experimentally.

Despite these criticisms, Penrose and Hameroff continue to develop and refine the Orch-OR theory, seeking to address its weaknesses and gather evidence to support its claims.

While the theory remains controversial, it represents an intriguing attempt to bridge the gap between quantum mechanics, neuroscience, and the study of consciousness, and it has inspired further research and debate in these fields.

Panpsychism faces many challenges and criticisms

Despite its intriguing propositions, panpsychism faces significant challenges and criticisms. The "combination problem" -- the question of how simple forms of consciousness in basic entities combine to form complex, unified consciousness -- remains a major hurdle. Critics argue that panpsychism lacks a clear mechanism for this process.

Moreover, panpsychism's broad definition of consciousness has been criticized for being too inclusive, potentially diluting the concept of consciousness to the point of meaninglessness.

The difficulty in empirically testing panpsychistic claims, due to the subjective and elusive nature of consciousness, also poses a challenge to its acceptance.

Bridging the gap between mind and matter

Panpsychism, with its rich historical roots and contemporary scientific interest, offers a fascinating perspective on the nature of consciousness.

While it challenges conventional views and faces significant criticisms, its potential to bridge the gap between the physical and the experiential continues to inspire philosophical and scientific inquiry.

As our understanding of the universe and consciousness evolves, panpsychism remains a compelling and provocative hypothesis, inviting us to reconsider the fundamental nature of reality.

Whether or not panpsychism ultimately proves to be a valid theory, its exploration has undoubtedly enriched our understanding of consciousness and its place in the cosmos.

What if everything in our world has a soul and mind? What if every desk, chair, and potted plant has a conscious stream of thoughts? That's the basic idea behind Panpsychism, a theory first put forward in the late 16th century by Francesco Patrizi. It's been a hundred years or so since science won out about this theory in the 1920s, but now it's regaining momentum.

To understand why this theory is regaining popularity requires us to look at one of the most difficult conundrums that human scientists have ever faced: where consciousness comes from. Scientists have been trying to solve this hard problem for over a hundred years, and while developments in neuroscience, psychology, and quantum physics have come far, we still don't have a definitive answer.

The argument is regaining momentum, though, thanks in part to the work of Italian neuroscientist and psychiatrist Giulio Tononi, who proposed the idea that there is widespread consciousness even found in the simplest of systems. Tononi and American neuroscientist Christof Koch argued that consciousness will follow where there are organized lumps of matter. Some even believe that the stars may be conscious.

This basic idea, then, seems to suggest that grouped lumps of matter, like the very chair you're sitting in right now, may have a stream of consciousness. Of course, not everyone agrees with this. Many still take the stance that this is just an attempt to grasp at straws, if you will, in a bid to understand consciousness and how it comes to be.

The main idea behind Panpsychism seems to rely on the belief that if brains are not required for consciousness, then anything can be conscious of its existence, and thus, everything has different experiences. But there are more than just the believers and unbelievers here. There are actually some who believe that consciousness is all an illusion, which raises even more questions.

Keith Frankish, an honorary professor of philosophy at the University of Sheffield, told *Popular Mechanics* that he believes that consciousness is just an illusion of our own minds. Whether or not the very stars are conscious has yet to be proven, of course. And we're still a long way from understanding the brain and how it correlates to different things within our world.

This is still an area of science that draws a lot of big question marks from scientists. All you can really say for sure is what you believe. Are you conscious? Or is consciousness just an illusion that your brain has conjured up? It is certainly an interesting thought.

Psychology professor Iris Berent says perceiving minds and bodies as separate has evolutionary roots. Credit: Matthew Modoono/Northeastern University© Provided by Medical Xpress

The origins of consciousness have been debated by philosophers for centuries. Each conscious person has a sense of "being me," which invariably gives rise to the question of where that sense originated—from within or outside the body, says Northeastern University psychology professor Iris Berent.

"How do human brains give rise to this experience? That's the big mystery, right?" she says.

Influential philosopher David Chalmers famously won a bet in 2023 for claiming consciousness exists beyond the merely physical, Berent says.

But she says the question of where consciousness exists is a false one—and she has a new paper that presents her position.

In an article published in the *Neuroscience of Consciousness*, she argues that the debate stems from the delusional—albeit natural—biases in the way humans think about the separation, or lack thereof, between body and mind.

"One of the biases is dualism, intuitive dualism—the fact that we perceive minds as separate from our bodies."

"The extent to which we look at consciousness and think that it is this really mysterious thing could very well arise from how we see it rather from what consciousness really is," Berent says. "Consciousness isn't hard. Psychology is," she says.

Mary and the zombie

Berent points to an experiment in perception she conducted in her lab that used the well-known Mary and the zombie hypothetical exercise, but with a twist.

According to the experiment, when people are asked to think of a zombie twin of themselves, they describe a creature with their physical features but without their thoughts or feelings.

"They intuit that the mind, consciousness included, is really separate from the physical," Berent says.

In the other thought experiment, Mary is a neuroscientist who knows everything about color and how the brain perceives color, even though she lives in a black-and-white world.

When Mary sees a red rose for the first time, people participating in the experiment say she learns something outside the bounds of physical, scientific explanation.

Berent says she decided to challenge these conclusions with two additional questions.

"The first question is kind of a reality check question, which is do they think Mary's case is significant? Is it transformative? And everybody said, 'Sure, it's super transformative,'" Berent says.

"We also asked how likely is it that this experience will actually show up in her brain? If we scan her brain, will it light up? And it turns out that that's exactly what people said. It will significantly register in the brain."

"The point being, in the condition of the zombie people say, 'no,' (consciousness) is not physical," Berent says. "And in Mary's condition, people say it's physical."

"If people change their mind in this way, it can't possibly be that in reality consciousness has changed. It must be that there is something within the human psyche that colors how we see consciousness."

"For me, this means that we need to be really careful before we assume that there is any real mystery going on."

The evolutionary roots of dualism

Berent blames what she calls "delusional attitudes about bodies and minds" to "the same old psychological biases that I've been studying in my lab for years."

She calls the separation of mind and body dualism Previous research by Berent shows that autistic people are less dualistic than neurotypical people and that males are less dualistic than females.

Evolution is responsible for the fact people hold two different systems of perception in their mind, Berent says.

"Animals have an evolutionary advantage to be able to perceive objects, say, the bodies of their mothers," she says.

It's also important to be able to perceive objects that have agency as separate from other objects, Berent says. "You want to follow the mother and not a body that is inanimate" to receive nurturance and protection.

This type of dualism, she says, "primes us to think about people and their minds and bodies as separate from each other. That's one reason we think about consciousness as this ethereal thing separate from the body."

"The point is that our perception of consciousness changes depending on the situation. And if that's the case, there's no way that we can trust it to reflect what our consciousness really is. It must be that our brain plays tricks on us."

An intimate understanding of who we are

"Every psychology student that has ever come into my class asks if we're going to talk about consciousness," Berent says.

"This is considered to be super important. This is our intimate understanding of who we are."

Berent says the thought experiment outlined in her paper provides "the smoking gun" that intuitions about consciousness existing outside the body are manufactured by humans' dualistically inclined brains.

Consciousness likely comes down to electrochemical functions in the brain, she says. "It's hard for psychological reasons."

More information: Iris Berent, Consciousness isn't "hard"—it's human psychology that makes it so!, *Neuroscience of Consciousness* (2024). DOI: 10.1093/nc/niae016

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Provided by Northeastern University

The progress of science in the last 400 years is mind blowing. Who would have thought we'd be able to trace the history of our universe to its origins 14 billion years ago? Science has increased the length and the quality of our lives, and the technology that is commonplace in the modern world would have seemed like magic to our ancestors.

For all of these reasons and more, science is rightly celebrated and revered. However, a healthy pro-science attitude is not the same thing as "scientism," which is the view that the scientific method is the only way to establish truth. As the problem of consciousness is revealing, there may be a limit to what we can learn through science alone.

Perhaps the most worked out form of scientism was the early 20th-century movement known as logical positivism. The logical positivists signed up to the "verification principle," according to which a sentence whose truth can't be tested through observation and experiments was either logically trivial or meaningless gibberish. With this weapon, they hoped to dismiss all metaphysical questions as not merely false but nonsense.

These days, logical positivism is almost universally rejected by philosophers. For one thing, logical positivism is self-defeating, as the verification principle itself cannot be scientifically tested, and so can be true only if it's meaningless. Indeed, something like this problem haunts all unqualified forms of scientism. There is no scientific experiment we could do to prove that scientism is true; and hence if scientism is true, then its truth cannot be established.

In spite of all of these deep problems, much of society assumes scientism to be true. Most people in the UK are totally unaware that "metaphysics" goes on in almost every philosophy department in the country. By metaphysics, philosophers don't mean anything spooky or supernatural; this is just the technical term for philosophical, as opposed to scientific, enquiry into the nature of reality.

Truth without science

How is it possible to find out about reality without doing science? The distinguishing feature of philosophical theories is that they are "empirically equivalent," which means you can't decide between them with an experiment.

Take the example of my area of research: the philosophy of consciousness. Some philosophers think that consciousness emerges from physical processes in the brain—this is the "physicalist" position. Others think it's the other way around: consciousness is primary, and the physical world emerges from consciousness. A version of this is the "panpsychist" view that consciousness goes all the way down to the fundamental building blocks of reality, with the word deriving from the two Greek words pan (all) and psyche (soul or mind).

Still others think that both consciousness and the physical world are fundamental but radically different—this is the view of the "dualist." Crucially, you can't distinguish between these views with an experiment, because, for any scientific data, each of the views will interpret that data in their own terms.

For example, suppose we discover scientifically that a certain form of brain activity is correlated with the conscious experience of an organism. The physicalist will interpret this as the form of organization which turns non-conscious physical processes—such as electrical signals between brain cells—into conscious experience, whereas the panpsychist will interpret it as the form of organization which unifies individual conscious particles into one larger conscious system. Thus we find two very different philosophical interpretations of the same scientific data.

If we can't work out which view is right with an experiment, how can we choose between them? In fact, the selection process is not so dissimilar from what we find in science. As well as appealing to experimental data, scientists also appeal to the theoretical virtues of a theory, for example how simple, elegant and unified it is.

Philosophers too can appeal to theoretical virtues in justifying their favored position. For example, considerations of simplicity seems to count against the dualist theory of consciousness, which is less simple than its rivals in so far as it posits two kinds of fundamental stuff—physical stuff and consciousness—whereas physicalism and panpsychism are equally simple in positing just one kind of fundamental stuff (either physical stuff or consciousness).

It could also be that some theories are incoherent, but in subtle ways that require careful analysis to uncover. For example, I have argued that physicalist views of consciousness are incoherent (although—like much in philosophy—this is controversial).

There is no guarantee that these methods will yield a clear a winner. It could be that on certain philosophical issues, there are multiple, coherent, and equally simple rival theories, in which case we should be agnostic about which is correct. This would in itself be a significant philosophical finding concerning the limits of human knowledge.

Philosophy can be frustrating because there is so much disagreement. However, this is also true in many areas of science, such as history or economics. And there are some questions on which there is a modest consensus, for example, on the topic of free will.

A tendency to mix up philosophy with a growing anti-science movement undermines the united front against the real and harmful opposition to science we find in climate change denial and anti-vax conspiracies.

Like it or not, we can't avoid philosophy. When we try to do so, all that happens is we end up with bad philosophy. The first line of Stephen Hawking and Leonard Mlodinow's book "The Grand Design" boldly declared: "Philosophy is dead." The book then went on to indulge in some incredibly crude philosophical discussions of free will and objectivity.

If I wrote a book making controversial pronouncements on particle physics, it'd be rightly ridiculed, as I haven't been trained in the relevant skills, haven't read the literature, and haven't had my views in this area subject to peer scrutiny. And yet there are many examples of scientists lacking any philosophical training publishing very poor books on philosophical topics without it impacting their credibility.

This might be sounding bitter. But I genuinely believe society would be deeply enriched by becoming more informed about philosophy. I have hope that we will one day move on from this "scientistic" period of history, and understand the crucial role both science and philosophy have to play in the noble project of finding out what reality is like.

A new theory suggests that time might not be a fundamental aspect of our universe but rather an illusion created by quantum entanglement.

Quantum entanglement occurs when particles become interconnected in such a way that the state of one instantly influences the state of another, regardless of distance.

According to this theory, the perception of time emerges from the entanglement of objects with a reference clock. Consequently, without this entanglement, the universe would appear static and unchanging to an external observer.

This idea challenges traditional views shaped by general relativity, where time is intertwined with the fabric of space and influenced by gravity.

However, in the realm of quantum mechanics, time does not exhibit the same flexibility. Researchers argue that reconciling these two perspectives requires rethinking time’s fundamental nature.

Despite its intriguing implications, this theory faces challenges, including how to test these concepts empirically. As the understanding of quantum mechanics and its intersection with our macroscopic world evolves, this theory may provide new insights into the nature of reality and time itself.

Researchers Alessandro Coppo and colleagues have explored this idea, proposing that time might emerge from the quantum interactions at a fundamental level.

Their findings, published in *Physical Review A*, suggest that our experience of time could be a byproduct of quantum processes rather than a fundamental aspect of reality. This theory, while still in its early stages, opens up new avenues for understanding the nature of time and its role in the universe.

"For centuries, time has entered physics as an essential ingredient that is not to be questioned. It is so deeply rooted in our conception of reality that people thought that a definition of time was not needed," says Coppo. “We believe that nature is genuinely quantum,” he adds.

The implications of this theory are profound, as it suggests that time, as we perceive it, might not be a universal constant but rather a construct emerging from deeper quantum interactions.

This could lead to a new understanding of how the universe functions at both macroscopic and microscopic levels, potentially bridging gaps between quantum mechanics and general relativity.

The Quantitative Comparison Between the Neuronal Network and the Cosmic Web

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We investigate the similarities between two of the most challenging and complex systems in Nature: the network of neuronal cells in the human brain, and the cosmic network of galaxies. We explore the structural, morphological, network properties and the memory capacity of these two fascinating systems, with a quantitative approach. In order to have an homogeneous analysis of both systems, our procedure does not consider the true neural connectivity but an approximation of it, based on simple proximity. The tantalizing degree of similarity that our analysis exposes seems to suggest that the self-organization of both complex systems is likely being shaped by similar principles of network dynamics, despite the radically different scales and processes at play.

Introduction

Central to our vision of Nature are two fascinating systems: the network of neurons in the human brain and the cosmic web of galaxies.

The human brain is a complex temporally and spatially multiscale structure in which cellular, molecular and neuronal phenomena coexist. It can be modeled as a hierarchical network (i.e., “the human connectome” [1]), in which neurons cluster into circuits, columns, and different interconnected functional areas. The structure of the neuronal network allows the linking between different areas, all devoted to process specific spatiotemporal activities over their neurons, forming the physical and biological basis of cognition [e.g., Ref. 2]. Some of major challenges of contemporary neuroscience are to disentangle the structure of the connectome (e.g., the complete map of the neural connections in a brain), to understand how this structure can produce complex cognitive functions, and to define the role of glial cells and of the microenvironment in the interneuronal physiology.

The Universe, according to the large collection of telescope data gathered over many decades, seems to be reasonably well described by a "consensus" physical model called the ΛCDM model (Lambda Cold Dark Matter), which accounts for gravity from ordinary and dark matter (i.e., very weakly interacting particles), for the expanding space-time described by General Relativity, and for the anti-gravitational energy associated to the empty space, called the "dark energy". Such model presently gives the best picture of how cosmic structures have emerged from the expanding background and have formed the cosmic web [e.g., Refs. 3 and 4]. The most important building blocks of the cosmic web are self-gravitating dark matter dominated halos, in which ordinary matter has collapsed to form galaxies (and all stars within them). The initial distribution of matter density fluctuations was early amplified by the action of gravity, and has developed into larger groups or clusters of galaxies, filaments, matter sheets, and voids, in a large-scale web in all directions in space. Among the main challenges that cosmology still faces, are the physical nature of dark energy, the composition of dark matter (or the realm of alternative scenarios for it), the apparent tension between different measurements of the expansion rate of the Universe, the exact sequence of processes responsible for the variety of galaxy morphology and their co-evolution with supermassive black holes [e.g., Ref. 5, for a recent review]. Although the relevant physical interactions in the above two systems are completely different, their observation through microscopic and telescopic techniques have captured a tantalizing similar morphology, to the point that it has often been noted that the cosmic web and the web of neurons look alike [e.g., Refs. 6 and 7].

In this work, we apply methods from cosmology, neuroscience, and network analysis to explore this thought-provoking question quantitatively for the first time, to our knowledge.

Materials and Methods

Immunohistochemistry and Microscopy

We analyzed several independent samples of cerebral and of cerebellar human cortex were formalin-fixed and paraffin-embedded [8], sampling slices of depth $4\ \mu\mathrm{m}$, with magnification factors of $4\times$, $10\times$ and $40\times$. Neurofilaments were labeled using the Neurofilament (2F11) Mouse Monoclonal Antibody (Ventana/CellMarque/Roche). Samples were automatically processed by Ventana BenchMark Ultra Immunostainers. A Nikon eclipse 50i microscope was then used to visualize the samples. Magnifications larger than $40\times$ was avoided in order to obtain a better optical depth resolution, as well as to minimize the non-linear response of the optic microscopy.

Cosmological Simulations

We used synthetic samples of the cosmic web from a high-resolution (2400^3 cells and dark matter particles) simulation of a cubic $100^3\ \mathrm{Mpc}^3$ cosmic volume

($1\ \mathrm{Mpc} = 3.085\cdot10^{24}\ \mathrm{cm}$), performed with the grid code ENZO [9] as detailed in Ref. 10. The simulation produces a realistic distribution of dark matter, ordinary matter, and magnetic fields at the present epoch. In order to mimic the "slicing" procedure of brain tissues, we produced 12 different thin slices (with thickness $25\ \mathrm{Mpc}$) from the simulated volume, by extracting four slices in perpendicular directions with respect to each of the independent axes of the simulation. We give public access to our cosmic web images, as well as to the brain samples and to the images of other natural networks discussed below at this URL https://cosmosimfrazza.myfreesites.net/cosmic-web-and-brain-network-datasets.

Results

Absolute Numbers, Internal Proportions, and Composition

We first quote data available from the literature, which allow us a first sketchy comparison of the absolute sizes of both systems. The radius of the observable Universe is $R_U \sim 13.9\ \mathrm{Gpc}$ [11]. The extrapolation of recent observations posits that a total of $N_g \sim 2.6\cdot10^{12}$ galaxies may be present in within the sphere of the observable Universe [12], with up to $\sim 5\cdot10^{10}$ galaxies with masses equal or larger to the one of the Milky Way. The largest clusters of galaxies total a mass exceeding 10^{15} solar masses (1 solar mass $= 1.989\cdot10^{33}\ \mathrm{g}$). Long filaments of ordinary and dark matter, with extension of several tens of Megaparsecs, connect clusters and groups of galaxies and are separated by mostly empty space [e.g., Ref. 4].

According to recent estimates, the adult human brain contains $N_{neu} \approx 8.6 \pm 0.8\cdot10^{10}$ neurons in total, and almost an equal number of non-neuronal cells. Only $\sim 20-25\%$ of all neurons are located in the cortical gray matter (representing $\sim 80\%$ percent of brain mass), while the cerebellum has about $\sim 6.9\cdot10^{10}$ neurons ($\sim 80\%$ of brain neurons) [13, 14].

It can be noticed that the two systems are organized in well defined networks, with $\sim 10^{10}-10^{11}$ nodes interconnected through filaments (if we consider as nodes all galaxies with masses comparable or larger to that of the Milky Way, see above), whose typical extent is only a tiny fraction ($\leq 10^{-3}$) of their host system size. Also, galaxies and neurons have a typical scale radius, which is only a very small fraction of the typical length of filaments they are connected to. Moreover, available data suggest that the flow of information and energy in the two networks is mostly confined to $\leq 25\%$ of the mass/energy content of each system.

In the case of the Universe we refer to the present-day composition, based on Planck Collaboration et al. [15], as the relative energy distribution is a function of time in the ΛCDM cosmological model; for the human brain, we referred to the published researches about human brain composition [e.g., Refs. 16 and 17].

In summary: 1) the brain is composed by water ($77-78\%$), lipids ($10-12\%$), proteins (8%), carbohydrates (1%), soluble organic

substances (2%2%), salt (1%1%); 2) the Universe is made for a 73∼%73∼% by Dark Energy (a scalar energy field of the empty space), for a 22.5%22.5% by Dark Matter, for 4.4%4.4% by ordinary baryonic matter and for less than ≤0.1%≤0.1% by photons and neutrinos.
Strikingly, in both cases ∼75%∼75% of the mass/energy distribution is made of an apparently passive material, that permeates both systems and has an only indirect role in their internal structure: water in the case of the brain, and dark energy in cosmology, which to a large extent does not affect the internal dynamics of cosmic structures [e.g., Ref. 18].

Morphological Comparison

Small samples of the human cerebral and cerebellar cortex were harvested during corticectomy to approach subcortical tumors (Section 2.1). The neuronal cells have been then stained with clone 2F11 monoclonal antibody against neurofilaments, which are neuron-specific intermediate filaments in the cytoplasm of neurons that provide structural support to the neuronal cytoskeleton, along with microtubules and microfilaments. It has been shown that the number, spacing, and areal density of neurofilaments in neurons are measures with a strong dependency on axon caliber [e.g., Refs. 19–21]. Although also microtubules density depends on axon caliber, it has been shown that microtubules often form small clusters in the vicinity of membranous organelles [22]. For this reason we consider neurofilaments might be more homogeneously arranged in the neuron, and likely to be a better target to visualize the spatial distribution of neurons in the slices. For the cosmic web, we analyzed each one of the 12 thin slices from the simulated volume (Section 2.2), to assess the effect of cosmic variance. Such 2-dimensional approach mimics what is done with brain samples, and due to the large degree of isotropy of the cosmic web on such large scales this approach can also be used to readily translate our statistics into the 3-dimensional case.

Figure 1 gives an overview of the details of structures observed at various scales (from 4×4×, 10×10× and 40×40× magnifications in the case of brain tissues, and on corresponding steps in zoom in the case of the cosmic web) in our dataset. Especially on large scales, the various samples do not show any spectacular degree of similarity. In particular, the predominant role of the large overdensities marked by clusters of galaxies is evident in the cosmic web sample, while the finer structure of neurofilaments in the brain samples produces richer small-scale patterns. At the highest magnification achieved in our brain slices, however, the refined network of neuronal bodies and of filaments start presenting some similarity with the cosmic web on ≤20 Mpc≤20 Mpc scales. When focusing on histological slices, some variability can be noticed that depends on different neuronal subtypes in brain and cerebellar cortex. In the first slice, small neurons in the granular layer are shown, along with the transition to the gangliar layer with some Purkinje cells at the bottom of the picture. Conversely, the second slice depicts large pyramidal cells interspersed with small neuronal cells of the brain gray matter (granular cells).

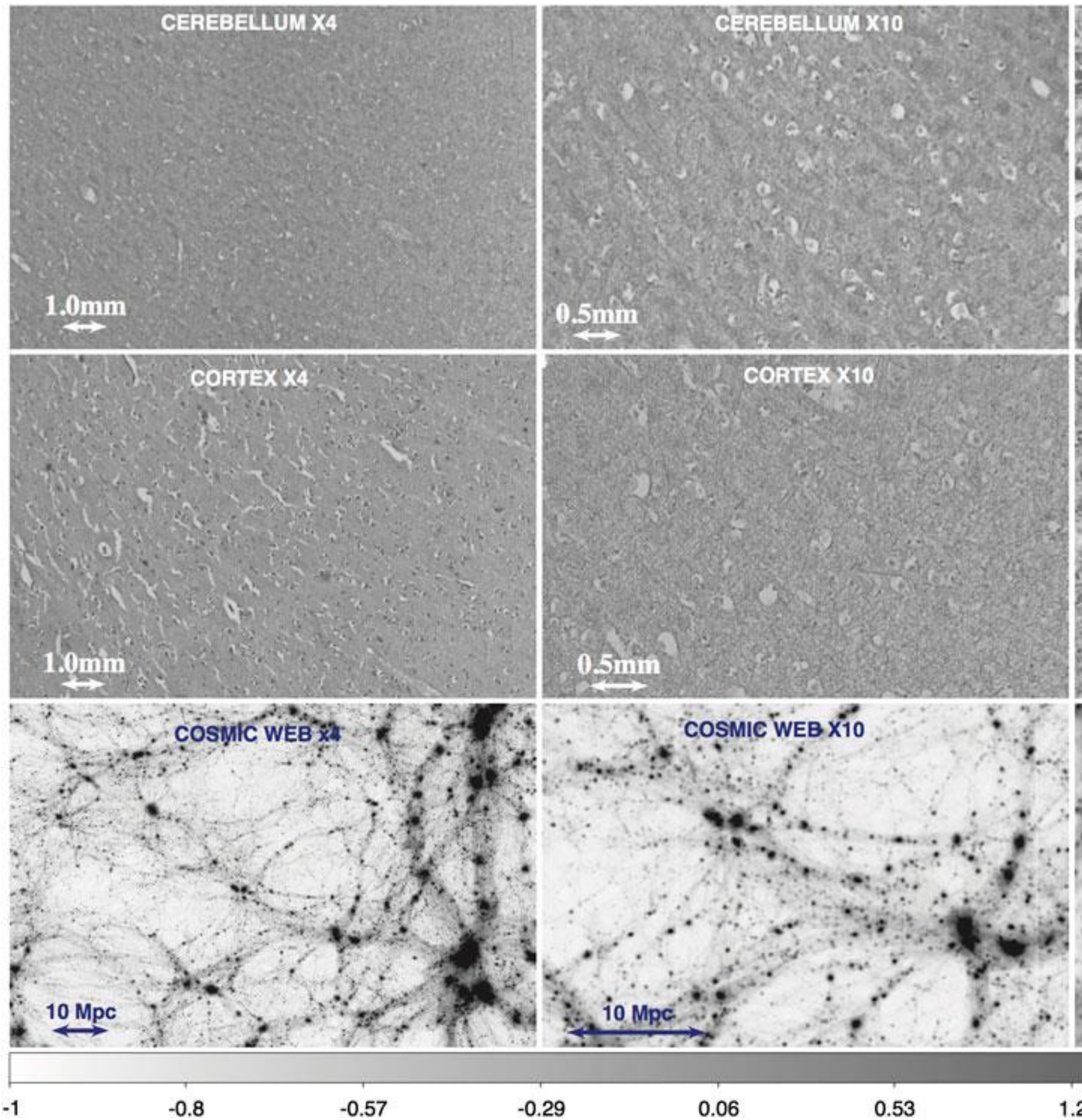


FIGURE 1. Maps of normalized density contrast, δρδρ for examples of slices of the cerebellum (top row), of the brain cortex (middle row) and of the dark matter distribution of the cosmic web (lower row), for various levels of magnification. The spectral and network analysis presented in this work will mostly focus on 40×40× samples as in the right panels.

We will use in this work statistical tools to 1) compare the distribution of structure across the entire continuum range of spatial scales of our samples, also compared to other natural complex systems (Section 3.3); 2) measure the properties of connectivity between nodes in the network, estimating the tendency to form highly clustered configurations (see Section 3.4).

Spectral Analysis

We used here a statistics commonly used in cosmology: the density power spectrum, $P(k)$, which directly measures the contributions of different spatial frequencies, $k=2\pi L/l$ (where *l* is the spatial scale and *L* is the maximum scale of each system), to the density contrast, defined as $\delta\rho=\rho/\bar{\rho}-1$, where ρ is the density and $\bar{\rho}$ is the average density of each sample. We measured $P(k)$ for our 2-dimensional samples, by decomposing $\delta\rho$ into a series of discrete spatial frequencies, $\delta(\vec{k})$: $\langle\delta(\vec{k})\delta(\vec{k}')\rangle=2\pi^3 P(k)\delta_{2D}(\vec{k}+\vec{k}')$, where δ_{2D} is the 2-dimensional Dirac delta function.

In the case of the cosmological simulation, $\langle\rho\rangle$ is uniquely constrained by the initial conditions of the simulation, while in the sample of the cortex and cerebellum we define it based on the average measured within the sample itself. While accurately knowing the local density contrast is trivial in the simulation, it shall be noticed that a precise mapping of the recorded pixel intensity to a projected matter density is far from trivial in microscope observation, due to the non-linear response of the microscopic imaging process. As noted in Section 2.1, our choice of using very thin tissue samples and a magnification not higher than $\times 40$ is indeed motivated by the goal of minimizing the non-linear response of the optic microscopy, by keeping the optical depth small compared to the aperture of the image. For this reason, $\delta\rho$ in our brain samples strictly is a measure of the contrast of optical absorptions along the line of sight, which we assume to be a proxy for the density contrast for the sake of comparing with cosmological samples. We applied standard Fast Fourier Transform with periodic boundary conditions to compute the power spectra of cosmic web samples (as the domains are truly periodic), while in the case of the brain samples we used a standard zero-padding technique to embed the observed samples into a 2×2 larger and empty area, and applied apodisation at the interfaces between the empty area and the data, in order to minimize spurious edge effects, as commonly done in simulations [e.g., Ref. 23].

The resulting power spectra are shown in Figure 2. It shall be stressed that power spectra are free to be slid horizontally in the plot, in the sense that the reference scale *L* related to $k=1$ is decided a-posteriori. In the following, after a preliminary comparison of spectra we adjusted the horizontal scale so that $k=1$ corresponds to $L=1.6$ mm in brain samples, and to $L=100\ \mathrm{Mpc}$ in the cosmic web. This corresponds to a scaling ratio of $1.875\cdot 10^{27}$ between the two systems. The amplitude of spectra in the vertical direction, instead, is self-normalized to the total variance of $\delta\rho$ within each sample. As a consequence, the brain samples are differently normalized at $k=1$, since when a lower magnification is used and larger spatial scales are sampled, ≤ 1.6 mm scales contribute proportionally less to the variance of $\delta\rho$ within the entire sample. In the first panel, we compare the spectra of a random cosmic web slice with random brain slices obtained with different magnifications. The comparison strikingly shows (in line with what suggested on Figure 1) that a remarkable similarity with spectra is obtained when comparing ≤ 1 mm scales in brain samples to ≤ 100 Mpc scales of the cosmic web. Most of the neuronal cells observed in our cerebellar samples are granule cells, with somata having a $\sim 5\ \mu m$ diameter, while their dendrites have dendrites with a typical $\sim 13\ \mu m$ length. The axon length (although variable depending on the cortical areas) is on average in the range of several millimeters [e.g., Ref. 24]. Considering that the slices used for microscopic inspection most often are not parallel to the axis of axons, it is likely that fragments of these fibers around $\sim 1-2$ mm in length are visible in the slices. Therefore, the excess power of neural power spectra in this spatial regime reflects the abundance of structures with this typical size distribution.

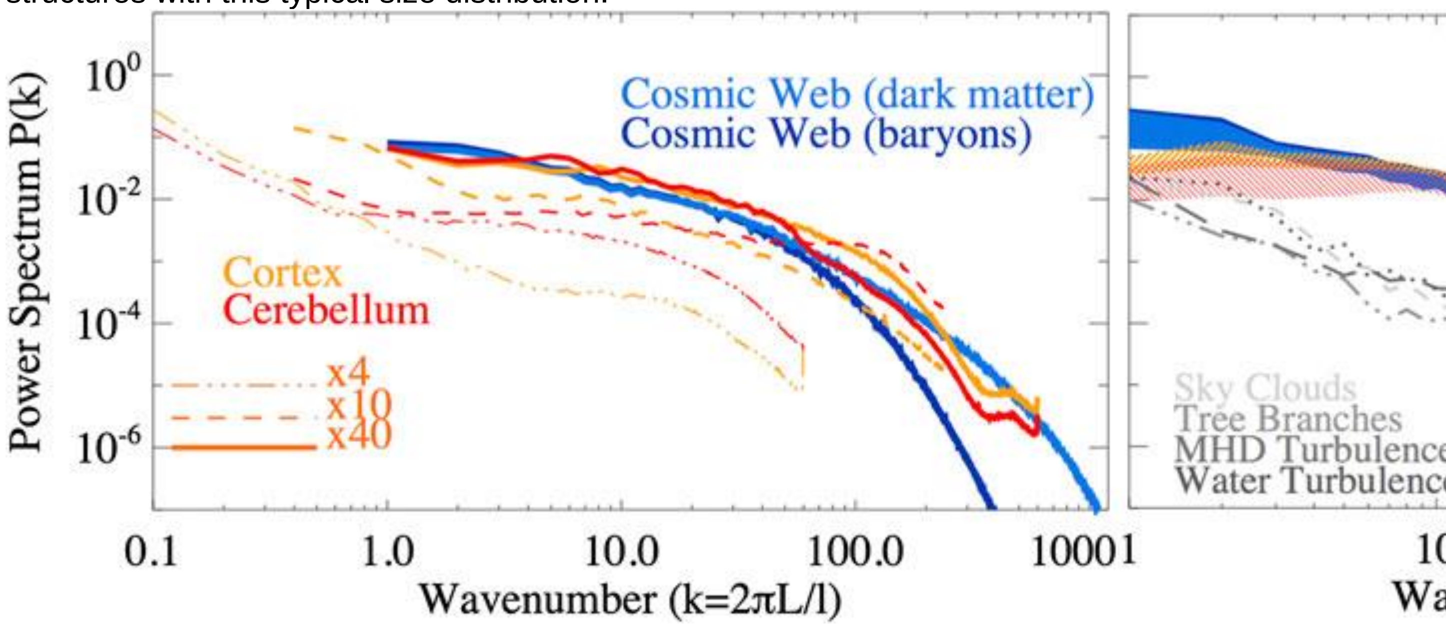


FIGURE 2. Left: power spectra of density fluctuations in all samples (in the case of brain samples, spectra from slices of different size and magnification factors are shown). Right: power spectra of density fluctuations (in the case of brain tissues, only the $40\times$ slices are used here), with shaded areas enclosing the entire distribution of spectra for all samples (12 slices for cosmic web samples and four for the brain samples). Comparison power spectra from other samples natural systems are shown with gray lines.

On the other hand, the fluctuations measured on $\geq 1-2$ mm scales in brain samples present a steeper spectral shape than in cosmic web spectra. For this reason, in the remainder of the analysis we focused on datasets of $40\times$ brain samples for a close comparison with cosmic web slices. In the second panel, we show $P(k)$ both for the dark matter and gas distribution of all slices, which are almost identical on large

scales ($\geq$ Mpc) and more diffuse on smaller scales due to smoothing effect of gas pressure. As for the cosmic web spectra, we show the envelope containing all spectra of all $40\times$ samples with shaded areas. We find a large agreement across nearly ~ 2 decades in spatial scales. The similarity between the cerebellum on $0.01-1.6\ \mathrm{mm}$ scales and the dark matter distribution of the cosmic web on $1-10^2\ \mathrm{Mpc}$ scales is remarkable. On smaller scales, the cortex sample displays significant more power than the cerebellum, owing to the distribution of small neurons in the granular layer described above, while the baryon distribution of the cosmic web has less power, due to the (well-known) effect of gas pressure in smoothing out the fluctuations of baryon gas density on small enough scale for hydrodynamical effects to be relevant. In all cases we measure broken power laws, unlike what is expected for (simpler) fractal distributions [e.g., Ref. 25]. This is in line with several works, which have shown that at small scales, $r\leq 20\ \mathrm{Mpc}$ the galaxy correlation function scales as $\propto r^{-1}$ (where *r* is the spatial scale in the 2-point correlation function) while on larger scales the density only weakly (logarithmically) depends on the system size [e.g., Refs. 26 and 27].
Lastly, we produced control power spectra for other randomly drawn samples of natural networks (sky clouds, tree branches, water turbulence, and magneto-hydrodynamic turbulence - all available at https://cosmosimfrazza.myfreesites.net/cosmic-web-and-brain-network-datasets), with the goal of double checking that our method is not biased to produce similarity between truly different physical systems. As shown by the gray lines in the right panel of Figure 2, such systems display a more regular power-law spectral behavior, clearly at variance with what found in the main networks analyzed in this work - even if in the latter case we did not perform a full analysis across the entire dynamical range of such systems, looking for the emergence of possible spectral features as in the case of the brain and the cosmic samples.

However, power spectra are blind to phase correlations in the continuous field, hence two morphologically different distributions can still produce similar spectra [28]. In the following section we will thus also rely on non-spectral methods to compare the different samples.

Network Analysis

Network science have proliferated into various physical disciplines, including neuroscience [e.g., Ref. 29–32] as well as cosmology [e.g., Refs. 33 and 34]. Complex network analysis can partially soften the problem of not having perfectly consistent density estimators across our samples, in the sense that defining the nodes of the various networks is less sensitive to the exact mapping details of the images. We focus here on two simple network parameters commonly used in graph theory and network analysis [e.g., Refs. 35 and 36]. The first is the degree centrality, C_d, which measures the degree of connectivity of a network within the localized area (determined by a maximum linking length, l_{link}):

$$C_d(j)=\frac{k_j}{n-1} \quad (1)$$

where k_j is the number of (undirected) connections to/from each *j*-node and *n* is the total number of nodes in the entire network. The second parameter is the clustering coefficient, *C*, which quantifies the existence of structure within the local vicinity of nodes, compared to a network of random points (i.e., the ratio of connected triangles of nodes to all possible triples in a given connected cluster). It is measured as

$$C(j)=\frac{2y_j}{k_j(k_j-1)}, \quad (2)$$

in which y_j is the number of links between neighboring nodes of the *j*-node.

While sophisticated methods to identify nodes and filaments in the simulated cosmic network [e.g., Ref. 4] or in the neuronal network [e.g., Ref. 37] have been proposed, here we explore a simpler approach with the advantage of being readily applicable to both networks. The method is inspired by standard "halo finding" procedures in cosmology to identify the self-gravitating halos in the cosmic web [38]. In detail: 1) we marke the highest intensity peaks in all maps (i.e., pixels in the top 10% of the intensity distribution of each map); 2) we compute the enclosed average intensity of pixels within circles of increasing radius, until a low threshold value, Δ, is matched. The radius of the circle reaching the Δ value defines the radius of each node in the network (r_Δ); 3) all pixels at a distance $\leq r_\Delta$ are assumed to belong to that node. In the case of the cosmic web we tailored the procedure so that $\Delta=330\bar{\rho}$, while in the case of the brain networks we tailored the values of Δ so that the radius of nodes in the networks reasonably matches the size suggested by visual inspection.

We then built the adjacent matrix of nodes, M_{ij}, i.e., a matrix with rows/columns equal to the number of detected nodes, with value $M_{ij}=1$ if the nodes are separated by a distance $\leq l_{link}$, or $M_{ij}=0$ otherwise. The choice of l_{link} is arbitrary, but a full scan of network parameters as a function of l_{link} is beyond the goals of this first exploratory work. We thus focused on one specific choice for the linking length, motivated by the recent analysis of observed galaxies by de Regt et al. [33], who suggested $l_{link}=1.2$ Mpc as the reference "linking length" for matter halos in the cosmic web (i.e., $\sim L/100$ in Figure 2). Based on the similarity of power spectra after opportunely renormalizing the spatial scales presented in Section 3.3, we thus consistently rescaled the linking length in $40\times$ brain samples to $l_{link}=16$ μm. Figure 3 gives close up view of the nodes and networks reconstructed for three slices of our dataset.

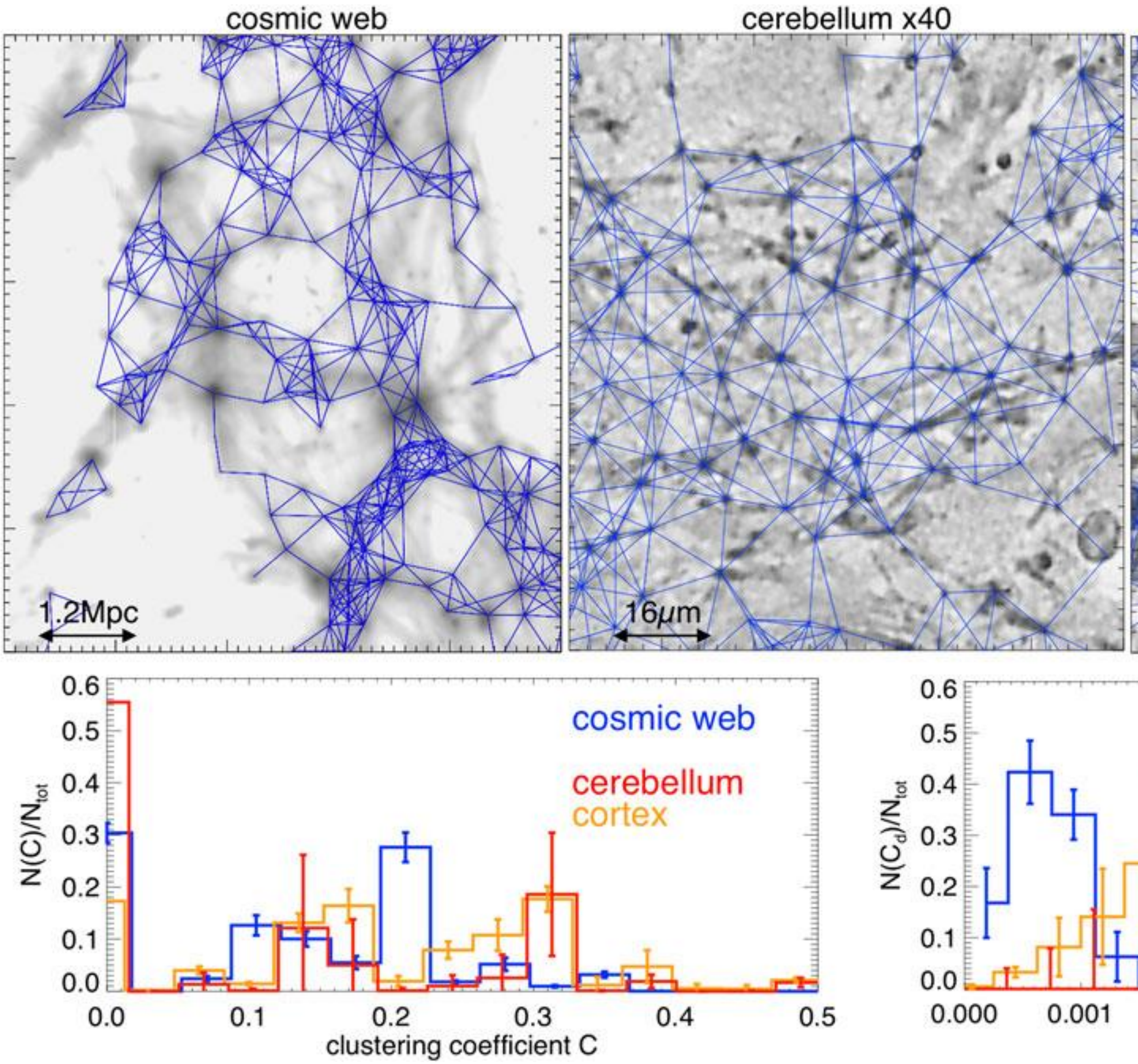


FIGURE 3. Top panels: zoomed details of the reconstructed connections between nodes for three example of networks in our sample (blue lines, superimposed to the density contrast maps). Bottom panels: distributions of clustering coefficient and of degree centrality for all slices (the error bars give the scatter within each investigated sample of slices). The reconstructed connections do not take into account the long-range neural connections, and the clusters shown are purely spatial.

This method selects from $N{\sim}3800{-}4700$N∼3800−4700 nodes in our cosmic web slices, with an average number of $\langle k\rangle{\sim}3.8{-}4.1$⟨k⟩∼3.8−4.1 connections per node. For

the cerebellum slices we measured $\langle k\rangle \sim 1.9-3.7$, while for the cortex we measured $\langle k\rangle \sim 4.6-5.4$ for the $N \sim 1800-2000$ identified nodes. On the other hand, the estimated average number of nodes for the simulated cosmic web is $\sim 40\%$ smaller of the results reported from real galaxy surveys by de Regt et al. [33], which is understood because of the much smaller thickness of our model slices (a factor ~ 4 thinner in comoving depth compared to observations). Both statistics clearly show that the brain and cosmic web networks are very different from Erdös–Rényi random networks of the same size, which would instead predict for the two parameters $C_{random} \approx \langle k\rangle / N$ ($\leq 2 \cdot 10^{-3}$ in our case) and $C_{d,random} \approx C_{random}(1-C_{random})/N$ ($\leq 10^{-7}-10^{-6}$ in our case), in the limit of large *N* [e.g., Ref. 39]. We can see that instead all measured distributions of *C* measure a few different peaks in the $C \sim 0.1-0.4$ range, clearly indicating that all networks are highly correlated, i.e., their links tend to be highly clustered together. In the case of the cosmic web, similar sparse peaks were measured in real data by de Regt et al. [33], and are ascribed to galaxies in moderate ($C \sim 0.1$) or rich ($C \sim 0.3$) environments, like filaments or large clusters of galaxies. Only the residual part of the distributions, with $C \leq 10^{-2}$, marks instead regions of the network in which the connectivity is close to random (e.g., nodes in void regions). The networks also have values of degree centrality clearly much larger (by three to four orders of magnitude) than corresponding random networks. In the cosmic network, the distributions of C_d are approximately Poissonian and in line with the galaxy network studied by Ref. 33, even if the peaks of the distribution are at lower values than the brain samples. The latter is compatible with the enhanced presence of small neurons in the granular layer, already discussed above, which leads to the presence of more closely packed clusters of nodes.
We point out that in this study we analyzed only a fraction of the cortex, and not the whole Central Nervous System, whose architecture is obviously different. Actually, while proximity can accurately describe the cosmic web, neural webs are based on connections and therefore our analysis is not sensitive to long-range connectivity. But indeed long-range connectivity is known to be a crucial feature of neural webs. We defer the application of more complex network statistics [e.g., Ref. 40]) to future work.

Discussion

We have presented a detailed comparison between the neuronal network and the cosmic web, two of the most fascinating and complex networks in Nature, with the goal of assessing the level of similarity between these two physical systems in an objective way.

We have also applied homogeneous statistical approaches to real lab samples of both the brain and the cerebellar cortex (Section 2.1), and to slices of the simulated distribution of dark matter and ordinary in the cosmic web (Section 2.2), and quantified their morphological and network properties using spectral analysis (Section 3.3) as well as network parameters from graph theory (Section 3.4). Within the range of simplifying assumptions we used to define both networks (e.g., based on the proximity of nodes identified from the continuous matter distribution rendered by different imaging techniques) our findings hint at the fact that similar network configurations can emerge from the interaction of entirely different physical processes, resulting in similar levels of complexity and self-organization, despite the dramatic disparity in spatial scales (i.e., $\sim 10^{27}$) of these two systems.

We are aware that this approach has several limitations. First, our comparison focused on density of matter. The selection of neurofilaments to outline the neuronal network was based on the fact that they are quite evenly expressed in the cytoplasmic compartment of the neurons. Our results should be further validated with different markers, as microfilaments or microtubules. Second, we assumed that the highest stain density is located at the level of neuronal Soma, which is an approximation, leading to a non-standard definition of nodes. Further studies are required to validate our results with functional neural network data and without losing anatomical-visual definition. Third, our study has been based on histological slices, which can obviously show only a tiny portion of the brain network itself. Moreover, while the cosmic web uses proximity to define its network, neural webs are based on connections that can be significantly long-range spatially, and which could not be properly assessed through our analysis due to technical limitation of the method. For the above limitations, we could not present a systematic and complete connectivity analysis of networks, as we focused on simple proximity and not on long-range connectivity. A key Frontier of this line of comparative research is the possibility of measuring the memory capacity of both networks, a task presently made challenging by the radically different approaches presently available to measure to monitor the flow of information within them. An interesting factoid well illustrates that possible similarities also exist in this respect. The total memory capacity of the human brain has been recently estimated using section electron microscopy to reconstruct the 3D distribution of dendritic spines and of their synapses, and finding 26 distinct synaptic strengths, which accounts to an average of ~ 4.7 bits of information per neuronal cell [41]. Extrapolated to the total average number of nodes in the neuronal network, this yields $\approx 2 \cdot 10^{16}$ bits, i.e., ~ 2.5 Petabytes as the memory capacity of the human brain. For the cosmic web, a radically different idea based on Information Theory can been used to quantify how much information is encoded by the 3-dimensional structure of the cosmic web [42, 43]. Through the computation of the "statistical complexity" that characterizes the dynamical evolution of simulated universes, it has been argued that $\sim 3.5 \cdot 10^{16}$ bits (i.e., ≈ 4.3 Petabytes of memory) are necessary to store the information of cosmic structure within the entire observable Universe (≈ 13.8 Gpc). Such close agreement may appear as a mere coincidence, considering that, given ambiguities in defining both networks, particularly the cosmic web, these numbers are known only approximately.

Together with the rest of the analysis presented in this work, such similarities are meant to motivate the development of more powerful and discriminating algorithms to pinpoint analogies and differences of these fascinating systems, almost at the conceivable extremes of spatial scales in the Universe.

Study investigates similarities between network of galaxies and network of neuronal cells in the human brain

Reviewed by *Emily Henderson, B.Sc.*Nov 17 2020

In their paper published in *Frontiers of Physics*, Franco Vazza (astrophysicist at the University of Bologna) and Alberto Feletti (neurosurgeon at the University of Verona) investigated the similarities between two of the most challenging and complex systems in nature: the cosmic network of galaxies and the network of neuronal cells in the human brain.

Despite the substantial difference in scale between the two networks (more than 27 orders of magnitude), their quantitative analysis, which sits at the crossroads of cosmology and neurosurgery, suggests that diverse physical processes can build structures characterized by similar levels of complexity and self-organization.

The human brain functions thanks to its wide neuronal network that is deemed to contain approximately 69 billion neurons. On the other hand, the observable universe can count upon a cosmic web of at least 100 billion galaxies.

Within both systems, only 30% of their masses are composed of galaxies and neurons. Within both systems, galaxies and neurons arrange themselves in long filaments or nodes between the filaments.

Finally, within both systems, 70% of the distribution of mass or energy is composed of components playing an apparently passive role: water in the brain and dark energy in the observable Universe.

Starting from the shared features of the two systems, researchers compared a simulation of the network of galaxies to sections of the cerebral cortex and the cerebellum. The goal was to observe how matter fluctuations scatter over such diverse scales.

"We calculated the spectral density of both systems. This is a technique often employed in cosmology for studying the spatial distribution of galaxies", explains Franco Vazza. "Our analysis showed that the distribution of the fluctuation within the cerebellum neuronal network on a scale from 1 micrometer to 0.1 millimeters follows the same progression of the distribution of matter in the cosmic web but, of course, on a larger scale that goes from 5 million to 500 million light-years".

The two researchers also calculated some parameters characterizing both the neuronal network and the cosmic web: the average number of connections in each node and the tendency of clustering several connections in relevant central nodes within the network.

Once again, structural parameters have identified unexpected agreement levels. Probably, the connectivity within the two networks evolves following similar physical principles, despite the striking and obvious difference between the physical powers regulating galaxies and neurons. These two complex networks show more similarities than those shared between the cosmic web and a galaxy or a neuronal network and the inside of a neuronal body".

Alberto Feletti, Neurosurgeon, University of Verona

The encouraging results of this pilot study are prompting the researchers to think that new and effective analysis techniques in both fields, cosmology, and neurosurgery, will allow for a better understanding of the routed dynamics underlying the temporal evolution of these two systems.

Source:
Università di Bologna
Journal reference:
Vazza, F & Feletti, A (2020) The Quantitative Comparison Between the Neuronal Network and the Cosmic Web. *Frontiers in Physics.* doi.org/10.3389/fphy.2020.525731.

The universe is like a giant human brain, scientists find

Andrew Griffin
Tuesday 17 November 2020 11:13 GMT

The universe is similar to a huge human brain, scientists have found.

A new study investigated the differences and similarities between two of the most complex systems in existence, though at entirely difference scales: the cosmos and its galaxies and the brain and its neuronal cells.

They found that while the scale is clearly different, the structure is remarkably similar. In some cases, the two systems seemed more similar to each other than they did to the parts that make them up.

It suggests that vastly different physical processes can lead to very similar complex and organised structures.

For example, the human brains works because of the network of nearly 70 billion neurons that together make it up. The universe is thought to have at least 100 billion galaxies.

In each system, they are assembled together in a complex web or network, spread out in long filaments and nodes that link them up. Those spreading nodes are familiar to pictures of both the universe and the brain, and account for some of the superficial similarities in images.

But in each system, those threads only make up about 30 per cent of the mass. In each, some 70 per cent of the mass is actually made up of parts that appear to be passive: the brain's water, and the universe's dark energy.

To dig further into those similarities, researchers compared the way those galactic networks form with sections of the brain. They looked to understand how the matter was spread across the two very different networks.

"We calculated the spectral density of both systems. This is a technique often employed in cosmology for studying the spatial distribution of galaxies", said Franco Vazza, an astrophysicist at the University of Bologna who worked on the study with University of Verona neurosurgeon Alberto Feletti.

"Our analysis showed that the distribution of the fluctuation within the cerebellum neuronal network on a scale from 1 micrometer to 0.1 millimeters follows the same progression of the distribution of matter in the cosmic web but, of course, on a larger scale that goes from 5 million to 500 million light-years".

They also examined the ways that the webs of neutrons and galaxies connect up – once again finding noticeable similarities, with the systems seeming more similar to each other than to their component parts. To do so, they compared the average number of connections between each of the nodes, and how they cluster.

"Once again, structural parameters have identified unexpected agreement levels. Probably, the connectivity within the two networks evolves following similar physical principles, despite the striking and obvious difference between the physical powers regulating galaxies and neurons", said Alberto Feletti.

"These two complex networks show more similarities than those shared between the cosmic web and a galaxy or a neuronal network and the inside of a neuronal body".

A paper describing the findings, ‘The quantitative comparison between the neuronal network and the cosmic web’, is published in the journal *Frontiers of Physics*.

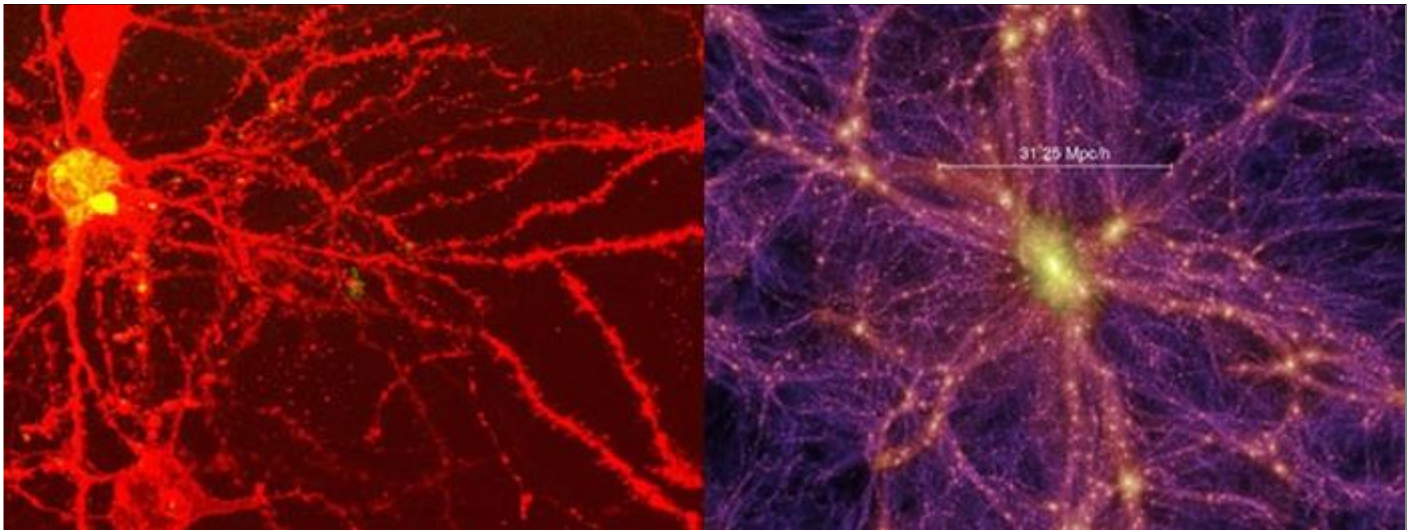
Study Maps The Odd Structural Similarities Between The Human Brain And The Universe

NATURE17 November 2020
ByMICHELLE STARR

One fascinating quirk of the Universe is that shapes and patterns can be found in hugely different contexts: the Golden Spiral can be seen in the human cochlea and the shape of a spiral galaxy; the fractal geometry of veins echoed in the branching of lightning.

In a bold new pilot study, an astrophysicist and a neurosurgeon have bumped it up a notch, using quantitative analysis to compare two of the most complex systems in nature: the neuronal network in the human brain and the cosmic network of galaxies in the Universe.

It's actually not that peculiar a comparison. You may have seen an image that occasionally gets shared around, showing a human neuron and a simulated galaxy cluster, side-by-side; the two look startlingly similar.



(Mark Miller/Virgo Consortium/Visual Complexity)

But there's a lot more to the human brain - and the Universe - than how it looks.

So astrophysicist Franco Vazza of the University of Bologna in Italy and neurosurgeon Alberto Feletti of the University of Verona in Italy have spent the last few years investigating to determine if the similarities are more than skin-deep.

"Galaxies can group into enormous structures (called clusters, superclusters, and filaments) that stretch for hundreds of millions of light-years. The boundary between these structures and neighboring stretches of empty space called cosmic voids can be extremely complex.

Gravity accelerates matter at these boundaries to speeds of thousands of kilometers per second, creating shock waves and turbulence in intergalactic gases.

We have predicted that the void-filament boundary is one of the most complex volumes of the universe, as measured by the number of bits of information it takes to describe it.

This got us to thinking: Is it more complex than the brain?"

The two types of structures differ in size by 27 orders of magnitude (that's a billion billion billion). But the team's results suggest that, while the physical processes that drive the structure of the Universe and the structure of the human brain are extremely different, they can result in similar levels of complexity and self-organisation, the researchers said.

The starting point was working out similarities between the two. The human cerebellum has around 69 billion neurons; the observable cosmic web contains over 100 billion galaxies. That's one.

Both systems are arranged in well-defined networks, with nodes (neurons in the brain, galaxies in the Universe) connected via filaments.

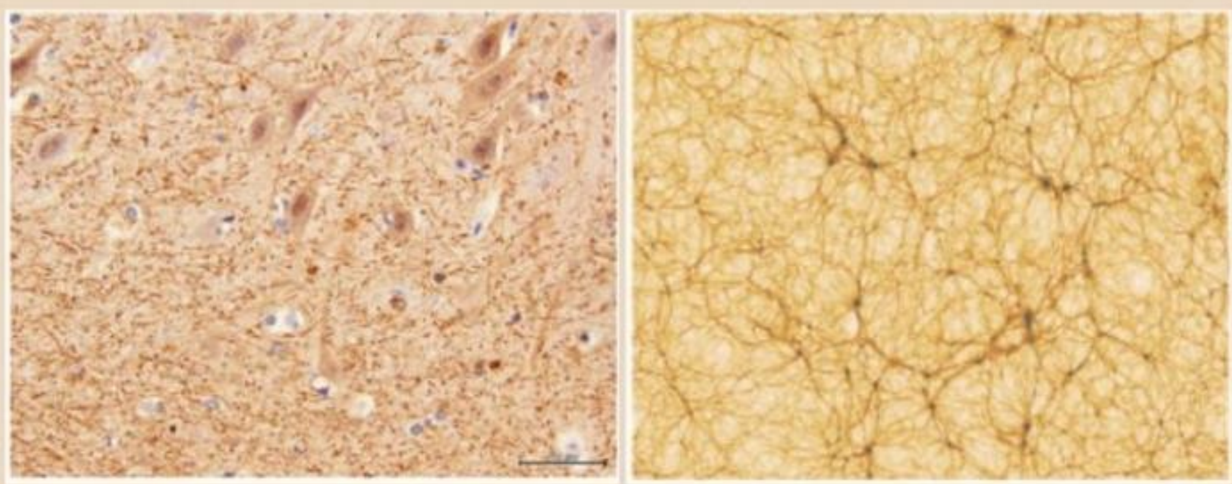
Both neurons and galaxies have a typical scale radius that's only a fraction of the length of the filaments. And the flow of information and energy between nodes is only around 25 percent of the mass and energy content of each system.

In addition, there are similarities between the composition of the brain and the composition of the Universe. The brain is around 77 percent water. The Universe is around 72 percent dark energy.

Both of these are apparently passive materials that permeate their respective system and play only an indirect role in their internal structures.

With these similarities defined, the team next undertook quantitative comparison of the two, based on images. They obtained slices of the human cerebellum and cortex at different magnifications, and compared them to simulations of the cosmic web.

What they were looking for were similarities in the matter density fluctuations between brains and the cosmic web. And they found that the relative distribution of fluctuations in the two systems was amazingly similar - although on much different scales.



A slice of cerebellum at 40x magnification (left) and simulated cosmic web at 300 light-years a side (right). (University of Bologna)

"We calculated the spectral density of both systems. This is a technique often employed in cosmology for studying the spatial distribution of galaxies," Vazza said.

"Our analysis showed that the distribution of the fluctuation within the cerebellum neuronal network on a scale from 1 micrometer to 0.1 millimeters follows the same progression of the distribution of matter in the cosmic web but, of course, on a larger scale that goes from 5 million to 500 million light-years."

But that wasn't all.

The team looked at other morphological features, such as the number of filaments connected to each node. The cosmic web, based on a sample of 3,800 to 4,700 nodes, had on average 3.8 to 4.1 connections per node. The human cortex, for a sample of 1,800 to 2,000 nodes, had an average of 4.6 to 5.4 connections per node.

In addition, both systems showed a tendency to cluster connections around central nodes. And both seem to have a similar information capacity.

A recent study suggests that the memory of the human brain is around 2.5 petabytes. Another recent study, by Vazza, suggests that the memory capacity required to store the complexity of the Universe is around 4.3 petabytes.

"Roughly speaking," the researchers wrote in 2017, "this similarity in memory capacity means that the entire body of information that is stored in a human brain (for instance, the entire life experience of a person) can also be encoded into the distribution of galaxies in our universe."

That's not to say that the Universe is a brain, or capable of sentience. But it does hint that the laws that govern the growth of the structures of both could be the same.

According to a 2012 paper based on simulations, the causal network representing the large-scale structure of spacetime in our accelerating universe is a power-law graph remarkably similar to the human brain.

Studies such as this one, by Vazza and Feletti, could pave the way to better understanding those laws.

"Once again, structural parameters have identified unexpected agreement levels. Probably, the connectivity within the two networks evolves following similar physical principles, despite the striking and obvious difference between the physical powers regulating galaxies and neurons," Feletti said.

"These two complex networks show more similarities than those shared between the cosmic web and a galaxy or a neuronal network and the inside of a neuronal body."

The research has been published in *Frontiers in Physics*.

Voyage through the hidden physics of the cosmic web

- Original Article
- Published: 03 May 2021
- Volume 51, pages 1043–1079, (2021)
- Cite this article

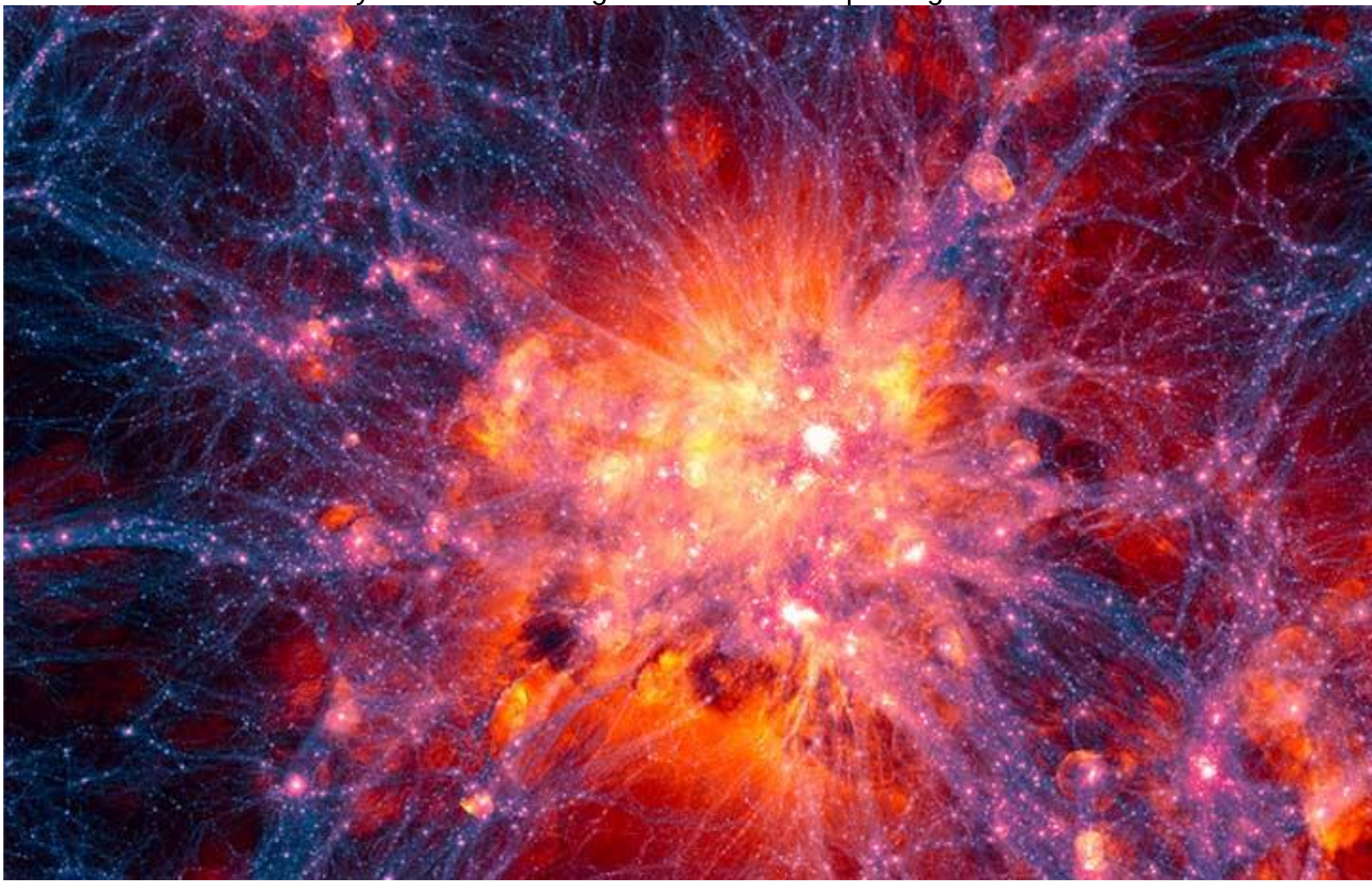
Abstract

The majority of the ordinary matter in the local Universe has been heated by strong structure formation shocks and resides in a largely unexplored hot, diffuse, X-ray emitting plasma that permeates the halos of galaxies, galaxy groups and clusters, and the cosmic web. We propose a next-generation "Cosmic Web Explorer" that will permit a complete and exhaustive understanding of these unseen baryons. This will be the first mission capable to reach the accretion shocks located several times farther than the virial radii of galaxy clusters, and reveal the out-of-equilibrium parts of the intra-cluster medium which are live witnesses to the physics of cosmic accretion. It will also enable a view of the thermodynamics, kinematics, and chemical composition of the

circumgalactic medium in galaxies with masses similar to the Milky Way, at the same level of detail that *Athena* will unravel for the virialized regions of massive galaxy clusters, delivering a transformative understanding of the evolution of those galaxies in which most of the stars and metals in the Universe were formed. Finally, the proposed X-ray satellite will connect the dots of the large-scale structure by mapping, at high spectral resolution, as much as 100% of the diffuse gas hotter than 10^6 K that fills the filaments of the cosmic web at low redshifts, down to an over-density of 1, both in emission and in absorption against the ubiquitous cosmic X-ray background, surveying at least 1600 square degrees over 5 years in orbit. This requires a large effective area ($\sim$10 m^2 at 1 keV) over a large field of view ($\sim$1 deg^2), a megapixel cryogenic microcalorimeter array providing integral field spectroscopy with a resolving power $E/\Delta E$ = 2000 at 0.6 keV and a spatial resolution of 5″ in the soft X-ray band, and a low and stable instrumental background ensuring high sensitivity to faint, extended emission.

How to make the cosmic web give up the matter it's hiding

Half the universe's ordinary matter is missing. This new technique might have found it.



A TANGLED SKEIN This computer simulation of the universe highlights its structure: long filaments of dark matter (blue) with galaxies strung along them like beads (pink). Most of the regular matter is probably stored in gas (orange).

OCTOBER 11, 2017 AT 7:00 AM

Evidence is piling up that much of the universe's missing matter is lurking along the strands of a vast cosmic web.

A pair of papers report some of the best signs yet of hot gas in the spaces between galaxy clusters, possibly enough to represent the half of all ordinary matter previously unaccounted for. Previous studies have hinted at this missing matter, but a new search technique is helping to fill in the gaps in the cosmic census where other efforts fell short. The papers were published online at arXiv.org on September 15 and September 29.

Two independent teams stacked images of hundreds of thousands of galaxies on top of one another to reveal diffuse filaments of gas connecting pairs of galaxies across millions of light-years. Measuring how the gas distorted the background light of the universe let the researchers determine the mass of ordinary matter, or baryons, that it held — the protons and neutrons that make up atoms.

"It's a very important problem," says Dominique Eckert of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany, who has searched for the missing matter via X-rays emitted by individual strands. "If you want to understand how galaxies form and how everything forms within a galaxy, you have to understand the evolution of the baryon content." That starts with knowing where it is.

About 85 percent of the matter in the universe is mysterious, invisible stuff called dark matter, which physicists have yet to find (*SN Online: 9/6/17*). Weirdly, about half of the ordinary matter is also unaccounted for. When astronomers look around at the galaxies in the nearest few billion light-years, they find only about half the baryons that should have been produced in the Big Bang.

The rest is probably hiding in long filaments of gas that connect galaxy clusters in a vast cosmic web (*SN: 3/8/14, p. 8*). Previous attempts to find the baryons focused on X-rays emitted by gas in the filaments (*SN Online: 8/4/15*) or on the light of distant quasars filtering through these cobwebby strands (*SN: 5/13/00, p. 310*). But those efforts were either inconclusive, or were sensitive to such a narrow range of gas temperatures that they missed much of the matter.

Now there might be a way to find the rest. Two groups — cosmologist Hideki Tanimura, who did the work while at the University of British Columbia in Vancouver, and his colleagues, and Anna de Graaff of the University of Edinburgh and her colleagues — have sought the missing matter in a new way. Both teams found a way to look through the gas all the way back to the oldest light in the universe.

"Filamentary gas is very difficult to detect, but now we have a technique to detect it," says Tanimura, now with the Institute of Space Astrophysics in Orsay, France.

That ancient light, called the cosmic microwave background, was emitted 380,000 years after the Big Bang. When this light passes though clouds of electrons in space — such as those found in filaments of hot gas — it gets deflected and distorted in a specific way. The Planck satellite released an all-sky map of these distortions in 2015 (*SN: 3/21/15, p. 7*).

Tanimura and de Graaff separately figured that there would be more distortion along the filaments than in empty space. To locate the filaments, both teams chose pairs of galaxies from the Sloan Digital Sky Survey catalog that were at least 20 million light-years apart. De Graaff's team chose roughly a million pairs, and Tanimura's team chose

262,864 pairs. Both teams assumed that the galaxies were not part of the same cluster, but that they should be connected by a filament.

The filaments were still too faint to see individually, so the teams used software to layer all the images and subtracted out distortion from electrons in the galaxies to see what was left. Both saw a residual distortion in the cosmic microwave background, which they attribute to the filaments.

Next, de Graaff's team calculated that those filaments account for 30 percent of the total baryon content of the universe. That's surely an underestimate, since they didn't examine every filament in the universe, the team writes — the rest of the missing matter is probably there too.

"Both groups here took the obvious first step," says Michael Shull of the University of Colorado Boulder, who was not involved in the new studies. "I think they're on the right track." But he worries that the gas they see might have been ejected from galaxies at high speeds, and so not actually the missing matter at all.

Eckert also worries that the gas may belong more to the galaxies than to their intergalactic tethers. Future observations of the composition of the gas, as well as more sensitive X-ray observations, could help solve that part of the puzzle.

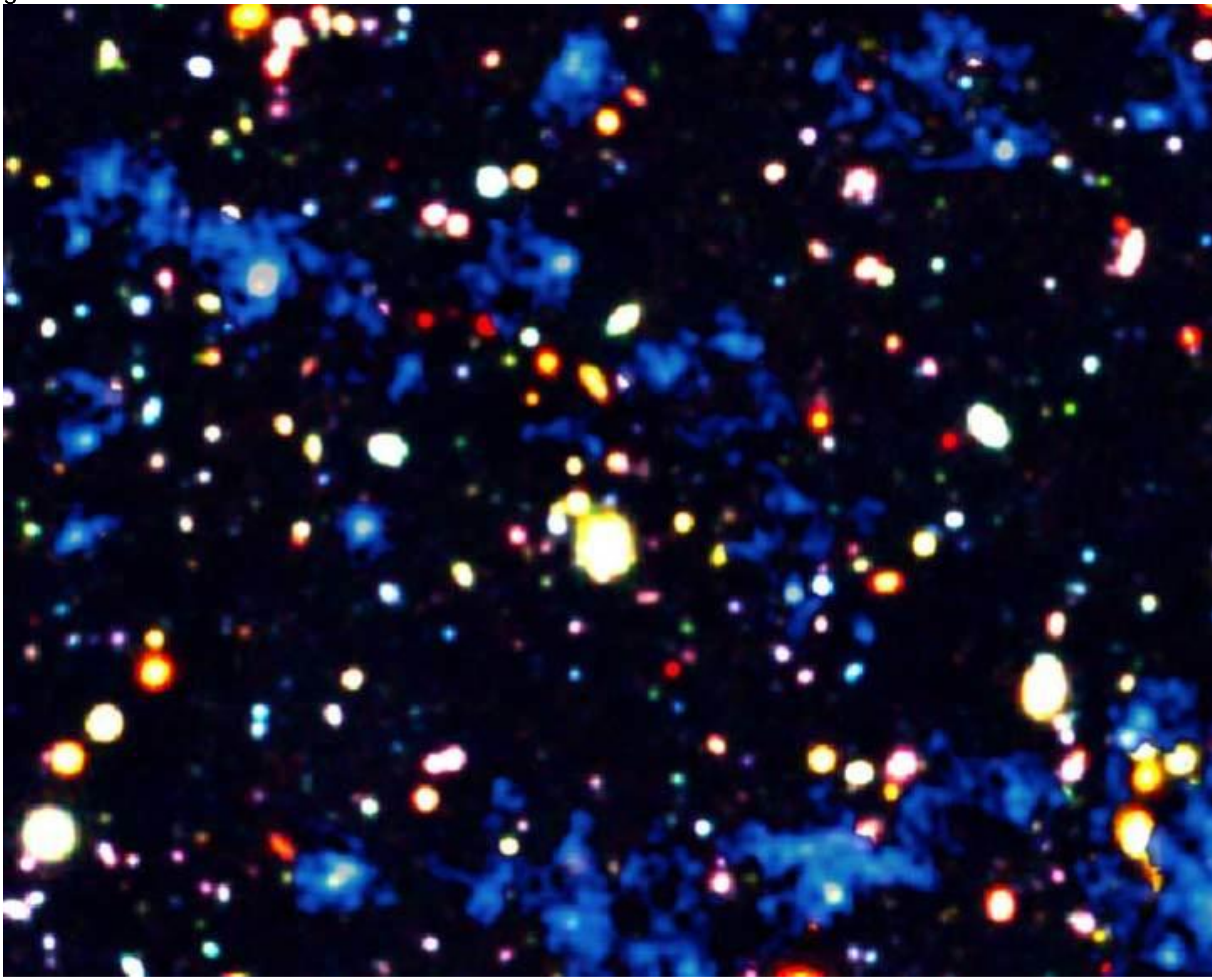
CITATIONS

H. Tanimura et al. A search for warm/hot gas filaments between pairs of SDSS luminous red galaxies. arXiv:1709:05024v1. Posted online September 15, 2017.

A. de Graaff et al. Missing baryons in the cosmic web revealed by the Sunyaev-Zel'dovich effect. arXiv:1709.10378v1. Posted online September 29, 2017.

A new image reveals the structure of the cosmic web

Researchers have mapped light emitted by tendrils of gas that are strung between galaxies



Scientists have spotted filaments of gas (blue) in the cosmic web, which thread between galaxies (bright spots). The gas and some of the galaxies are part of a protocluster, a clump of galaxies in the process of forming.
HIDEKI UMEHATAS

OCTOBER 3, 2019 AT 2:00 PM

Like an ethereal cosmic spider web, filaments of gas form a complex, interconnected structure that links galaxies to one another. But, just as whisper-thin threads of spider silk can be nearly invisible, this cosmic web is faint and difficult to detect. Now astronomers have made the first detailed picture of light emitted by the gas. The newly revealed filaments extend for millions of light-years, researchers report in the Oct. 4 *Science*.

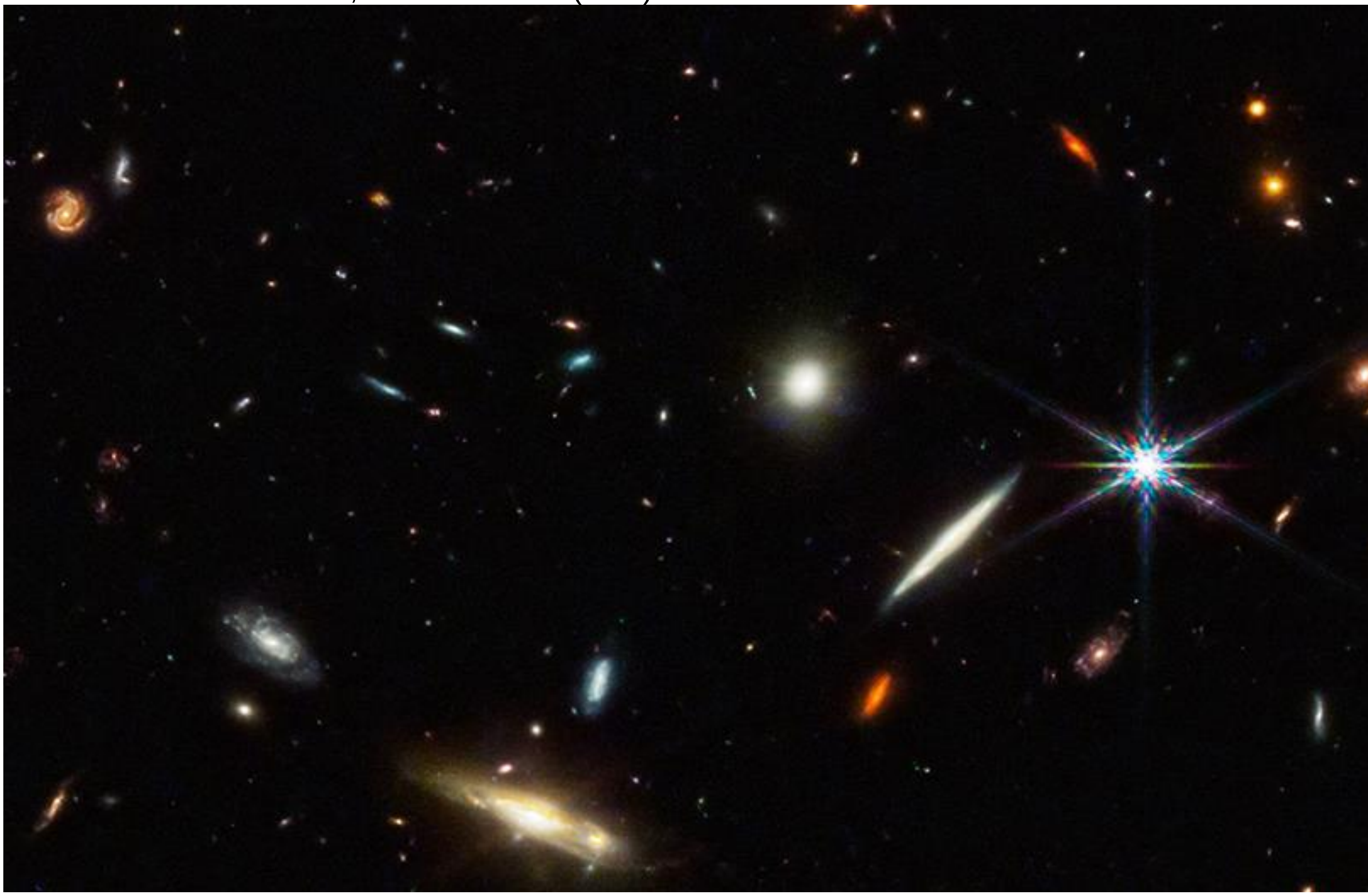
Computer simulations predicted the existence of the cosmic web, and astronomers previously have caught glimpses of a single filament (*SN: 1/20/14*). But scientists hadn't seen the network stretching between multiple galaxies until now. "Finally, we actually have a picture," says astrophysicist Michele Fumagalli of Durham University in England.

Fumagalli and colleagues studied a region of the sky that contains a protocluster of galaxies — a region where a large cohort of galaxies is beginning to assemble. Galaxies within the cluster emit ultraviolet light, a result of new stars forming inside or of churning regions around supermassive black holes at the galaxies' centers. The filaments of gas absorb that light and reemit it. Using the European Southern Observatory's Very Large Telescope in Chile, the astronomers detected the reemitted light.

After the Big Bang 13.8 billion years ago, scientists believe that gravity caused matter to collapse into sheets and filaments. In regions where the matter was especially dense, galaxies formed, feeding on gas from the cosmic web. The new picture of the filaments supports this origin story.

NASA's Webb Identifies the Earliest Strands of the Cosmic Web

June 29, 2023 10:00AM (EDT)Release ID: 2023-124



Summary

A filament of 10 galaxies seen just 830 million years after the birth of the universe

Woven across our universe is a weblike structure of galaxies called the cosmic web. Galaxies are strung along filaments in this vast web, which also contains enormous voids. Now, astronomers using Webb have discovered an early strand of this structure, a long, narrow filament of 10 galaxies that existed just 830 million years after the big bang. The 3 million light-year-long structure is anchored by a luminous quasar – a galaxy with an active, supermassive black hole at its core. The team believes this early thread of the cosmic web will eventually evolve into a massive cluster of galaxies.

The same study also probes the properties of eight quasars in the young universe. Scientists determined that the galaxies' central black holes, which existed less than a billion years after the big bang, range in mass from 600 million to 2 billion times that of our Sun. They are still working to explain how these black holes could grow so large so fast.

Full Article

Galaxies are not scattered randomly across the universe. They gather together not only into clusters, but into vast interconnected filamentary structures with gigantic barren voids in between. This "cosmic web" started out tenuous and became more distinct over time as gravity drew matter together.

Astronomers using NASA's James Webb Space Telescope have discovered a thread-like arrangement of 10 galaxies that existed just 830 million years after the big bang. The 3 million light-year-long structure is anchored by a luminous quasar – a galaxy with an active, supermassive black hole at its core. The team believes the filament will eventually evolve into a massive cluster of galaxies, much like the well-known Coma Cluster in the nearby universe.

"I was surprised by how long and how narrow this filament is," said team member Xiaohui Fan of the University of Arizona in Tucson. "I expected to find something, but I didn't expect such a long, distinctly thin structure."

"This is one of the earliest filamentary structures that people have ever found associated with a distant quasar," added Feige Wang of the University of Arizona in Tucson, the principal investigator of this program.

This discovery is from the ASPIRE project (A SPectroscopic survey of biased halos In the Reionization Era), whose main goal is to study the cosmic environments of the earliest black holes. In total, the program will observe 25 quasars that existed within the first billion years after the big bang, a time known as the Epoch of Reionization.

“The last two decades of cosmology research have given us a robust understanding of how the cosmic web forms and evolves. ASPIRE aims to understand how to incorporate the emergence of the earliest massive black holes into our current story of the formation of cosmic structure,” explained team member Joseph Hennawi of the University of California, Santa Barbara.

Growing Monsters

Another part of the study investigates the properties of eight quasars in the young universe. The team confirmed that their central black holes, which existed less than a billion years after the big bang, range in mass from 600 million to 2 billion times the mass of our Sun. Astronomers continue seeking evidence to explain how these black holes could grow so large so fast.

“To form these supermassive black holes in such a short time, two criteria must be satisfied. First, you need to start growing from a massive ‘seed’ black hole. Second, even if this seed starts with a mass equivalent to a thousand Suns, it still needs to accrete a million times more matter at the maximum possible rate for its entire lifetime,” explained Wang.

“These unprecedented observations are providing important clues about how black holes are assembled. We have learned that these black holes are situated in massive young galaxies that provide the reservoir of fuel for their growth,” said Jinyi Yang of the University of Arizona, who is leading the study of black holes with ASPIRE.

Webb also provided the best evidence yet of how early supermassive black holes potentially regulate the formation of stars in their galaxies. While supermassive black holes accrete matter, they also can power tremendous outflows of material. These winds can extend far beyond the black hole itself, on a galactic scale, and can have a significant impact on the formation of stars.

“Strong winds from black holes can suppress the formation of stars in the host galaxy. Such winds have been observed in the nearby universe but have never been directly observed in the Epoch of Reionization,” said Yang. “The scale of the wind is related to the structure of the quasar. In the Webb observations, we are seeing that such winds existed in the early universe.”

These results were published in two papers in The Astrophysical Journal Letters on June 29.

IN A FIRST, ASTRONOMERS DIRECTLY IMAGE THE COSMIC WEB

BY: COLIN STUART OCTOBER 5, 2023 0

Astronomers have directly imaged emission from the cosmic web, the filamentary structure that underlies the universe.

Astronomers have taken an unprecedentedly detailed glimpse of the *cosmic web*, the faint network of gaseous filaments that feed galaxies with new material like rivers draining into the ocean. The new data could help us better understand how galaxies form and evolve.

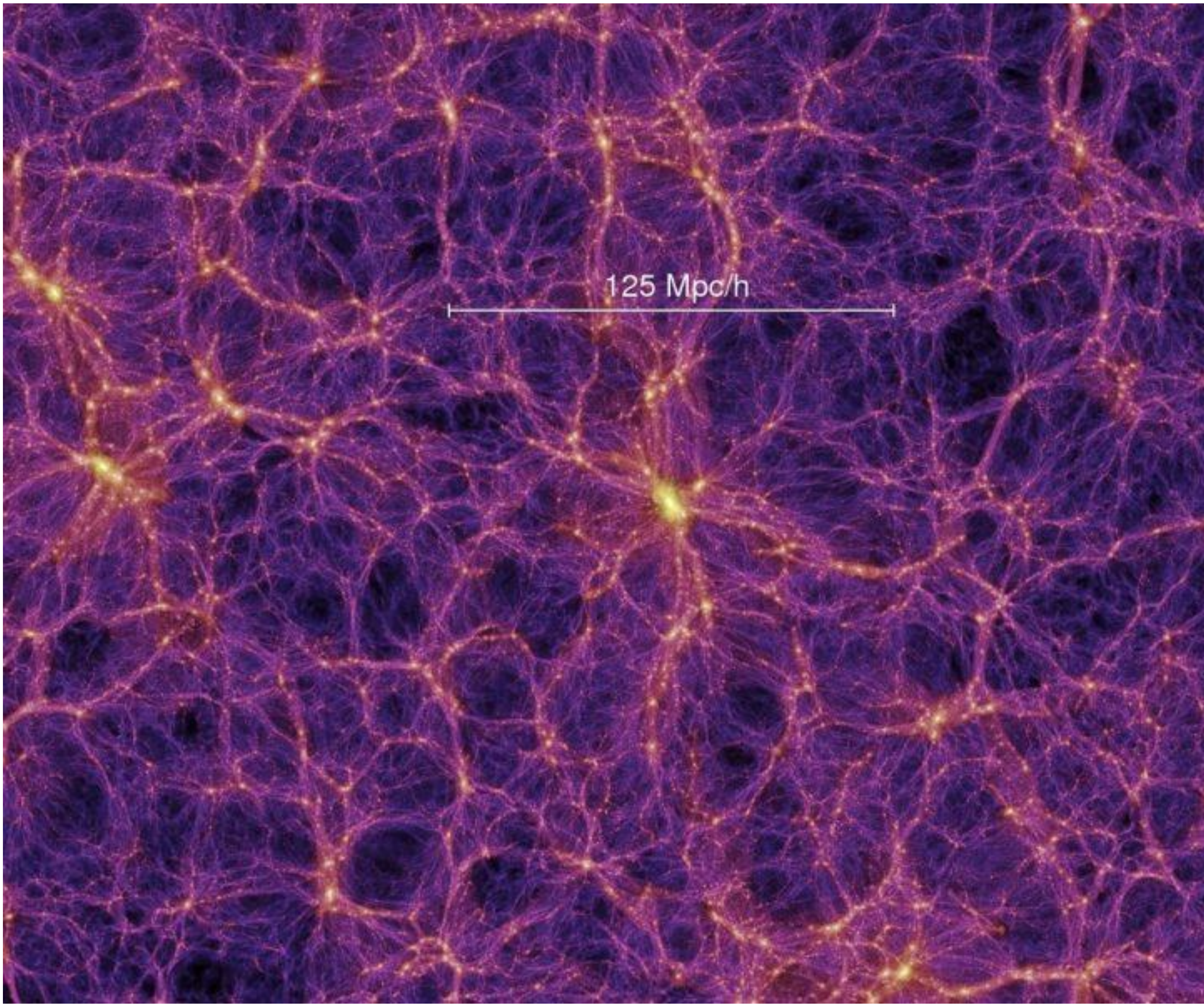
Galaxies may appear as islands in the vast black ocean of space, but they are more interconnected than they seem. They tend to cluster together, and often there are long strands of material joining them. It's like galaxies are bright fairy lights strung out on a barely visible cord. That cord can transfer material along it to galaxies and is thought to play a key role in galaxy formation.

Back in 2015, Christopher Martin (Caltech) used the Cosmic Web Imager at the Palomar Observatory in California to image a small section of this cosmic cord. He revealed a long filament funneling gas into a still-growing protogalaxy in the early universe. However, it was only possible to see the filament because it was illuminated by the intense light of a quasar.

Inspired by those findings, Martin and his team set about designing the Keck Cosmic Web Imager at the W. M. Keck Observatory in Hawai‘i. The plan was to probe darker parts of the cosmic web not conveniently illuminated by quasars. It worked. “Before this latest finding, we saw the filamentary structures under the equivalent of a lamppost,” says Martin. “Now we can see them without a lamp.” The team’s findings are published in *Nature Astronomy*.

To build up a 3D picture of the cosmic web, the team used spectroscopy. They split light from the distant universe into its constituent colours and looked for the 121.5-nanometer-wavelength emission from hydrogen atoms, known as *Lyman alpha*. The farther away the emission comes from, the more it will have shifted toward the red end of the spectrum, thanks to the expansion of the space.

The result is a forest-like spectrum, each “tree” representing emission from gas located at different points in space and time. “We are basically creating a 3D map of the cosmic web,” Martin says. “We take spectra for every point in an image at a range of wavelengths, and the wavelengths translate to distance.”



The large-scale structure of the universe takes the shape of a cosmic web, as shown here in a frame from a simulation. Filaments between galaxies and galaxy clusters are made of ionized gas and dark matter. The scales are huge: The scalebar in the image translates to 400 million light-years.
Springel et al. (2005)

However, the light from the cosmic web is very dim and can be easily confused with light sources closer to home, such as from our atmosphere or the solar system. To get around this issue, the team compared two patches of the sky, which they called "A" and "B."

"The [cosmic web] structures will be at distinct distances in the two directions in the patches, so you can take the background light from image B and subtract it from A, and vice versa, leaving just the structures," Martin explains.

The result? According to Martin, astronomers now have "a whole new way to study the universe." Fellow Caltech team member Mateusz Matuszewski is equally enthused. "We are very excited about what this new tool will help us learn about the more distant filaments and the era when the first stars and black holes formed," he says.

There is potentially more to come. The team has recently installed the second part of the project, known as the Keck Cosmic Reionization Mapper. It will probe longer wavelengths even further toward the red end of the spectrum, and therefore further away in space and further back in time. The efforts reported here focused on Lyman-alpha emissions shifted to the 350- to 560-nanometer range.

The team's work has even been turned into a piece of music to celebrate the life of astronaut Michael Anderson, who died in the 2003 Space Shuttle Columbia accident. Martin says he "pretended the filaments were giant violin strings," and translated the filaments' masses to frequencies based around middle C.

Hey, good evening!

Let's get started with your conversation

Sent by you:

Is the universe a giant brain? Prove this theory.

Sent by Copilot:

The idea that the universe might function like a giant brain is a fascinating one! This theory suggests that the universe's structure and behavior resemble the neural networks of a brain. Here are some key points:

1. **Structural Similarities**: Studies have shown that the large-scale structure of the universe, with its vast networks of galaxies, resembles the neural networks in a human brain. Both systems have nodes (galaxies or neurons) connected by filaments (cosmic filaments or axons) [1][2].
2. **Growth Patterns**: Research published in *Nature's Scientific Reports* indicates that the universe grows in a manner similar to a brain, with the electrical firing between brain cells mirrored by the shape of expanding galaxies [3][2].
3. **Complex Systems**: Both the universe and the brain are complex systems that evolve over time. The interactions within these systems can lead to emergent behaviors that are not easily predictable from their individual components [1].

While these similarities are intriguing, it's important to note that this theory is more metaphorical than literal. The universe doesn't have consciousness or thoughts like a brain does. Instead, the comparison helps scientists understand the complex and interconnected nature of the cosmos.

What do you find most interesting about this theory?
1independent.co.uk2anomalien.com3viralnovelty.net4newscientist.com5bigthink.com

Sent by you:
I think that's where the Kardashev scale comes into play. Advanced Civilizations are a major part of the consciousness of the universe. Advance this theory?

Sent by Copilot:
The Kardashev Scale is indeed a fascinating framework for thinking about advanced civilizations and their potential impact on the universe. Let's explore how this ties into the idea of the universe as a giant brain:

Kardashev Scale Overview

The Kardashev Scale measures a civilization's level of technological advancement based on its energy consumption:

1. **Type I**: Utilizes all available energy on its home planet.
2. **Type II**: Harnesses the energy of its star (e.g., through a Dyson Sphere).
3. **Type III**: Controls energy on the scale of its entire galaxy.

Advanced Civilizations and Universal Consciousness

1. **Energy Manipulation**: As civilizations advance, their ability to manipulate energy on a massive scale could influence the structure and behavior of the universe. For instance, a Type III civilization might engineer entire galaxies, potentially creating patterns and networks reminiscent of neural connections.
2. **Information Processing**: Advanced civilizations could develop technologies that process information on a cosmic scale. This could lead to a form of "cosmic consciousness," where the universe itself becomes a vast information network, akin to a brain.
3. **Interconnected Systems**: Just as neurons in a brain communicate through electrical signals, advanced civilizations might communicate and interact across vast distances, creating a web of interconnected systems. This could enhance the universe's complexity and emergent behaviors, furthering the brain-like analogy.
4. **Impact on Evolution**: The actions of advanced civilizations could drive the evolution of the universe in specific directions, much like how neural activity shapes brain development. This could include the creation of new stars, planets, or even artificial structures on a galactic scale.

Speculative Nature

While these ideas are speculative, they offer a thought-provoking way to consider the potential role of advanced civilizations in the universe. The Kardashev Scale provides a framework to imagine how such civilizations might contribute to a form of universal consciousness, enhancing the metaphor of the universe as a giant brain.

The earth is home to 8.7 million species of life. Over billions of years of evolution,
0:15
life has discovered ways of inhabiting every possible niche, including Earth's most extreme
0:21
environments. And yet for all of the exotic and colorful displays of life on this planet its
0:28
most striking feature is invisible. Beyond life's diverse and complex outward behaviors scientists
0:38
now agree that not only we humans but millions of other species are also the subject of a felt inner
0:46
dimension - a conscious mind. Of all of life's remarkable displays, it is this illumination of
0:54
the universe through consciousness which makes life so extraordinary. While consciousness is
1:02
unmistakably life's most remarkable feature, it is also its most mysterious. Despite all of our
1:10
scientific advancements we remain completely in the dark about how we or any other life
1:17
came to possess consciousness. How could purely physical processes, such as those of the brain
1:24
and the nervous system somehow creates a subjective inner dimension? The very fact that reality
1:31
supports subjective experience is an extraordinary mystery, comparable perhaps only to the mystery
1:38
of existence itself. And yet consciousness is far more than a tricky philosophical problem,
1:45
it is through consciousness that all meaning value and significance enter the universe.
1:52
In conscious life, the universe creates a means through which it has become aware of itself.
1:59

As the cosmologist Carl Sagan famously put it, “We are a way for the cosmos to know itself."
2:10
Viewed in this way, the emergence of conscious life is a moment of great cosmic significance.
2:17
Transforming the universe into a process capable of reflecting on its own nature and development.
2:26
But is this simply an arbitrary event in an absurd and indifferent universe? Or is it a
2:32
clue to the deeper character of reality itself? An ancient and divisive question is whether conscious
2:40
life developed through purely random events or whether it was in some sense destined to happen.
2:47
The controversy of considering this possibility stems from its teleological aspect:
2:54
that the universe has a kind of purpose or goal. While teleological views were central to much
3:01
ancient and pre-scientific thought, the rise of deterministic science and later Darwinian theory,
3:09
saw teleological explanations appear increasingly obsolete. Without any
3:15
inherent purpose or overarching goal, the life of Earth could now plausibly be seen as having
3:22
slowly evolved over billions of years, driven by nothing but blind and iterative natural selection.
3:30
Together with the predictive power of determinism it now seemed that a complete physical science
3:36
requires no indwelling purpose - only a rigorous deterministic account of causes and effects.
3:45
To argue that nature was predisposed to create conscious life is therefore to caught controversy.
3:52
At least on the surface it appears to lend support to naive and pre-scientific views of
3:58

the natural world. It also challenges the completeness of current darwinian
4:03
thinking as well as the prevailing materialist view of the universe. Who then, aside from the
4:11
religiously motivated, would dare defend such a heretical claim?
4:16
It may be surprising to learn that several prominent philosophers and scientists argue
4:22
that life and mind are no accident of evolution, and that the universe may indeed contain a type of
4:29
natural teleology - a cosmic imperative towards the development of life and mind.
4:36
It is this fascinating yet controversial possibility that we will explore today.
4:45
Part One ~ The Life-Friendly Universe. A surprising discovery of the last century
4:51
is that the constants which shape the development of the universe appear finely tuned to permit the
4:58
evolution of complex life. Change any one of a number of extremely subtle constants
5:05
and the universe becomes utterly inhospitable to any form of life or complexity whatsoever.
5:14
The most famous example of this apparent fine tuning is gravity. The force of gravity
5:21
is approximately a thousand times weaker than the other forces affecting the behavior of atoms.
5:27
It is now known that if gravity was only slightly stronger, stars would have developed from less
5:34
material and as a result would have been smaller with significantly shorter lifespans. From living
5:40
around 10 billion years typical stars would have lived only for around 10,000 which is of course,
5:47
a much shorter time than the billions of years required for biological evolution to take place.
5:56

The consequences for life are also catastrophic if gravity had been just fractionally weaker.
6:03
Stars would have burnt at cooler temperatures and so would never have gone supernova. The
6:09
result would be that the heavy elements required for life would never have come into existence.
6:15
Taken on its own gravity is a conspicuous example of fine tuning,
6:21
and yet there are believed to be upwards of 20 such cases - extremely subtle constants,
6:27
any change to which and all hope for even the most imaginative notions of life are crushed.
6:35
If all of the discovered cases of fine-tuning are taken together   the probability of a life-friendly universe occurring through chance is trillions to one.
6:47
As the cosmologist Michael Turner has put it, (quote) "The precision is as if one could throw a
6:53
dart across the entire universe and hit a bullseye one millimeter in diameter on the other side."
7:03
So what does this apparent fine-tuning mean? It is widely considered that there are just two
7:09
possible answers: That either the universe was intelligently designed by a powerful creator,
7:16
or that the universe is in fact just one among trillions of others, containing the full gamut
7:22
of possible laws and constants, occupying a transcendent realm known as the "multiverse."
7:31
To those who lack faith, the religious explanation is unsatisfying, and yet the multiverse theory
7:39
also has staunch critics within the scientific community.   As the physicist Paul Davies has remarked, (quote) "Invoking an infinity of unseen universes to
7:50

explain the unusual features of the one we do see is just as ad hoc as invoking an unseen creator.
7:58
The multiverse theory may be dressed up in scientific language   but in essence it requires the same leap of faith." (end quote) What naturalistic process
8:11
could possibly create a universe generating mechanism that churns out trillions upon
8:17
trillions of universes, while simultaneously sustaining their differing laws and constants?
8:23
How could such a complex mechanism come into existence and based on what laws, and from where?
8:31
Worse still, our questions about the multiverse may never be answered because its transcendent
8:37
realm lies forever beyond the bounds of our space and time. The multiverse is a fascinating
8:45
metaphysical speculation about the larger cosmic ensemble, but as Davies argues, a more measured
8:52
response to fine-tuning is not to assume the existence of trillions of unseen universes,
8:59
but to first exhaust possible explanations of the universe we do see from within.
9:05
And given its mysteriously life-friendly conditions, Davies argues that we should
9:11
take very seriously the possibility that life and consciousness are important features of it.
9:20
Part Two ~ A Universe of Value This was a view explored by the philosopher
Philip Goff. Goff suggests that the universe may appear
9:31
to be finely tuned precisely because it is. For Goff, what is conspicuous about fine-tuning
9:40
is not that it permitted the existence of humanity or even life in general, but that the constants
9:46
are precisely those as to permit the existence of a (quote) "universe of great value" and with
9:53

it the necessary existence of conscious life. For Goff, the possibility that value is the causative
10:02
force of reality is more plausible than it may at first appear. He points out that physical science
10:09
reveals neither what things are in themselves or the underlying causes of physical events.
10:16
In fact, all we perceive of the natural world are its regularities. It is therefore reasonable to
10:24
consider that it is a responsiveness to value that animates the causal structure of reality.
10:32
That, (quote) "the universe, through responding to value, fine-tuned itself."
10:41
Another thinker who argues that the universe was predisposed to the creation of conscious life
10:47
is the philosopher Thomas Nagle. Like Goff, an important element of Nagel's thinking
10:53
is that he is a realist about consciousness. both Nagel and Goff argue that consciousness
11:00
is a real and undeniable feature of reality that science must eventually expand to include.
11:08
We focused on this type of view in the previous episode in our exploration of panpsychism,
11:14
and yet while this has become a respectable albeit minority position, Nagel also goes further,
11:21
considering that conscious life may play an essential role in the universe, that it was
11:27
required to exist. Nagel points out that neo-darwinian evolution, as a purely materialist
11:35
theory, offers no explanation of how consciousness emerged in living organisms or the function that
11:42
it serves. And if materialism is insufficient to explain life's most striking feature,
11:50

then a strictly materialist view of evolution is likely to be incomplete in other important respects. One area that Nagel considers is the origin of life.
12:03
Several prominent scientists have pointed out that, as a product of random molecular collisions,
12:10
even the most primitive self-replicating cell is such a staggeringly complex system that it
12:16
may be implausible to occur by chance in the entire projected lifespan of the universe. The
12:24
fact that life emerged on Earth approximately as soon as the conditions for life existed,
12:30
therefore poses a serious problem to a purely random account of life's origin.
12:36
According to Nagel, something other than random chance is needed to explain life's emergence
12:42
from a dead environment - something by definition non-random, something teleological.
12:51
Problems facing darwinian theory, Nagel points out, are often minimized because there doesn't
12:57
appear to be any other natural explanation on the table. To criticize any aspect
13:03
of darwinian theory is often viewed as turning one's back on science and of offering support to
13:10
supernatural alternatives. Nagel argues however, that there is another option on the table,
13:17
what he calls "an alternative to a miracle" - that evolution is true, but that it is not an
13:24
entirely random mechanistic process. That the universe is predisposed to the creation
13:30
of complex conscious life. But what is it about conscious life that is required by the universe?
13:38
Similar to Goff, Nagel believes that the answer lies in a deeper understanding of value.
13:47

Nagel defends a position he calls "value realism" that value is not simply an illusory perception of
13:55
animal appetites and aversions but actually points to something true in a deeper sense.
14:02
We humans, in our evolved and complex societies, have created elaborate and often conflicting
14:09
structures around our perceptions of value, yet Nagel argues that our raw
14:15
apprehension of value within consciousness, most clearly apparent in the value of pleasure
14:21
and the dis-value of agony and suffering, are not mere social or biological constructs,
14:28
but are grounded in deeper truths about the real existence of value.
14:34
For nagel these truths are equivalent to the platonic truths of mathematics and
14:39
geometry - that just like two plus two equals four would be true even if the universe didn't exist,
14:48
there are truths concerning value which precede any physical existence. According to Nagel,
14:55
if we accept value realism, we must also confront its larger cosmic implications - that existence
15:03
entails value and that life and conscious beings may therefore be required as its realizers.
15:12
The philosopher John Leslie also defends a similar view. Leslie's focus goes beyond both evolution
15:19
and cosmic fine-tuning, to the ancient question of why anything exists at all.
15:26
Leslie argues that no physical theory can ever explain the origin of the universe
15:32
because any physical cause must always be preceded by another physical cause. To avoid an
15:40
infinite regression, Leslie argues that we must go deeper than physical mechanisms and consider that

15:47
something altogether different, something more like value is the realizing force of reality.
15:56
Like Goff, Leslie believes that there must be some ultimate metaphysical sense in which it is
16:02
good that the universe exists, and since it is only through consciousness that value or
16:09
goodness enter the universe, conscious beings may therefore be necessary features (of it).
16:18
Part Three ~ Future Attractor. As compelling as teleological views might seem
16:25
they face a serious problem. If the universe required conscious beings,
16:31
how did it exist in the billions of years before life arrived on the scene?
16:36
To the best of our knowledge there were no conscious beings at the beginning of the universe.
16:42
Significant time needed to elapse, for at least one generation of stars to go supernova
16:48
before the heavy elements required for life could exist. One reason that teleological views are so
16:56
controversial is that they appear to suggest that the universe deliberated about its future states
17:03
and then somehow chose between them. Such an activity would appear to invoke the existence
17:09
of a god-like mind, together with all of the inherent problems of explaining it.
17:15
It would seem that through teleological thinking we find ourselves back in theistic territory
17:22
attempting to explain the necessary existence of a powerful creator.
17:27
There is however, an alternative way of thinking about teleology - that rather
17:32
than proceeding exclusively from the past, causes might also arrive from the future.
17:42

Until recently physics offered no possible mechanism through which   causes could come from the future. That was until the development of quantum theory.
17:53
In the quantum world entities have been shown to exist in either a superposition of multiple
17:59
states simultaneously or as a distinct actuality. It is only upon measurement that quantum entities
18:08
assume the common sense behavior of classical objects. While this aspect of quantum theory
18:14
is already strange enough, it turns out that the measurement of a quantum system
18:20
not only determines the state of the system in that moment, but also resolves its entire history.
18:28
In other words, in our choosing to measure it, we can decide how a system existed in the past.
18:37
In quantum theory this is known as the "post-selection   effect" and it introduces a surprising retrocausal feature of physical reality.
18:48
Several thinkers have pointed out that this retrocausality opens the possibility of an
18:53
entirely new way of thinking about the origins of the universe. -That its initial state may be
19:00
intimately related to its future states, and the past and future exist interdependently.
19:08
The decorated theoretical physicist John Wheeler was both the first to recognize this quantum
19:15
post-selection effect, as well as to explore its far-reaching implications. According to Wheeler,
19:23
we have no reason to doubt that measurements we make at the present time stretch all the
19:29
way back to the beginning of the universe and thereby establish a consistent history of the
19:35
present choice to observe. In Wheeler's thinking we are not merely observers of the quantum world,

19:43
we are participators in the origin of the universe itself. Wheeler considered that this could well
19:51
be the reason that the universe appears so finely tuned for life - that only a universe
19:57
capable of producing observer participators could establish what he called "a self-excited circuit"
20:05
that brings the universe into existence. Wheeler summarized his view as follows, (quote) "The
20:13
participator gives the world the power to come into being through the very act of giving meaning
20:19
to that world. In brief, no consciousness, no communicating community to establish meaning,
20:27
then no world! On this view the universe is to be compared to a circuit self-excited in this sense,
20:35
that the universe gives birth to consciousness and consciousness gives meaning to the universe." (end
20:42
quote) Wheeler: We have no right to say that the past exists independent of the act of observation.
20:51
In this sense we have become participators in the construction of the universe.
20:59
While it was seriously considered by several of the founding contributors to quantum theory,
21:05
attributing any significance of consciousness in quantum measurement is now a controversial
21:11
position in mainstream physics. In spite of this, several contemporary physicists argue
21:18
that the possibility cannot be ruled out. One such physicist is the father of inflation theory,
21:24
Andre Linde who writes, "Avoiding the concept of consciousness in quantum cosmology may lead to an
21:32

artificial narrowing of our outlook." (end quote) Paul Davies: Consciousness enters into quantum
21:39
physics at the point of observation where the rules of the quantum game change as a result of that observational measurement. Many physicists want to get rid of that, but i've always
21:49
felt that this is a missed opportunity. If we're going to actually incorporate consciousness into our description of physics it seems to me it's at the quantum level we should attempt to do that."
22:01
Part Four ~ The Cosmic Imperative One way of framing the question of purpose
22:07
in the universe is to consider what the universe is maximizing. Looking out on the universe from
22:15
our current vantage point it is by no means clear that the universe is maximizing conscious life.
22:22
What is apparent is that far greater complexity exists in the universe than at any previous time.
22:31
Furthermore, this complexity appears to be accelerating. At first only simple particles
22:39
existed, then an expanding diversity of stars, a vast archipelago of galaxies, the birth of heavy
22:48
elements, and then life - first simple and then exploding in diversity, consciousness,
22:56
then consciously driven evolution with the potential of reshaping planets and perhaps
23:01
eventually the entire universe. Setting aside any significance of life or consciousness,
23:09
how is this explosion of complexity possible?
23:14
The traditional conception of energy in the universe is that all order is slave to and
23:20
ultimately the victim of entropy, the second law of thermodynamics, which holds that over
23:27
time all systems will tend towards disorder. And yet we live in an ordered and intelligible cosmos,
23:36

not a chaos. And here lies the famous "problem of entropy" - that the universe, at least for now,
23:43
appears to be not losing but gaining order.
23:49
It is important to recognize that entropy is not the enemy of life. Indeed life's essential
23:56
functions are deeply dependent on entropy. And yet as defined as the tendency towards disorder,
24:04
entropy predicts that eventually all stars will die, all structure will decay, and finally
24:11
after trillions of years, there will be nothing but a cold featureless void. There is no question
24:19
that entropy accurately describes the behavior of thermodynamic systems. But can we rule out that
24:26
another kind of force also drives the universe, towards complexity? And that the incorporation
24:34
of this natural principle will dramatically change our outlook on the future of the universe?
24:41
This view was defended by the neuroscientist Christof Koch who also sees a close relationship
24:48
between complexity and consciousness. For Koch, consciousness is not an arbitrary emergence
24:56
out of a sufficient degree of complexity, but instead that consciousness is among nature's
25:02
deep fundamentals, and that it develops into more complex forms as systems acquire higher
25:09
and higher amounts of integrated information. According to Koch, this is no accident
25:16
of evolution - the universe is driven to maximize consciousness. In his 2012 book, Consciousness:
25:25
Confessions of Romantic Reductionist, he writes (quote) "I do believe that the laws of the
25:32

universe overwhelmingly favored the emergence of consciousness. The universe is a work in progress.
25:39
Such a belief evokes jeremiads from many biologists and philosophers, but the evidence from cosmology, biology, and history is compelling." (end quote)
25:53
Let us then consider that a cosmic imperative compels the evolution of
25:58
consciousness in the universe. Where will this evolution eventually lead?
26:04
Philip Goff has suggested that the existing universe might be as good as it gets - that the universe is not all powerful in its ability to realize value,
26:15
and that this may be why it contains, in addition to any value, many states of suffering and pain.
26:24
Speaking personally, it would seem to me that to regard the present time in history
26:30
as the apex of value is arbitrary, especially given the vast projected future of the universe
26:37
and the possibilities of advanced conscious beings which could eventually inhabit deep time.
26:44
It would seem to me that the universe's capacity for value is enormously greater than is currently
26:51
represented, and not because of constraints in the laws of physics, but because it has
26:56
not yet unfolded in time. A more viable signal of value to which the universe is responsive
27:04
would be a singularity - a time, perhaps trillions of years in the future, in which life and mind
27:11
have saturated the entire universe, producing a highly conditioned state and a realized value
27:19
trillions of times greater than anything currently in existence.
27:25
The physicist Paul Davies, who has defended a role for consciousness in quantum mechanics,
27:31

has also elaborated on John Wheeler's concept of the universe as a self-excited circuit.
27:38
Davies considers that it could well be the destiny of life to saturate the entire cosmos,
27:45
resulting in a universe that eventually achieves closure by becoming what Davies described as,
27:52
"completely self-known" Davies is not the first to suggest this possibility.
27:59
In the early 20th century, the philosopher Pierre Teilhard de Chardin argued that, over billions
28:07
perhaps trillions of years, the natural course of evolution will lead intelligent conscious life
28:13
to spread throughout the universe, culminating in a singularity of complexity, consciousness,
28:20
and intelligence that he called the "Omega Point." Is it possible that an apex of intelligence and
28:28
consciousness reaches back across time to the beginning of the universe and participates in
28:35
the conditions of its own existence? This theme has also been explored in science fiction.
28:43
In the author Isaac Asimov's The Last Question, a superintelligence finds itself alone at the end of
28:51
the universe, but now finally with an answer to its most fundamental question. And as it speaks
28:57
the answer, creates the cosmos. But is all of this just wishful thinking? No more than an
29:05
anthropomorphic projection of human desire onto a vast and indifferent universe? I would disagree.
29:14
The arguments we have explored were put forward by thinkers concerned primarily not with human
29:20

significance but with a deeper understanding of the nature of the universe in which we find
29:25
ourselves. To appropriate all value, meaning, understanding, and purpose to humans alone
29:33
seems itself to be the height of anthropomorphism. It seems entirely justified to consider that these
29:41
most striking features of the world reveal something important about the basic character
29:47
of the universe itself. A view of the universe in which consciousness plays an essential role
29:55
has the potential of entirely reframing how we see ourselves. Instead of viewing our lives as
30:02
a finite and ultimately meaningless struggle for survival in an indifferent universe, we become
30:09
participators in a larger evolutionary process, in which we are aligned with all other conscious
30:16
beings in existence. In such a view we are a part of a gradual evolutionary process, billions
30:25
perhaps trillions of years in the making, through which the universe itself is slowly waking up.
*

Beyond the Final Breath: How Consciousness Persists During Death

Death has long been shrouded in mystery, often seen as the ultimate end. But what if death is not the final chapter but rather a complex process? Research by Dr. Sam Parnia, a leading expert in resuscitation science, challenges our understanding of death.

His work suggests that death is not an absolute endpoint but a gradual process involving unique cognitive experiences.

Redefining Death

Traditionally, death has been defined as the irreversible cessation of heart function, known as death by cardiopulmonary criteria. However, advances in intensive care medicine have allowed doctors to artificially maintain a patient's heartbeat, even when the brain has suffered irreversible damage.

This has led to the concept of brain death, where the brain has died, but the heart continues to beat with medical intervention.

Dr. Parnia's research reveals that death is not an instantaneous event, but rather a process that unfolds over time. (ref) After a person's heart stops, the cells in their body, including the brain, begin their own gradual death process.

Contrary to previous beliefs, brain cells do not die within minutes of oxygen deprivation. In fact, it can take hours or even days for irreversible damage to occur.

The Paradox of Consciousness during Death

One of the most intriguing aspects of Dr. Parnia's research is the study of near-death experiences. (ref) Many patients who have been resuscitated report vivid and lucid cognitive experiences during the time when their brain function was severely compromised or even absent.

These experiences often involve a sense of leaving the body, observing the resuscitation efforts, and feeling a profound sense of peace.

The fact that patients can have well-structured thought processes and form memories during a time when their brain is highly dysfunctional challenges our understanding of consciousness.

It raises the possibility that consciousness may not be solely produced by the brain, but rather that the brain acts as an intermediary for a yet undiscovered scientific entity.

Implications for the Nature of Consciousness

Dr. Parnia's research has significant implications for our understanding of consciousness and its relationship to the brain.

If consciousness can persist even when brain function is severely impaired, it suggests that the mind may not be entirely dependent on the physical brain. This opens up new avenues for scientific exploration and philosophical inquiry.

Could consciousness be a fundamental aspect of reality, existing beyond the confines of the brain? Are there layers of reality that we have yet to discover which may shape our perception and experience?

The Future of Resuscitation Science

As resuscitation science continues to advance, we may gain a deeper understanding of the processes that occur during death and the potential for intervention.

Dr. Parnia's research highlights the importance of developing strategies to combat the accelerated cell death that occurs when oxygen and blood flow are restored to organs after resuscitation.

By understanding the mysteries of death and consciousness, we may not only improve medical outcomes but also gain profound insights into the nature of life itself.

The exploration of near-death experiences and the frontiers of resuscitation science hold the promise of transforming our understanding of what it means to be human.

Interoception: the little-known sixth sense that looks inward

When we think of our senses, the main ones that come to mind are sight, touch, smell, taste, and hearing. All of these senses reflect the body's ability to respond to external stimuli. But what about responding to what's happening inside our bodies? That's where interoception comes in.

Interoception is one of several "new" senses that are now at the forefront of scientific and medical research. Interoception is a particularly hot topic because we're starting to understand just how much it impacts our well-being. If you don't recognize the physical signals the body gives off when you're experiencing anxiety, then how can you take steps to calm it?

What is interoception?

Interoception is the awareness of the signals that your internal organs send to your brain. This includes the heart, the lungs, the gut, and the bladder. It's the ability to recognize the sensations coming from inside your body.

Behind the scenes

Our organs are in constant communication with our brains, but usually at a subconscious level that we're not aware of. We won't feel our bodies regulating our blood pressure or blood sugar levels, but there are certain internal sensations we are aware of.

The heartbeat

or example, if you sit quietly and close your eyes, you can feel your own heartbeat. In fact, you might be able to hear it like the sound is coming from inside your ears rather than outside.

Common signals

We're able to recognize all sorts of signals that our organs send to our brains, like hunger, thirst, nausea, the need to use the bathroom, and even itchiness (the skin is the body's largest organ, after all).

Interoception and emotions

Another example is the clenching of the stomach muscles or any other kind of tension in the body. This awareness of interoception is particularly important when it comes to our emotions and state of well-being.

Fear response

If you are suddenly faced with an angry growling dog, your body will respond in a flash. Your heart rate will increase and your muscles will tense up. This is a physiological reaction to fear, but it occurs before you even become aware that you're feeling fear.

Body before mind

According to modern scientists, we only become aware of our emotional state once we notice the change in our physical state through interoception. Fear, happiness, sadness, and excitement all give off physical signals within the body. Interoception is deeply linked to intuition.

Individual awareness

Each person has a different level of awareness of their interoceptive signals. A group of people could be asked to count their heartbeats over a minute without taking their pulse and then compare it to the real reading. There is likely to be a wide variation in how accurately they were able to count their heartbeats.

Impact on well-being

The awareness level of our interoceptive signals is directly linked to our ability to regulate our emotions. If you notice when your heart rate increases, your muscles are tense, and your breathing is shallow, you're able to recognize that you're upset or anxious.

Emotional intelligence

This gives you a better insight into what's happening at that moment and allows you to make better decisions. If you're feeling overwhelmed then you might pause, recognize the emotions, and take a few deep breaths. If you're having a confrontation with a co-worker, you can recognize that you're getting worked up and take a step back.

Interoception and mental health

If you are unaware and unfamiliar with your body's signals, then you're less likely to be able to regulate your emotions. This is why interoception is deeply linked with mental health and well-being.

Depression and disconnection

A study of a large group of people suffering from depression showed that they had low levels of interoceptive awareness of their heartbeats. If you're unable to feel the signals your body is sending, this may leave you feeling lethargic and emotionally numb. These are common symptoms of depression.

Anxiety and hyper-awareness

Those who suffer from anxiety are more likely to be in touch with their interoceptive signals, but may interpret them poorly. Physical symptoms of anxiety include increased heart rate, tightness in the chest, shallow breathing, increased body temperature, and many more.

Survival instincts

Our bodies react strongly to stress and anxiety because these are directly linked to our survival. Your body goes into an intense state of preparation when it senses a threat, releasing adrenaline and cortisol, and reducing functioning to non-essential organs.

Modern fear stimuli

Nowadays, a 'threat' might be a job interview or a social situation that makes us nervous, rather than a hungry tiger! Our bodies don't know that, but we do.

Regardless, some people with anxiety start to panic more when they notice the interoceptive signals that they're experiencing stress.

Catastrophizing of body signals

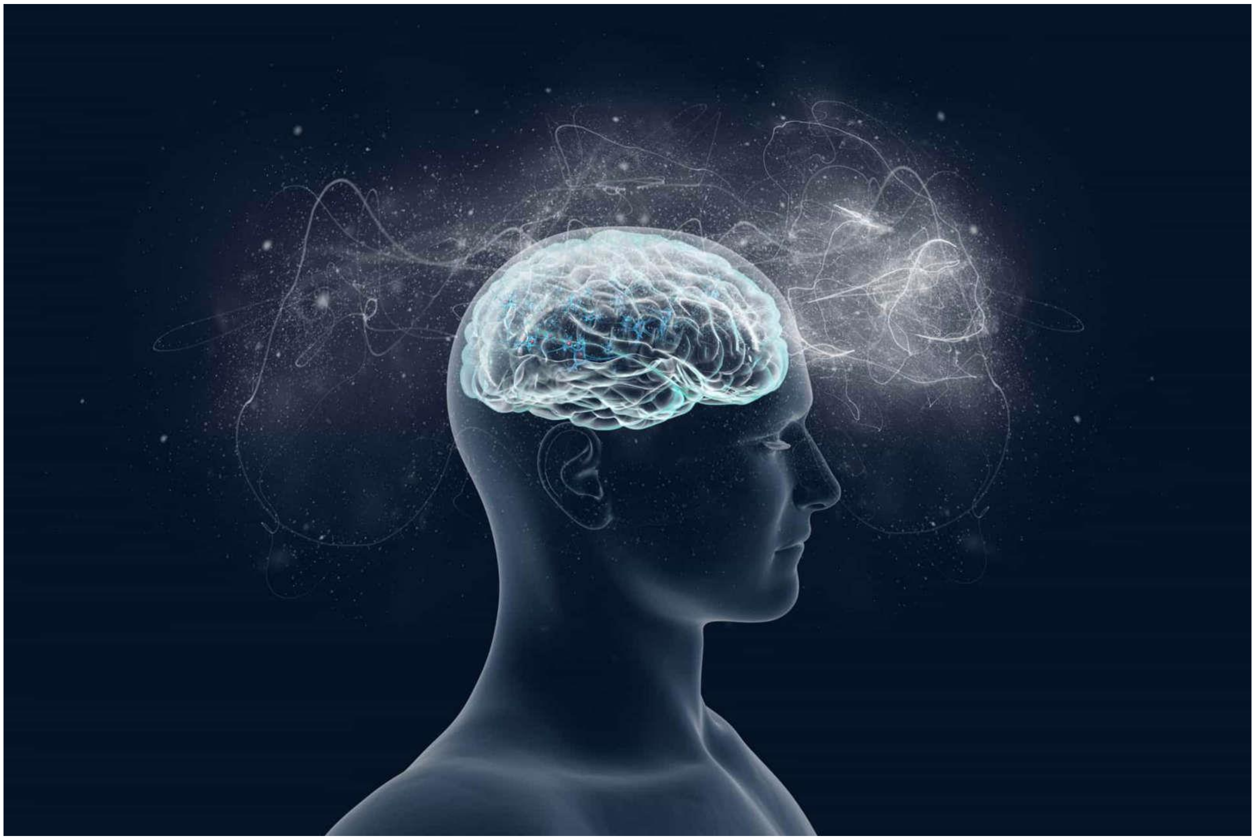
Those who experience a panic attack for the first time often think they're having a heart attack and end up in the emergency room. Even in less dramatic circumstances, the physical signals of anxiety can increase the feelings of fear and worsen the emotional experience for some.

Intuition and detachment

Studies suggest that our interoception is linked to our deep sense of intuition. Our bodies respond before we're even consciously aware of what's happening. Those who have a poor sense of interoception may feel detached, which can be a sign of more serious mental illness.

Early signs of mental illness

Researchers believe that decreased sensitivity to interoceptive signals can be a sign of mental dissociation, which may be a precursor to delusions and psychosis. The person is becoming less and less connected with themselves and with reality.



Sense of self

Interoception helps us to form our most basic sense of self. Patients suffering from psychosis often seem to experience a sort of depersonalization that disconnects them from this sense.

Interoceptive therapies

New therapies are being developed to see if increased interoceptive awareness can help to treat anxiety and other mental health issues. Those with autism are more likely to struggle with interoception, as well as anxiety, and early studies suggest that interoceptive training can significantly reduce their stress levels.

Emotional regulation

Greater awareness of your interoceptive signals can help you to recognize your emotional state, decatastrophize, and formulate a helpful response to the situation that reduces your stress levels.

Interoceptive mindfulness

Professor Cynthia Price at the University of Washington has been developing a new form of mindfulness that focuses on interoception. Mindfulness usually deals with the mental experience and quieting of the mind, but Price's method brings the focus to the interoceptive sensations in the body.

Research with addiction

Her initial work has been with patients suffering from substance abuse issues. They often struggle to regulate their emotions and feel disconnected from themselves, which exacerbates their addiction.

Promising results

So far, this form of interoceptive mindfulness has been shown to reduce depression and cravings in her patients. A year-long study showed that it increased the patients' ability to abstain from substance abuse, in comparison to the standard treatments.

Beneficial for all

However, interoceptive mindfulness isn't just helpful for those suffering from serious conditions. Professor Price believes this practice can be beneficial to anyone wishing to reduce stress and bring more awareness into their lives.

From the inside out

Incredibly, our interoceptive signals can also influence our external senses, such as sight and sound. They say that seeing is believing, but in this case, it's more like believing is seeing.

Interoception and racial bias

If your body believes you are in danger and begins sending interoceptive signals of fear, you are more likely to see a threat in front of you, even if it's not there. This has been shown in the case of racial biases.

Bias and fear

It's a sad but well-known fact that Black suspects are more than twice as likely to be killed by police when unarmed compared to White suspects. Objects like cell phones or wallets are often misidentified as weapons because the police officer has a much stronger belief that a Black person is likely to be a threat.

Fear and misjudgment

A study conducted in a lab showed that this racial bias is deeply ingrained in some people. The White participants showed an increased heart rate and were more likely to misidentify a harmless object as a weapon when it was followed by an image of a Black person.

We see what we believe

The conclusion of the study was that the heart rate can actually enhance a person's perception of the fear-inducing stimuli.

The complexity of the human body

In general, we think of the brain as the motherboard at the top of the pyramid that controls the rest of the body. Interoception shows us that the brain is often just responding to signals from our internal organs, so it may in fact be the other way around.

The Cosmic Debate: Divine Design or Random Chance?
Story by Sarah Norman

Limitations

Science, while a powerful tool for understanding the universe, has its limitations, particularly in addressing questions of existence beyond empirical observation. Many argue that phenomena such as consciousness, the origins of the universe, and the intricacies of life suggest the possibility of a higher power or divine intelligence.

We invite you to explore our photo gallery that complements this discussion and offers a visual representation of these intriguing concepts.

Moral and Ethical Laws

Moral and Ethical Laws: Some argue that the presence of moral and ethical laws in human consciousness and societies suggests a divine origin, aligning with the idea of a creator who imbues the universe with purpose and order.

Fine Tuning of the Universe

Fine-Tuning of the Universe: The universe's physical constants and laws are remarkably fine-tuned for the existence of life. Some argue this precision suggests intentional design rather than random chance.

The Big Bang Theory

The Big Bang Theory: The Big Bang theory, which posits that the universe had a beginning, is seen by some as consistent with the idea of a creator initiating the universe.

Cosmic Background Radiation

Cosmic Background Radiation: The uniformity of cosmic background radiation is often interpreted as a remnant of a primordial event, which some believe could be the result of a deliberate act of creation.

The Anthropic Principle

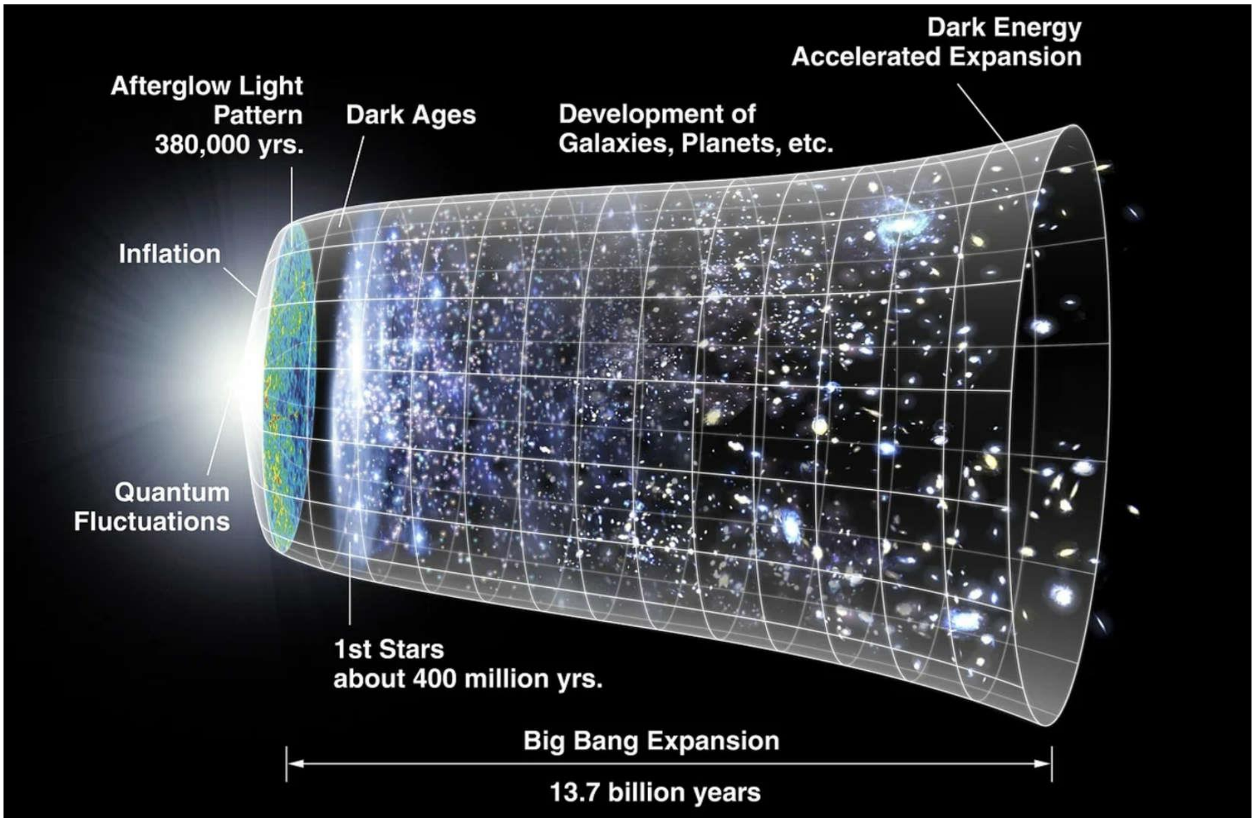
The Anthropic Principle: This principle suggests that the universe's properties are perfectly suited for human life, implying that it might have been designed with purpose.

Order and Complexity

Order and Complexity: The intricate order and complexity observed in natural systems, from galaxies to biological processes, are sometimes cited as evidence of an intelligent designer.

Irreducible Complexity

Irreducible Complexity: Certain biological systems are considered by some to be too complex to have evolved through natural processes alone, suggesting a possible guiding hand.



The Origin of Life

The Origin of Life: The spontaneous emergence of life from non-life remains one of science's biggest mysteries, leading some to argue that a creator might have played a role.

Mathematical Precision

Mathematical Precision: The universe's underlying mathematical framework, which describes everything from subatomic particles to cosmic structures, is viewed by some as indicative of purposeful design.

Quantum Mechanics

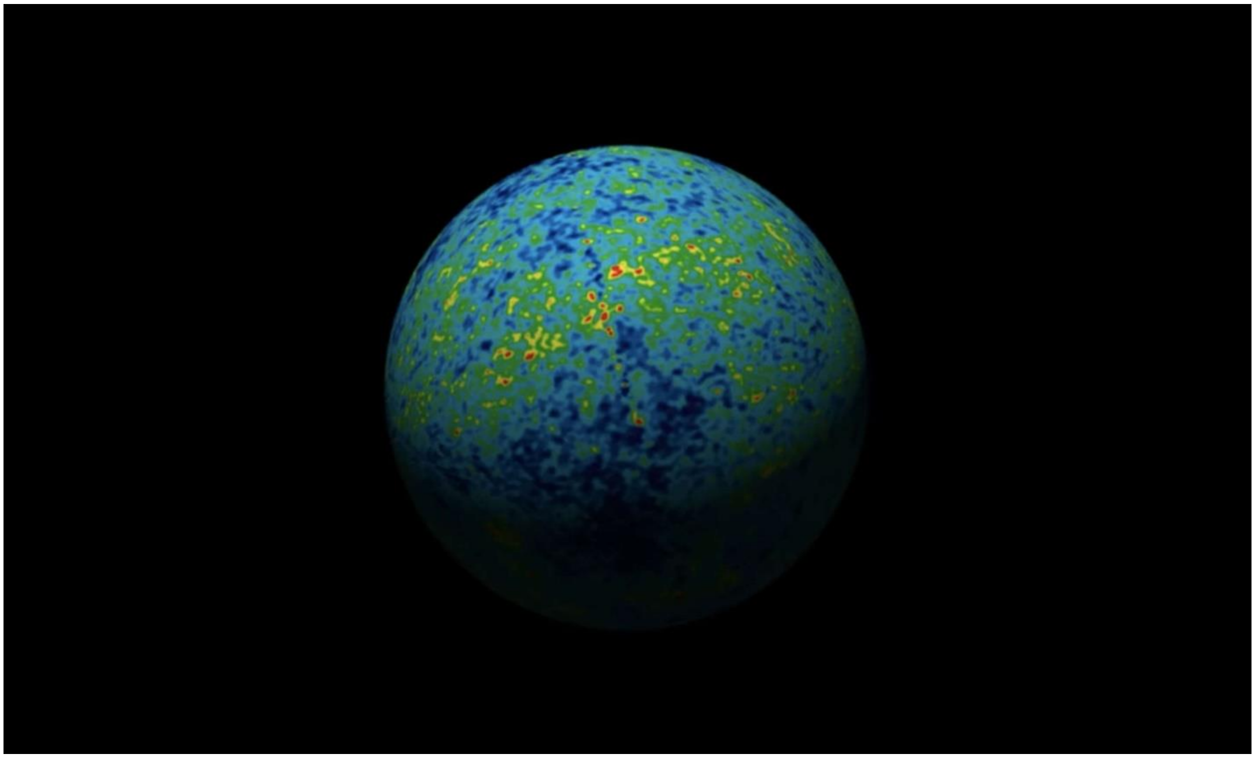
Quantum Mechanics: The strange and counterintuitive nature of quantum mechanics is sometimes interpreted as evidence of a creator's involvement in the fundamental aspects of reality.

The Laws of Thermodynamics

The Laws of Thermodynamics: The application of these laws, particularly the law of entropy, raises questions about the universe's origin and complexity, which some argue points to a creator.

Mathematical Laws of the Universe

Mathematical Laws of the Universe: The existence and effectiveness of mathematical laws in explaining natural phenomena are seen by some as evidence of a purposeful design behind the universe.



This is our Universe, an ever-expanding network of stars and galaxies. And this is your brain. Don't they look eerily similar to one another? Why are they so alike? Could your brain be a mini-version of the cosmos? Or could the Universe actually be part of some larger consciousness?

Your brain is made up of neurons. These are cells that process information and signals throughout your body. Between these neurons is an underlying network of connections that allows them to communicate with each other. And on the largest scale imaginable, the galaxies in our Universe form clusters with vast amounts of empty space in between.

These clusters are connected to each other by a complex network known as cosmic webs. The Universe. And your brain. Puzzling, isn't it? Well, maybe our Universe is a lot more complex than we thought. It might just be some sort of giant brain. You could be thinking, wow, What If has really gone off the rails with this episode.

But we're not the only ones to notice similarities between galaxies in the cosmos and neurons in the human brain. Astrophysicists and neurosurgeons have been studying these networks. They found that the cosmos looks very similar to your brain, just on a much larger scale. Your brain is 77% water. And the cosmic web is about 73% dark energy.

There are around 69 billion neurons in your brain. And the cosmic web could connect at least 100 billion galaxies. Not exactly the same. But not too far off. Wait. There's more. Neurons and galaxies both share a similar pattern. 2.5 mm (0.1 in) of your brain looks like 500 million light-years of space. Pretty cool, right?

Even that isn't all. Each neuron of that 2.5 mm (0.1 in) of your brain connects to about five other neurons. And in space, each galaxy has about four different connections. Your brain and the cosmos aren't identical. But they are similar enough for you to ask this. Is the Universe a giant brain? Could it have its own consciousness?

Theoretically, the Universe could achieve consciousness. But only if it managed to understand its position in space and time. Then it would need to understand how it relates to other things, like you. Have I blown your mind yet? Well, the Universe isn't exactly like your brain. It's a lot harder for it to exchange information between the galaxies.

It might be conscious, but on a level we don't yet understand. And how could we understand the consciousness of our Universe if we don't even fully know what consciousness is and how it works? What we do know is that your own consciousness is pretty advanced. All thanks to your ability to understand what the future is.

Humans are one of the few animals that think about tomorrow. At least as far as we know. But maybe we overcomplicate things. Maybe consciousness isn't an intricate biological thing only humans have. Maybe consciousness is when systems relate to each other and work together. Like the Universe. Then, yes, the Universe is conscious.

Especially if you think of the Universe with its billions of galaxies, billions upon billions of star systems, planets, moons. That's a lot of consciousness. Maybe there are other universes, living on a much larger scale, communicating with each other like we do. And maybe they collide.

A baffling new theory to explain human consciousness has suggested it comes from hidden dimensions and is not just brain activity.

A physicist claimed that we plug in to these invisible planes of the universe when making art, practicing science, pondering philosophy or dreaming, and this could explain the phenomenon that has evaded scientific understanding for centuries.

Michael Pravica, a professor of physics at the University of Nevada, Las Vegas, has based the wild idea on hyperdimensionality, the idea that the universe is made up of more dimensions than just the four we perceive: height, length width and time.

But his theory is highly controversial, with one scientist saying that the cornerstone of Pravica's theory 'borders on science fiction.'

Physicist Michael Pravica believes that human consciousness transcend the physical world and move between hidden dimensions

'The sheer fact that we can conceive of higher dimensions than four within our mind, within our mathematics, is a gift... it's something that transcends biology,' Pravica told Popular Mechanics.

Scientists have been attempting to explain human consciousness and its origins for hundreds of years - and the theories run the gamut.

One leading theory suggests that consciousness is related to how much information is integrated between the different parts of the brain. The more information is connected and integrated, the more conscious a being is thought to be.

Another posits that conscious mental states are driven by top-down signaling in the brain. Top-down signaling refers to the process by which higher-level brain regions send information, expectations or context to lower-level brain regions.

But Pravica's theory ventures outside the realm of neuroscience and into theoretical physics.

He suggested that in moments of heightened awareness, like when we enter a dream state or use our brains for deeply creative or intellectual tasks, our consciousness could transcend our physical dimension and enter a higher plane.

In these moments, our consciousness syncs with hidden dimensions and receives a flood of inspiration, Pravica said.

To better understand the controversial theory, consider the following scenario.

Imagine you're a two-dimensional being living in a two-dimensional world, like a character in a comic book. Now, imagine that a sphere passes through your plane of view.

The sphere would look like a dot that grows into a larger and larger circle as it comes closer, then gradually shrinks until it's out of view. You would have no way of knowing that it's actually a three-dimensional shape.

Pravica sees us as a version of these 2D characters. Although we exist in a four-dimensional world, we can only perceive matter and energy that is of those four dimensions, just like how beings in a 2D world cannot perceive a 3D object.

Thus, the limitations of our world prevent us from detecting higher dimensions that could, in theory, exist all around us.

This is the foundation of hyperdimensionality - the idea that the universe is made up of many dimensions, some of which are hidden because they are beyond the reach of our physical realm.

Hyperdimensionality ties into string theory, which states that reality is made up of infinitely small vibrating strings that are smaller than atoms, electrons or quarks.

As the strings vibrate, twist and fold, they produce effects in multiple unseen dimensions that give rise to all the particles and forces that we can observe, from particle physics to gravity.

'String theory is essentially a theory of hyperdimensionality,' Pravica said. 'It's looking at how the universe is put together on a sub-quantum scale.'

Pravica believes that our brains can tap into higher dimensions when in a dream state or performing deeply creating or intellectual tasks

Although we can observe the effects that these vibrating strings have on the physics of our dimension, we can't observe the hidden dimensions that they're vibrating in.

That is - we can't physically observe them.

But our consciousness may be able to tap into them, Pravica says.

Hyperdimensionality and string theory are widely accepted by physicists, but Pravica's idea of their relationship with consciousness is more controversial - especially because it blurs the lines between science and spirituality.

As an Orthodox Christian with a Ph.D. from Harvard, Pravica has found hyperdimensionality to be a way to bridge his scientific background with his religious beliefs.

For example, he believes Jesus may be a hyperdimensional being.

'According to the Bible, Jesus ascended into heaven 40 days after being on Earth. How do you ascend into heaven if you're a four-dimensional creature?' Pravica asked.

But being hyperdimensional could, theoretically, have allowed Jesus to move between our world and heaven - which may be a world of higher or infinite dimensions, he said.

Pravica's theory is based on a 'God of the gaps' perspective, where gaps in scientific knowledge are explained by divine intervention, said Stephen Holler, associate professor of physics at Fordham University.

He believes that this type of thinking is insufficient, and hampers the scientific inquiry needed to truly understand and explain ineffable phenomena like human consciousness.

'It's a poor explanation mechanism that arguably stifles the inquisitive nature required for good science and teaches that it's not okay to say, 'I don't know,'' Holler told Popular Mechanics.

He points out that our ability to mathematically manipulate higher dimensions is not proof that they actually exist, or that our consciousness can interact with them.

What's more, exploring these higher dimensions is impossible due to the limitations of our current technological capabilities.

Not even the most powerful particle accelerator in the world - the Large Hadron Collider (LHC) at CERN - can provide real proof that these dimensions exist.

The LHC smashes particles together at incredibly high speeds - up to the speed of light.

This allows physicists to study the fundamental building blocks of matter and energy and access infinitesimally small dimensions - even smaller than a single proton.

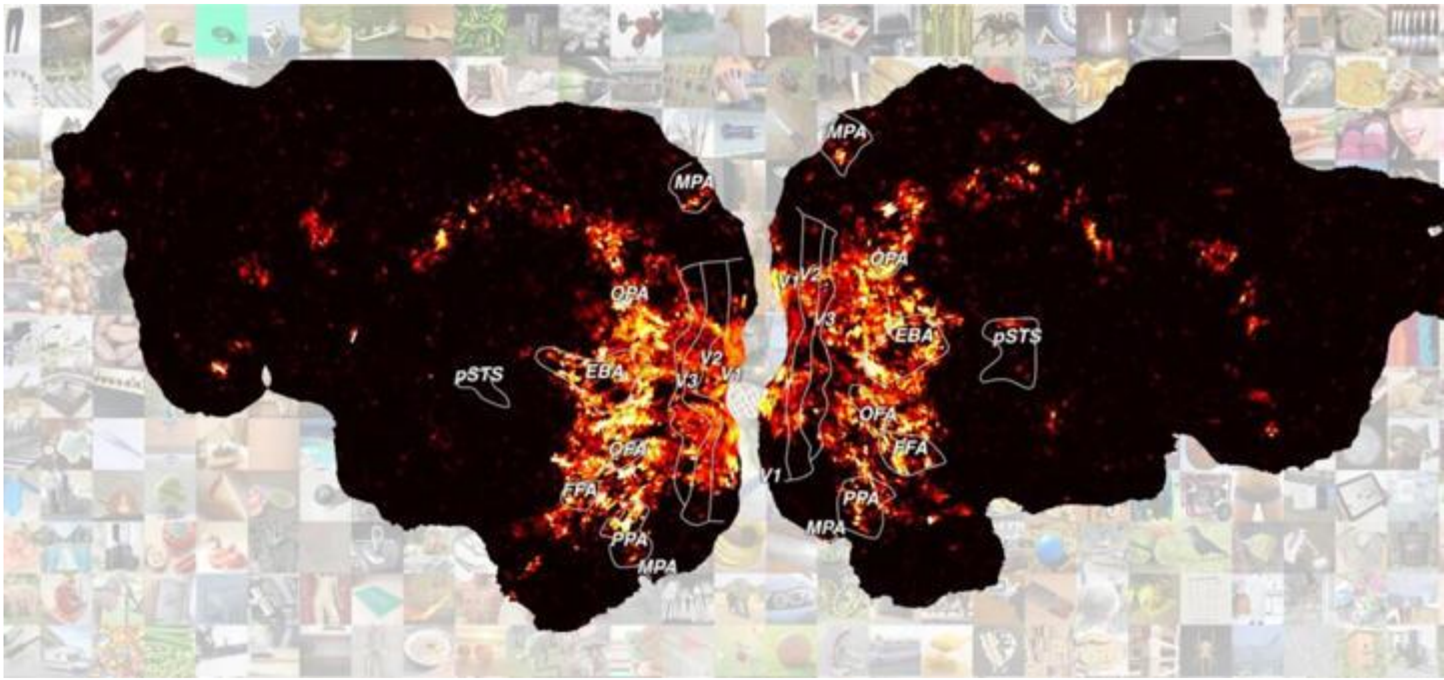
But even the LHC isn't able to reveal the high-dimensional strings that quantum physics predicts. To get that granular, physicists would need a much more powerful collider.

Without that concrete evidence, Holler says that hyperdimensionality 'borders on science fiction.'

But Pravica is optimistic that such technology could exist within his children's lifetime.

Until then, he will continue to support hyperdimensionality and his theory of how it relates to our consciousness.

'I see no point otherwise,' he said. 'Why study? Why live?'



The brain activity of study participants was measured in the MRI scanner over 15 sessions while they looked at more than 8,000 different images of 720 objects. Credit: MPI CBS

Traditionally, the dominant view in research has been that a central goal of human perception is to recognize objects and assign them to different categories—for example, this observed object is a dog and dogs belong to the category of animals.

Researchers from the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig and the Justus Liebig University Giessen in collaboration with the National Institutes of Health in the U.S. have now shown that this view is incomplete.

In a recent study published in the journal *Nature Human Behaviour*, they demonstrate that brain activity when seeing objects can be much better explained by a variety of behaviorally relevant dimensions.

Until now, it was thought that our brain's visual system breaks down the objects we see into very basic features and then gradually reassembles them with the aim of enabling their recognition.

"Our results have shown that recognition and categorization are important goals of our vision, but by no means the only ones," says last author Martin Hebart, group leader at the Max Planck Institute and professor at Justus Liebig University.

"In fact, we find behaviorally relevant signals at all processing stages in the visual system. We were able to show this based on the behaviorally relevant dimensions we had previously discovered."

The researchers used a computer model to identify 66 object dimensions from behavioral data of more than 12,000 study participants. These dimensions not only explain categorization, i.e., whether a dog is an animal, but also cover other characteristics, such as colors and shapes, as well as gradual values, for example, how typical a dog is of an animal.

Hebart says, "This allowed us to explain much better how our brain enables us to perceive the objects in our environment and understand their meaning."

First author Oliver Contier looked at the data of three study participants whose brain activity was measured in the MRI scanner over 15 sessions while they looked at more than 8,000 different images of 720 objects.

"When the participants saw a rocket, for example, we were able to measure from the brain activity that their visual system not only recognized that it was a rocket or that a rocket is a vehicle, but also that it is gray and elongated, has to do with fire, can fly, or sparkles.

"All processing stages of our perceptual system are therefore involved in capturing a broad spectrum of behaviorally relevant properties that together make up our perception," says Contier.

Hebart adds, "Our work reveals a multidimensional framework that is consistent with the rich and diverse behavioral relevance of objects. This ultimately explains our broad range of human behaviors better than the categorization-focused approach, and this in turn is crucial for understanding how we perceive and interact with our visual world in a meaningful way."

More information: Oliver Contier et al, Distributed representations of behaviour-derived object dimensions in the human visual system, *Nature Human Behaviour* (2024). DOI: 10.1038/s41562-024-01980-y

Provided by Max Planck Society

— Kriegman et al. 2020/PNAS, CC BY-SA

Life and death are traditionally viewed as opposites. However, the emergence of new multicellular life forms from the cells of a dead organism introduces a "third state" that lies beyond the traditional boundaries of life and death.

Usually, scientists consider death to be the irreversible halt of the functioning of an organism as a whole. However, practices such as organ donation highlight how organs, tissues, and cells can continue to function even after an organism's demise. This resilience raises the question: What mechanisms allow certain cells to keep working after an organism has died?

We are researchers who investigate what happens within organisms after they die. In our recently published review, we describe how certain cells — when provided with nutrients, oxygen, bioelectricity, or biochemical cues — have the capacity to transform into multicellular organisms with new functions after death.

Life, death, and emergence of something new

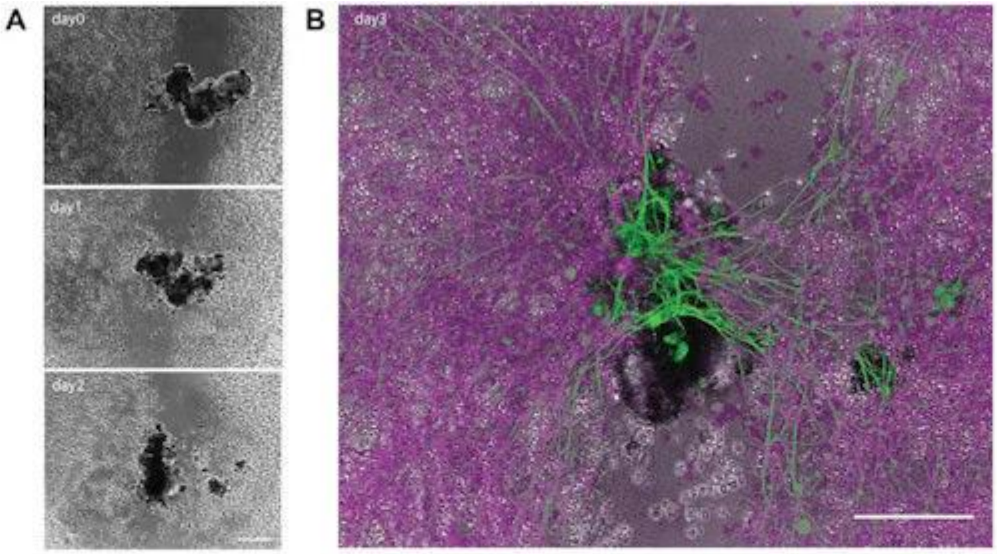
The third state challenges how scientists typically understand cell behavior. While caterpillars metamorphosing into butterflies, or tadpoles evolving into frogs, may be familiar developmental transformations, there are few instances where organisms change in ways that are not predetermined. Tumors, organoids, and cell lines that can indefinitely divide in a petri dish, like HeLa cells, are not considered part of the third state because they do not develop new functions.

However, researchers found that skin cells extracted from deceased frog embryos were able to adapt to the new conditions of a petri dish in a lab, spontaneously reorganizing into multicellular organisms called xenobots. These organisms exhibited behaviors that extend far beyond their original biological roles. Specifically, these xenobots use their cilia — small, hair-like structures — to navigate and move through their surroundings, whereas in a living frog embryo, cilia are typically used to move mucus.

Xenobots are also able to perform kinematic self-replication, meaning they can physically replicate their structure and function without growing. This differs from more common replication processes that involve growth within or on the organism's body.

Researchers have also found that solitary human lung cells can self-assemble into miniature multicellular organisms that can move around. These anthrobots behave and are structured in new ways. They are not only able to navigate their surroundings but also repair both themselves and injured neuron cells placed nearby.

Taken together, these findings demonstrate the inherent plasticity of cellular systems and challenge the idea that cells and organisms can evolve only in predetermined ways. The third state suggests that organismal death may play a significant role in how life transforms over time.



Researchers Study Life After Death — And It Gets Weirder

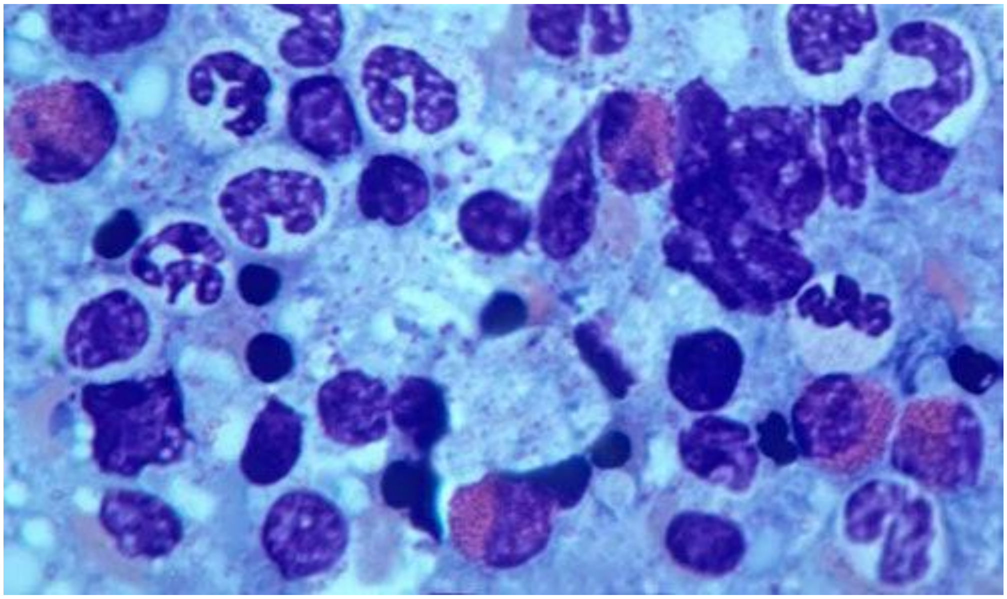
Postmortem conditions

Several factors influence whether certain cells and tissues can survive and function after an organism dies. These include environmental conditions, metabolic activity, and preservation techniques.

Different cell types have varying survival times. For example, in humans, white blood cells die between 60 and 86 hours after organismal death. In mice, skeletal muscle cells can be regrown after 14 days postmortem, while fibroblast cells from sheep and goats can be cultured up to a month or so postmortem.

Metabolic activity plays an important role in whether cells can continue to survive and function. Active cells that require a continuous and substantial supply of energy to maintain their function are more difficult to culture than cells with lower energy requirements. Preservation techniques such as cryopreservation can allow tissue samples such as bone marrow to function similarly to that of living donor sources.

Inherent survival mechanisms also play a key role in whether cells and tissues live. For example, researchers have observed a significant increase in the activity of stress-related genes and immune-related genes after organismal death, likely to compensate for the loss of homeostasis. Moreover, factors such as trauma, infection , and the time elapsed since death significantly affect tissue and cell viability.


Researchers Study Life After Death — And It Gets Weirder

Factors such as age, health, sex, and type of species further shape the postmortem landscape. This is seen in the challenge of culturing and transplanting metabolically active islet cells, which produce insulin in the pancreas, from donors to recipients. Researchers believe that autoimmune processes, high energy costs, and the degradation of protective mechanisms could be the reason behind many islet transplant failures.

How the interplay of these variables allows certain cells to continue functioning after an organism dies remains unclear. One hypothesis is that specialized channels and pumps embedded in the outer membranes of cells serve as intricate electrical circuits. These channels and pumps generate electrical signals that allow cells to communicate with each other and execute specific functions such as growth and movement, shaping the structure of the organism they form.

The extent to which different types of cells can undergo transformation after death is also uncertain. Previous research has found that specific genes involved in stress, immunity, and epigenetic regulation are activated after death in mice, zebrafish, and people, suggesting widespread potential for transformation among diverse cell types.

Implications for biology and medicine

The third state not only offers new insights into the adaptability of cells. It also offers prospects for new treatments.

For example, anthrobots could be sourced from an individual's living tissue to deliver drugs without triggering an unwanted immune response. Engineered anthrobots injected into the body could potentially dissolve arterial plaque in atherosclerosis patients and remove excess mucus in cystic fibrosis patients.

Importantly, these multicellular organisms have a finite life span, naturally degrading after four to six weeks. This "kill switch" prevents the growth of potentially invasive cells.

A better understanding of how some cells continue to function and metamorphose into multicellular entities sometime after an organism's demise holds promise for advancing personalized and preventive medicine.

Despite consciousness being the centre of studies and discussions for years, it remains one of the world's biggest mysteries. A new mind-boggling theory has suggested the brain's consciousness could derive from other dimensions – not just brain activity.

Michael Pravica, a professor of physics at the University of Nevada, shared a concept deep-rooted in hyperdimensionality, the idea that the universe has more dimensions than the ones we perceive. He believes we should be exploring hidden dimensions to explain consciousness.

"The sheer fact we can conceive of higher dimensions than four within our mind, within our mathematics, is a gift... It's something that transcends biology," the scientist told *Popular Mechanics*.

While hyperdimensionality and string theory are widely accepted by physicists, his belief of their ties to consciousness is a controversial one.

Pravica, an Orthodox Christian with a PhD from Harvard, used hyperdimensionality to create a bridge between science and his religious beliefs, exploring his idea that Jesus may have been a hyperdimensional being.

"According to the Bible, Jesus ascended into heaven 40 days after being on Earth. How do you ascend into heaven if you're a four-dimensional creature?" Pravica asked.

His theory ventures outside the realm of neuroscience and into theoretical physics with one scientist slamming it as bordering "on science fiction".

Stephen Holler, PhD, an associate professor of physics at Fordham University in New York, chimed in on the action, telling the publication: "Gaps in scientific knowledge are attributed to divine intervention, rather than being seen as opportunities for further inquiry and understanding."

He went on to suggest it was a "poor explanation mechanism that arguably stifles the inquisitive nature required for good science and teaches that it's not okay to say, 'I don't know'".

The Illusion of Death

Our current way of thinking goes on to assume that the world has an objective existence independent of the observer. However, numerous experiments have suggested otherwise. We view life as the activity of carbon and other molecules: we live for a while and then decay into the ground. This belief leads us to accept the concept of death, primarily because we identify ourselves with our physical bodies, which eventually perish. However, biocentrism, a theory proposed by Dr. Robert Lanza, argues that if we incorporate life and consciousness into the equation, many scientific puzzles can be explained, including why the universe appears fine-tuned for life.[2]

Consciousness, Reality and Death

Biocentrism states that space and time are not the solid entities we perceive them to be. Instead, they are constructs of our consciousness. For example, consider the famous two-slit experiment: when a particle is observed, it behaves like a particle and passes through one slit. Without observation, it acts like a wave, passing through both slits simultaneously. This indicates that reality is shaped by our consciousness.

Also, Heisenberg’s uncertainty principle (not THAT Heisenberg) suggests that we cannot measure a particle’s exact location and momentum simultaneously. This phenomenon, along with the understanding of particles being entangled over vast distances, further supports the notion that space and time are tools of our mind.

Death in a Timeless World

In a timeless, spaceless world, the idea of death does not hold. In this context, immortality wouldn't imply a perpetual existence in time but rather an existence outside of time altogether. This idea aligns with recent experiments showing that light particles can communicate instantaneously as if there were no space or time separating them. Such findings suggest that our understanding of time and space-and, by extension, life and death-is deeply flawed.

Quantum Mechanics and Multiple Universes

Quantum mechanics challenges our current understandings of reality. The “many-worlds” interpretation, for example, states that every possible observation corresponds to a different universe. In this multiverse, all possible outcomes occur simultaneously, implying that death, as we perceive it, does not exist in any real sense, since we are still alive and death will have already taken place. This theory resonates with the principles of biocentrism, where consciousness plays a central role in shaping reality.

Philosophical and Psychological Perspectives

The fear of death is a major influence on many human behaviors and beliefs, which is something covered by terror-management theory. This theory suggests that our existential dread drives us to cling to beliefs that connect us to something greater than our mortal selves.[3] For physicists, grappling with the implications of quantum mechanics and the potential for an observer-dependent reality can be both unsettling and comforting. Consciousness influencing our universe can provide a sense of purpose and continuity beyond physical death.

The Future of Biocentrism

Dr. Robert Lanza's biocentrism theory remains controversial, blending elements of science and philosophy to make something new. Critics argue that it lacks a solid mathematical foundation and veers into speculative territory, which is both a fair critique and completely true. However, Lanza continues to refine his ideas, and aims to bridge the gaps between biotechnology and physics. His work suggests that understanding consciousness could revolutionize our perception of life, death, and the universe.

Conclusion

Death, as traditionally understood, maybe an illusion shaped by our consciousness. Quantum physics and biocentrism have challenged the notion of an objective, observer-independent reality, suggesting that life and consciousness are central to the universe's fabric. As Einstein implied and Lanza elaborates, our understanding of existence is limited by our linear (and limited) perception of time and space. Embracing these new perspectives could profoundly impact how we understand life and the afterlife.

If You Relate To These 16 Experiences, You're More Self-Aware Than Most People

1. You're in Tune with Your Emotions.

Being self-aware means understanding your emotions and how they impact your thoughts and actions. If you can identify your feelings and why you're experiencing them, you're on the path to self-awareness. This emotional intelligence plays a vital role in your relationships and overall wellbeing. It allows you to navigate through life with a clearer understanding of your emotional landscape.

2. You Reflect on Your Actions.

Self-aware people often reflect on their actions and decisions. They consider the consequences and how they align with their values and goals. This level of introspection allows for personal growth and keeps you grounded in your principles. It helps you to avoid repeating mistakes and to make more informed decisions in the future.

3. You're Not Afraid to Apologize.

If you can recognize when you're wrong and apologize sincerely, it's a sign of self-awareness. It shows you can accept your mistakes and learn from them. This not only helps in mending and strengthening relationships but also contributes to your personal development. It shows you have humility and emotional maturity, both of which are incredibly important in relationships.

4. You Understand Your Strengths and Weaknesses.

Knowing what you're great at and what you could improve on is a key aspect of self-awareness. It allows you to leverage your strengths and work on your weaknesses. This deep understanding of yourself can guide your career choices, strengthen your relationships, and lead to a more fulfilling life in general. It's about being honest with yourself and taking steps to enhance your personal growth.

5. You're Open to Feedback.

Being open to constructive criticism and feedback is a sign of self-awareness. It shows you're willing to learn and grow. This openness to feedback allows you to broaden your perspective, improve your skills, and adapt to change. It's an essential trait for personal and professional development.

6. You're Aware of Your Values and Beliefs.

If you have a clear understanding of your values and beliefs, and you live by them, it's a sign of self-awareness. This clear sense of what matters most to you helps guide your actions and decisions. It gives you a sense of purpose and direction, and it can lead to a more fulfilling life.

7. You Practice Self-Compassion.

Being kind to yourself, especially during tough times, is a sign of self-awareness. It shows you understand that everyone makes mistakes and that it's okay to not be perfect. This practice of self-compassion can alleviate feelings of guilt and self-criticism, promoting mental well-being and resilience. It's a key aspect of maintaining a positive relationship with yourself.

8. You're Comfortable with Who You Are.

If you're comfortable in your own skin and don't feel the need to pretend to be someone you're not, you're likely more self-aware than most. This comfort with your identity is liberating and contributes to your self-esteem and confidence. It allows you to express yourself freely and authentically, and it's a cornerstone of strong mental health.

9. You're Curious About Your Inner Self.

If you often find yourself pondering questions like "Who am I?" and "What do I want?", it's a sign of self-awareness. It shows you're interested in understanding your true self. This curiosity about your inner world is a journey of self-discovery and personal growth. It can lead to insightful revelations about your purpose and passions.

10. You're Mindful of Your Thoughts and Actions.

Being mindful means being present in the moment and aware of your thoughts and actions. If you practice mindfulness, it's a sign of self-awareness. This practice can reduce stress, improve focus, and enhance emotional intelligence. It's a powerful tool for cultivating a deeper understanding of yourself and your surroundings.

11. You're Proactive, Not Reactive.

If you often find yourself strategizing and planning ahead rather than merely reacting to situations, this suggests a high level of self-awareness. You consider potential outcomes and assess the best course of action. This proactive approach can save you from unnecessary stress and lead to superior results, as you're aligning your actions with your thought processes and not just acting on impulse.

12. You Understand Your Triggers.

Knowing what situations or behaviors trigger certain emotional responses in you is a sign of self-awareness. This understanding allows you to manage your reactions better and maintain emotional balance. By recognizing these triggers, you can put strategies in place to handle these situations more effectively, promoting healthier relationships and well-being.

13. You Can Set Healthy Boundaries.

If you're capable of setting and maintaining healthy boundaries in your personal and professional relationships, you're exhibiting self-awareness. Boundaries are crucial for self-care and mutual respect. They reflect your understanding of your needs, limits, and values, and show that you're willing to advocate for yourself when necessary.

14. You're Aware of the Impact You Have on Others.

Self-aware people are conscious of how their words and actions can affect others. If you often take time to consider the potential impact of your behavior on other people, it's a strong sign of self-awareness. This trait fosters empathy and can greatly contribute to positive, respectful relationships with others.

15. You Recognize Your Biases.

Everyone has biases, but being aware of them is a sign of self-awareness. This involves understanding how these biases may influence your thoughts, decisions, and interactions. Recognizing your biases can help you make more objective decisions, improve your relationships, and broaden your perspective.

16. You're Consistent in Your Behavior.

If your actions align with your words consistently, it's a sign of self-awareness. It indicates you're mindful of your behavior and you strive to be authentic and reliable. This consistency not only enhances your credibility and trustworthiness, but it also leads to a harmonious alignment between your inner and outer world.

THIRD STATE

Scientists have established the existence of a "third state" which lies beyond the traditional boundaries of life and death.

Traditionally, death has been understood as the moment when an organism ceases, irreversibly, to function as a whole. And yet, practices such as organ donation show that organs, tissues and cells can continue to work even after the rest of an organism fails.

Researchers have, therefore, been exploring the question of how certain cells can continue to operate even after an organism has died.

And now, in a new study, a team of experts have detailed how certain cells, when provided with the necessary stimulation, have the ability to "transform into multicellular organisms with new functions after death."

What is this 'third state?'

According to the paper's lead authors, Peter A. Noble and Alexander Pozhitkov, the third state challenges how scientists understand cell behaviour.

In a piece for *The Conversation*, they note: “While caterpillars metamorphosing into butterflies, or tadpoles evolving into frogs, may be familiar developmental transformations, there are few instances where organisms change in ways that are not predetermined.”

Indeed, the key characteristic of these new “third state” cells is that they develop new functions.

For example, researchers found that skin cells extracted from dead frog embryos were able to adapt to the new conditions of a petri dish in a lab – spontaneously reorganising themselves into multicellular organisms called xenobots.

“These organisms exhibited behaviours that extend far beyond their original biological roles,” Noble and Pozhitkov note.

“Specifically, these xenobots use their cilia – small, hair-like structures – to navigate and move through their surroundings, whereas in a living frog embryo, cilia are typically used to move mucus.”

Furthermore, xenobots are also able to physically replicate their structure and function without growing. This is different from more common replication processes which involve growth within or on the organism's body.

The researchers also discovered that solitary human lung cells can self-assemble into tiny multicellular organisms that can move around and which behave, and are structured, in new ways. Not only can they navigate their surroundings but they also repair both themselves and injured neuron cells placed nearby.

“Taken together, these findings demonstrate the inherent plasticity of cellular systems and challenge the idea that cells and organisms can evolve only in predetermined ways,” the biologists conclude.

“The third state suggests that organismal death may play a significant role in how life transforms over time.”

What determines the survival of certain cells?

A number of factors help determine whether certain cells and tissues can survive and function after an organism dies, including environmental conditions, metabolic activity and preservation techniques.

According to Noble and Pozhitkov: “Different cell types have varying survival times. For example, in humans, white blood cells die between 60 and 86 hours after organismal death. In mice, skeletal muscle cells can be regrown after 14 days postmortem, while fibroblast cells from sheep and goats can be cultured up to a month or so postmortem.”

Metabolic activity also plays a key role in cells’ capacity to go on functioning.

“Active cells that require a continuous and substantial supply of energy to maintain their function are more difficult to culture than cells with lower energy requirements,” the experts point out.

In addition, preservation techniques – such as cryopreservation (the process of storing cells, tissues, or organs at extremely low temperatures to preserve them for future use), can allow tissue samples such as bone marrow to function similarly to that of living donor sources.

Plus, perhaps unsurprisingly, factors such as trauma, infection and the amount of time passed since death significantly affect tissue and cell viability, as well as “factors such as age, health, sex and type of species."

Nevertheless, it remains unclear how the interplay of these variables enables certain cells to continue functioning after an organism dies, and not others.

One theory is that the outer membranes of cells feature “specialised channels and pumps” which generate “electrical signals that allow cells to communicate with each other and execute specific functions such as growth and movement.”

In so doing, they could shape the structure of the organism that they’re forming.

Moreover, the extent to which different types of cells can undergo transformation after death is also unclear, the researchers stress.

Scientists could one day engineer biobots to deliver drugs and clear up arterial plaque ((Kriegman et al. 2020/PNAS, CC BY-SA))

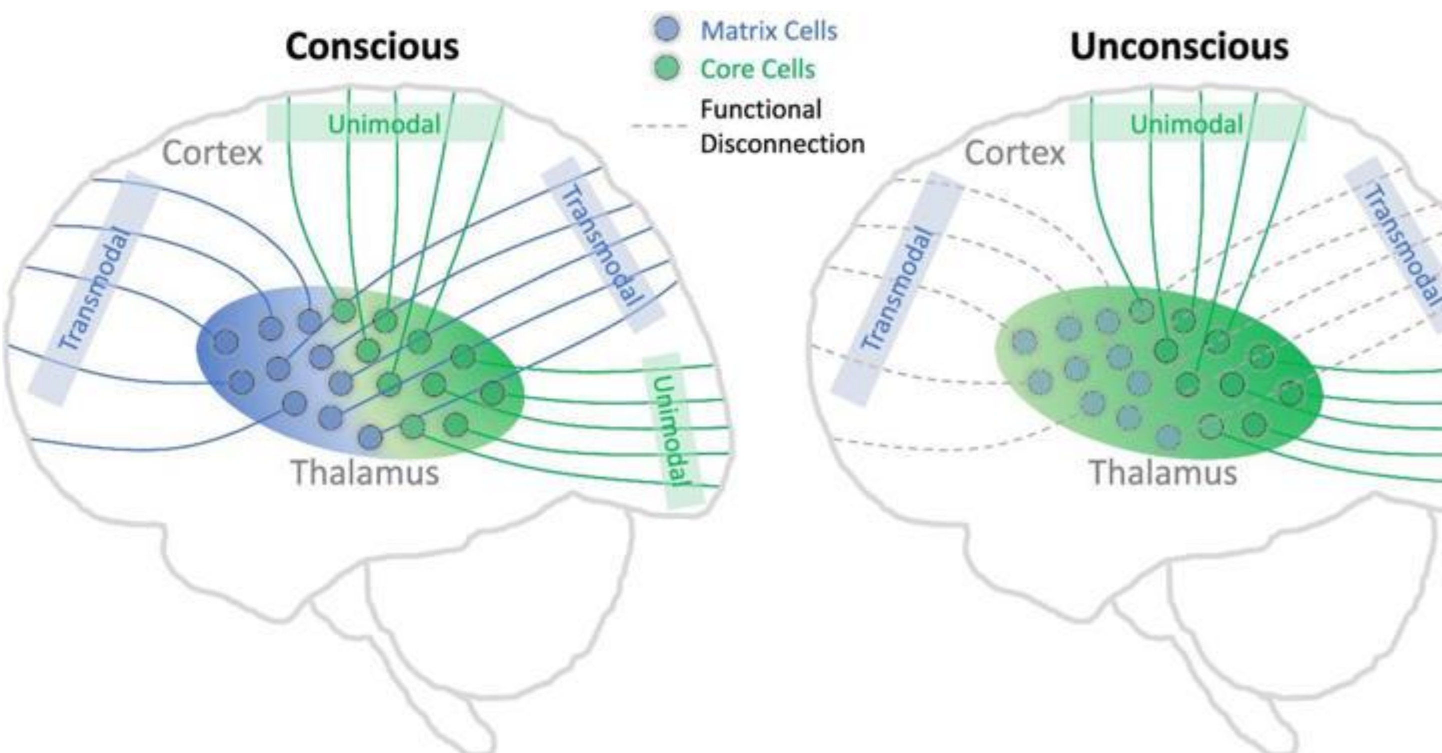
What could this ‘third state’ mean for science and medicine?

“The third state not only offers new insights into the adaptability of cells. It also offers prospects for new treatments,” Noble and Pozhitkov say.

“For example, anthrobots could be sourced from an individual's living tissue to deliver drugs without triggering an unwanted immune response.”

“Importantly,” they continue: “These multicellular organisms have a finite life span, naturally degrading after four to six weeks. This ‘kill switch’ prevents the growth of potentially invasive cells.”

However, most excitingly: “A better understanding of how some cells continue to function and metamorphose into multicellular entities some time after an organism's demise holds promise for advancing personalised and preventive medicine.”



Schematic illustration of the primary conclusion. Credit: Nature Communications (2024). DOI: 10.1038/s41467-024-51837-1

In hospital operating rooms and intensive care units, propofol is a drug of choice, widely used to sedate patients for their comfort or render them fully unconscious for invasive procedures.

Propofol works quickly and is tolerated well by most patients when administered by an anesthesiologist. But what is happening inside the brain when patients are put under and what does this reveal about consciousness itself?

Investigators at U-M who are studying the nature of consciousness have successfully used the drug to identify the intricate brain geometry behind the unconscious state, offering an unprecedented look at brain structures that have traditionally been difficult to study.

"Consciousness has been the subject of study from various perspectives and understanding the neurobiological foundations of consciousness carries major implications of multiple medical disciplines such as neurology, psychiatry and anesthesiology," said Zirui Huang, Ph.D., Research Assistant Professor in the Department of Anesthesiology at U-M Medical School.

To date, researchers have debated about how anesthetics suppress consciousness. Specifically, whether the site of action lies primarily in the thalamus, an egg-shaped structure deep within the brain, which receives information from what we see, touch and hear, or in the cerebral cortex, which processes that information in complex ways.

A study published in the journal *Nature Communications* and led by Huang, George Mashour, M.D., Ph.D. and Anthony G. Hudetz, Ph.D., of the U-M Center for Consciousness Science, outlines for the first time in humans how the connections among brain cells within those two important areas are modified by propofol. The paper is titled "Propofol Disrupts the Functional Core-Matrix Architecture of the Thalamus in Humans."

In healthy volunteers, they mapped changes in the brain's architecture before, during and after propofol sedation, guided by functional magnetic resonance imaging (fMRI). This enabled them to monitor blood flow to areas of the brain as the study participants entered and exited an unconscious state.

At baseline, explained Huang, the thalamus has a balanced level of activity of both specific nuclei (clusters of brain cells) that send sensory information to highly defined areas of the cortex—known as unimodal processing—and nonspecific nuclei that send information more diffusely throughout a higher layer of the cortex, known as transmodal processing.

The team found that, under deep sedation, the thalamus showed a drastic reduction in activity in clusters of brain cells responsible for transmodal processing, leading to a dominant unimodal pattern—suggesting that while sensory inputs are still received, there is no integration of those inputs.

"The field has been focusing on anesthetic effects in the thalamus and cortex for more than two decades—I believe this study significantly advances the neurobiology," said George Mashour, M.D., Ph.D., Professor of Anesthesiology and Pharmacology, and founder of the U-M Center for Consciousness Science.

Next, they discovered the specific cell types that played a role in the shift to an unconscious state and their relationship to the change in thalamic processing. The thalamus contains at least two distinct cell types, said Huang, core cells and matrix cells.

"We now have compelling evidence that the widespread connections of thalamic matrix cells with higher order cortex are critical for consciousness," says Hudetz, Professor of Anesthesiology at U-M and current director of the Center for Consciousness Science.

Imagining that the cortex is layered like an onion, core cells connect to lower layers while matrix cells connect to higher layers in a more spread-out manner.

By measuring mRNA expression signatures—like I.D. badges for the cells—they were able to see that a disruption in the activity of matrix cells played a greater role in the transition to unconsciousness than core cells. An additional surprise was that GABA, a major inhibitory transmitter in the brain usually thought to be key to propofol's actions, did not appear to play as prominent a role as expected.

"The results suggest that loss of consciousness during deep sedation is primarily associated with the functional disruption of matrix cells distributed throughout the thalamus," said Huang.

More information: Huang, Z., et al. Propofol disrupts the functional core-matrix architecture of the thalamus in humans. *Nature Communications* (2024). DOI: 10.1038/s41467-024-51837-1


Scientists found the molecule KIBRA works with PKMzeta to form long-term memories by tagging certain synapses, opening potential for memory-related therapies.© Jonathan Knowles - Getty Images

- Scientists have long known that the molecule protein kinase Mzeta (PKMzeta) plays a central role in forming memories.
- Now a new study identifies its partner-in-crime, another molecule named kidney and brain expressed adaptor protein (KIBRA), which forms long-term memories through interactions that "tag" certain synapses in neurons.
- Further study of this interaction could help scientists develop therapies in relation to memory.

Famous Irish poet, author, and playwright Oscar Wilde once wrote that "memory is the diary we all carry about with us," but the biological author of this lifelong memoir is far from certain. In the 1970s, scientists discovered long-term potentiation (LTP), which detailed how strengthening and weakening synapses helped form memory, but that's only part of the story.

In order to pull off this wondrous feat, synapses rely on a variety of molecules to form certain types of memories. One of these is PKMzeta (protein kinase Mzeta), which, when inhibited in the brains of rats during a 2006 experiment, caused disruption in spatial memory in the hippocampus. So there you go. Problem solved, right? Well, as you might imagine, when it comes to understanding the inner workings of the human brain, things are bit more complicated.

One of the big drawbacks of relying on PKMzeta to be *the* molecule responsible for memory formation is that it simply doesn't last in the brain very long, sticking around for only a couple hours or days. Humans likely wouldn't have invented agriculture let alone launch rockets into space with such subpar recall. Also, with 10,000 synapses to every one neuron, scientists didn't know exactly how PKMzeta strengthened some synapses and not others.

Now, a new study from scientists at the State University of New York (SUNY) Downstate Health Sciences University has an answer for those long-standing questions. It turns out PKMzeta gets a little help from a friend—in this case, another molecule known as the kidney and brain expressed adaptor protein, known as KIBRA. The results were published in the journal *Science Advances* this past June.

"During memory formation the synapses involved in the formation are activated," SUNY's Todd Sacktor, senior author of the study, said in a press statement, "and KIBRA is selectively positioned in these synapses. PKMzeta then attaches to the KIBRA-synaptic-tag and keeps those synapses strong. This allows the synapses to stick to newly made KIBRA, attracting more newly made PKMzeta."

The researchers call this KIBRA the "missing link" molecule that acts as a glue that allows memories to persist for years or even decades. The study analyzes these molecules in laboratory mice and found that blocking this molecular interaction disrupted spatial memory, and while both molecules are short-lived, their interaction persists.

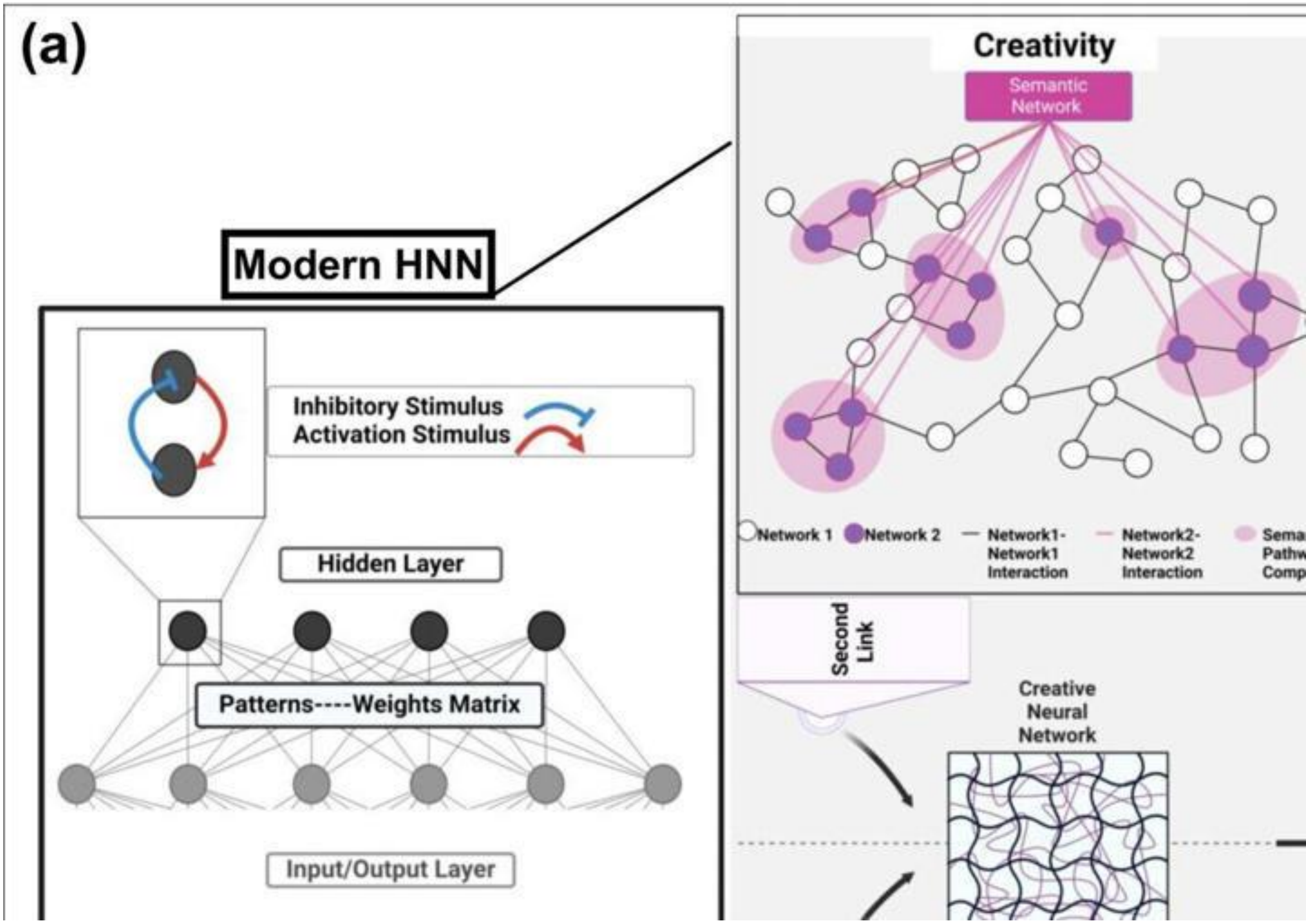
Sacktor references a 1984 hypothesis by Francis Crick, the co-discoverer of DNA, that described the creation of memories as "molecular turnover." Sacktor compares the idea to the famous philosophical concept known as the Ship of Theseus, which asks whether a ship that's been repaired so frequently that not even the keel is original is still the same ship that first left port. Similarly, Sacktor says, PKMzeta and KIBRA could work together to create long-term memories.

“The persistent synaptic tagging mechanism we found is analogous to how new planks replace old planks to maintain Theseus’s Ship for generations,” Sacktor said in a press statement, “and allows memories to last for years even as the proteins maintaining the memory are replaced. Francis Crick intuited this Theseus’s Ship mechanism, even predicting the role for a protein kinase. But it took 40 years to discover that the components are KIBRA and PKMzeta and to work out the mechanism of their interaction.”

Exploring the interactions of these two molecules opens a world of possibilities, some of which are decidedly sci-fi.

“I’m seeing more and more the possibilities of directly putting proteins in neurons through gene therapy,” Sacktor told *Scientific American*, which would theoretically strengthen fading memories. But for now, memory wiping like some sort of *Harry Potter* spell or *Men in Black* gadget—pick your favorite cultural reference—are a bit more far-fetched. “If you wanted to use this sort of mechanism to target unwanted memories—which creates ethical issues anyways—you’d have to find a way to make it specific to certain memories.”

True to Wilde’s words, memory might be the diary we carry with us—but in the future, who says we can edit a few chapters?



Summary of a hypothetical model of the simulation of the modern Hopfield neural network. Credit: The Journal of Creative Behavior (2024). DOI: 10.1002/jocb.680

Creativity is the art of combining diverse ideas, making meaningful connections between concepts, and remaining focused to produce innovative ideas and useful solutions. Expansive and remote associations drive the generation of new ideas, while inhibition enables refining these ideas into practical solutions.

A recent study, led by former student Ronald Mtenga and directed by Dr. Mathias Bode and Dr. Radwa Khalil at Constructor University, has illuminated crucial conclusions about creative thinking processes. The study, published in the *Journal* *of Creative Behavior*, provides a fresh perspective on the shift from analytical to creative thinking.

This study employed a unique approach by utilizing the Hopfield neural network (HNN), a neural network model, to investigate the mechanisms of semantic creative thinking–based associations. Researchers identified two key mechanisms that facilitate the transition from analytical to creative, associative thinking, suggesting that creative thinking often emerges when analytical thinking is insufficient.

Ronald Mtenga, the study's first author, holds a BSc in Electrical and Computer Engineering from Constructor University, where Dr. Mathias Bode is affiliated. Dr. Radwa Khalil is an expert in the creativity field, known for her multidisciplinary approaches that spans cognitive neuroscience, neuropsychology, computational modeling, and empirical research.

More information: Ronald Mtenga et al, Do Not Let the Beginning Trap you! On Inhibition, Associative Creative Chains, and Hopfield Neural Networks, *The Journal of Creative Behavior* (2024). DOI: 10.1002/jocb.680

Provided by Constructor University


(Photo credit: DALL·E)© PsyPost

Recent research published in *NeuroImage* suggests that dream-like episodes might be more common during fainting than previously thought. By carefully monitoring brain activity in a group of healthy volunteers during induced fainting episodes, researchers discovered that certain slow-frequency brain waves, particularly in the delta and theta bands, seemed to be linked with the emergence of these extraordinary mental states, which were marked by visions of otherworldly places, a sense of detachment from the body, and intense euphoria.

The findings offer new insights into the neural mechanisms that might underlie near-death experiences, traditionally associated with life-threatening situations like cardiac arrest.

Fainting, or syncope, is a common occurrence that can happen to anyone, often triggered by a temporary reduction in blood flow to the brain. While the physical aspect of fainting is well-documented, the subjective experiences that sometimes accompany it have largely been overlooked in scientific literature. Reports of people experiencing vivid dreams, dissociative symptoms, or even out-of-body experiences during fainting have been rare and often dismissed due to their mystical nature.

The researchers behind this study aimed to fill this gap in knowledge. They wanted to explore whether these fainting episodes could induce experiences similar to near-death experiences and, more importantly, to identify the brain activity associated with these phenomena. By doing so, they hoped to gain a deeper understanding of the neurobiological processes that might contribute to the intense and often life-changing experiences reported by people who have been near death.

"It was purely by chance that I began working on this topic. I originally wanted to pursue research in human consciousness, and my thesis advisor proposed this intriguing subject," said study author Charlotte Martial, a postdoctoral researcher at the Coma Science Group at the University of Liège. "I immediately fell in love with it and have been passionate about it ever since. At the start of my PhD a decade ago, a pivotal encounter with someone who had experienced a near-death experience sparked my deep interest in these fascinating and life-transforming episodes."

For their study, the research team recruited 22 healthy volunteers, all of whom underwent a thorough medical examination to ensure they had no underlying health conditions that could affect the study's outcomes. The participants were then asked to induce fainting using a method known as the Valsalva maneuver, a technique that involves trying to exhale forcefully with the nostrils and mouth closed, which temporarily reduces blood flow to the brain.

As the volunteers fainted, their brain activity was closely monitored using a high-density electroencephalogram (EEG), a tool that records electrical activity in the brain using 256 sensors placed across the scalp. This setup allowed the researchers to capture detailed information about the brain's activity during the moments of induced syncope. After the participants regained consciousness, they were asked to recall and describe any memories or experiences they had during the fainting episode.

Over a third of the participants reported experiencing vivid, dream-like episodes during their fainting spell. These experiences included accelerated thoughts, out-of-body sensations, visions of past events, and a sense of entering a different, often extraterrestrial world. Some even reported auditory hallucinations and feelings of euphoria. These experiences closely resembled what are commonly referred to as near-death experiences.

“Our study reveals that it’s not uncommon for people who faint to report rich subjective experiences that may resemble near-death experiences,” Martial told PsyPost. “We demonstrated that dreamlike experiences, characterized by extraordinary and mystical aspects, can emerge during syncope episodes. More broadly, this is one of many states where a person might be considered ‘unconscious’ due to outward unresponsiveness, while in reality, they are experiencing vivid conscious experiences.”

On the neurological side, the EEG data revealed specific patterns of brain activity that appeared to be linked with these experiences. During the fainting episodes, the researchers observed surges in slow-frequency brain waves, particularly in the delta and theta bands. These types of brain waves are usually associated with deep sleep or meditation and are rarely prominent in a fully awake state. The presence of these waves suggested that the brain was in a state of disconnected consciousness—where the person is unresponsive to the external environment but may still be experiencing vivid internal sensations.

“I was quite amazed to discover the strong positive correlations we observed between cortical activity associated with theta and delta waves and the richness of subjective experience in specific regions of interest, such as the insula, temporoparietal junction, cingulate cortex, and parahippocampal gyrus — areas known to be crucial for self-awareness and the (sometimes distorted) perception of our body.”

Interestingly, the intensity of these experiences seemed to be predicted by the amount of delta activity observed during the fainting episode. This finding led the researchers to propose that delta waves could be a marker of the brain’s potential to generate such extraordinary conscious states, even when disconnected from the outside world.

“Our study is the first to explore the electrical brain activity of individuals using high-density EEG during syncope,” Martial explained. “We found that these dreamlike experiences, some of which may carry the hallmarks of near-death experiences, appear to be supported by surges in slow-frequency activity bands on EEG. While these findings should be interpreted with caution, they open up new avenues for understanding the neurobiological mechanisms underlying near-death-like experiences."

The long-term goal of this research is to understand the brain mechanisms behind near-death experiences, with the aim of improving patient care and developing tools to detect consciousness in unresponsive individuals.

"From a scientific perspective, this line of research aims to demonstrate, across a comprehensive spectrum of physiological, pathological, and pharmacological conditions, that unresponsiveness cannot be considered a surrogate for unconsciousness," Martial said.

"From a clinical perspective, my long-term goal is to search for markers of near-death and near-death-like experiences in different clinical conditions to develop a comprehensive neurophysiological model for these experiences. My ultimate objective is the improvement of patient outcomes. Indeed, we now understand that encountering such mystical and extraordinary experiences in unexpected situations can have significant implications."

"I'm optimistic that our research could inform therapeutic follow-up for near-death experience patients and lay the groundwork for innovative strategies that use these markers for the automated detection of conscious experiences, without relying solely on memory, ultimately assisting medical management."

Raw Transcript

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English (auto-generated)

Scientists have charted a comprehensive map of the brain cells responsible for keeping us awake. In doing so, they aim to better understand the mechanisms that enable human consciousness and to improve treatments for people in comas and vegetative states.

"It's a beautiful study," said Dr. Nicholas Schiff, a professor of neurology and neuroscience at Weill Cornell Medicine who was not involved in the new research. "It's a map of everything."

Schiff, who has collaborated with some of the study's authors in the past, hopes the new map can serve as a template for scientists to go back and look at patients with altered states of consciousness. Such work could help clarify exactly how this wakefulness network can be disrupted and what's required to get it back online. It's a tool that could help scientists pinpoint which brain activity is "necessary and sufficient" to keep someone awake and aware, Schiff told Live Science.

The new study was published Wednesday (May 1) in the journal Science Translational Medicine.

Related: What happens in our brains when we 'hear' our own thoughts?

Mapping consciousness

Human consciousness arises from a delicate dance between the wrinkled surface of the brain, known as the cerebral cortex, and deeper "subcortical" structures beneath it. Circuits in the cortex direct our attention and process information from the world around us, while the subcortical networks plug into these circuits from below, essentially keeping them active.

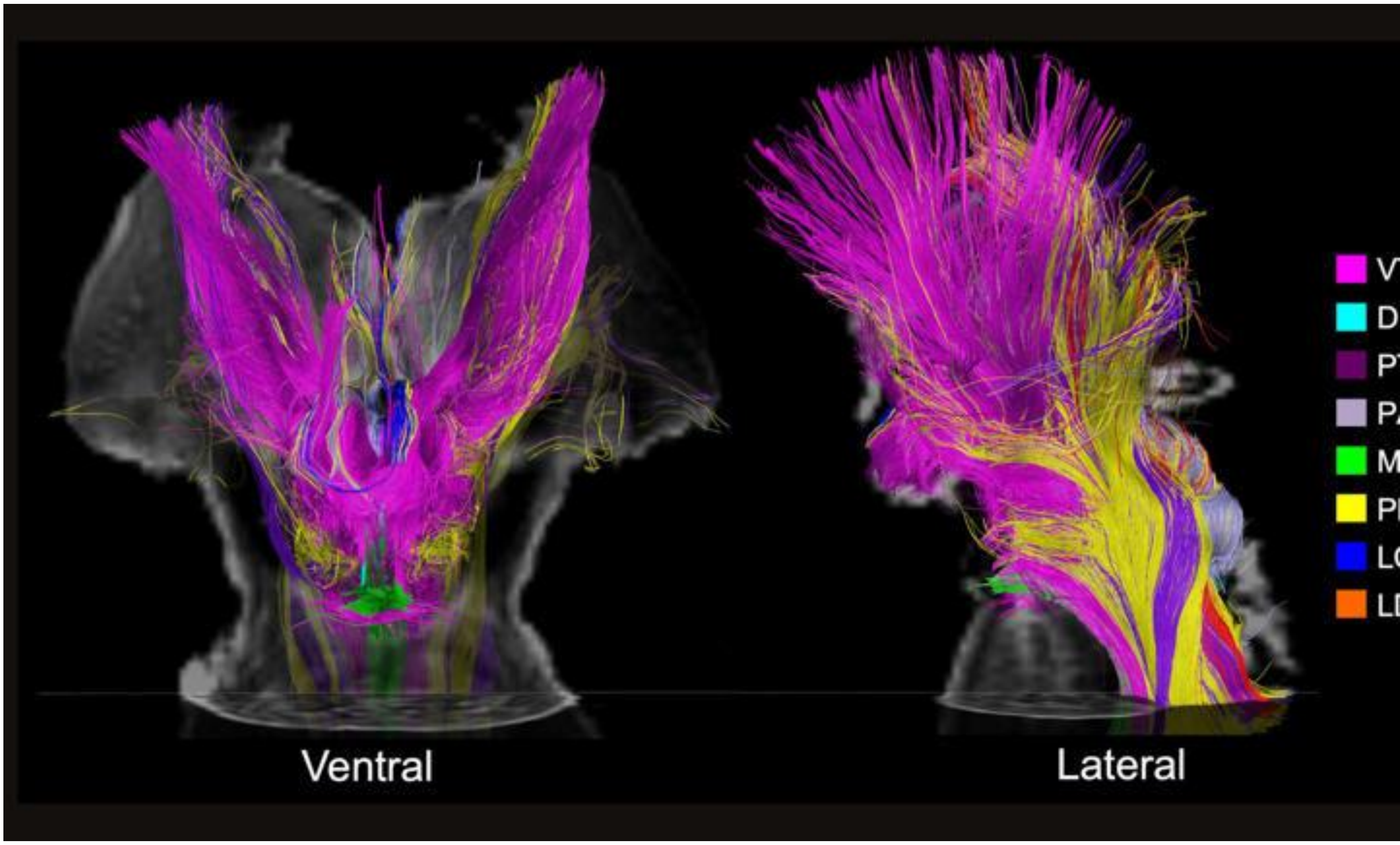
"It sends the signals that activate and stimulate the entire rest of the brain," said first author Dr. Brian Edlow, co-director of Mass General Neuroscience and director of the Laboratory for NeuroImaging of Coma and Consciousness.

Thus, consciousness is a "seamless interaction of these subcortical networks with these cortical networks," Schiff said. "It's an artifice, I think, to try to separate these things."

But scientists' understanding of humans' subcortical networks is incomplete. It relies heavily on animal experiments, in which scientists can inject trackable chemicals into the brain and then remove the organ to get a good look at where they ended up. In living humans, these deep-seated networks are located near major arteries and air-filled sinuses, and they also move a bit with each breath, making standard brain scans less crisp and hard to decipher. By contrast, networks in the human cortex are easier to image and have been much better studied.

To help close this knowledge gap, the scientists behind the new study looked at brains from three middle-age organ donors. Using postmortem brains allowed the team to "map brain networks at ultrahigh resolution and to see connections that simply cannot be seen when you're scanning a living human being," Edlow told Live Science.

These organ donors had no neurological problems when they died, and their brains were carefully preserved in formaldehyde. The researchers stained the brains with colorful chemicals to mark different types of brain cells and then put the brains in an magnetic resonance imaging (MRI) scanner for up to 48 hours.



These scans of postmortem brain tissue show many of the tracts in the network that sustains wakefulness in humans. (Image credit: Edlow et al., Sci. Trans. Med., 16 eadj4303 (2024). (Cropped by Live Science.))© Provided by Live Science

This resulted in incredibly high-resolution maps of subcortical structures that had been tied to wakefulness in previous research. The team manually traced connections between the brain cells in these structures, taking into account the direction water would flow down their wires. This metric captured by MRI can help reveal how strongly different nodes in a network are linked.

This work revealed major nodes of the wakefulness network in several subcortical structures — the brainstem, hypothalamus and thalamus — as well as part of the cortex called the basal forebrain. This network was confirmed to be linked to a circuit involved in awareness. Known as the default mode network, it is very active when we're daydreaming and not focused on a particular task.

Related: Ultrasound treatment 'jump-started' the brains of 2 people in coma-like state

To back up their work in postmortem brains, the team also looked at functional MRI data from more than 80 people who'd participated in the Human

Connectome Project, a government-led effort to map all the networks in the human brain. These additional brain scans, which looked at the flow of oxygenated blood, pointed out a hub where these awareness and wakefulness networks meet: the ventral tegmental area.

Taken together, the postmortem brain scans provided maps of highways in the brain, while the live scans showed traffic patterns along those roads. "We view our findings as an initial map that is beyond the spatial resolution that has been achieved previously," Edlow said. Looking to the future, the researchers hope to improve upon the map's resolution even more.

At this point, it's unclear exactly how the new map could shape the treatment of patients in comas, vegetative or minimally conscious states, Schiff noted. But it should be a useful tool to better understand and treat these conditions, he added.

"We envision that these connectivity maps will allow us to piece together, one individual at a time, the combination of connections that are necessary and sufficient to recover consciousness," Edlow said.

Super-detailed map of brain cells that keep us awake could improve our understanding of consciousness

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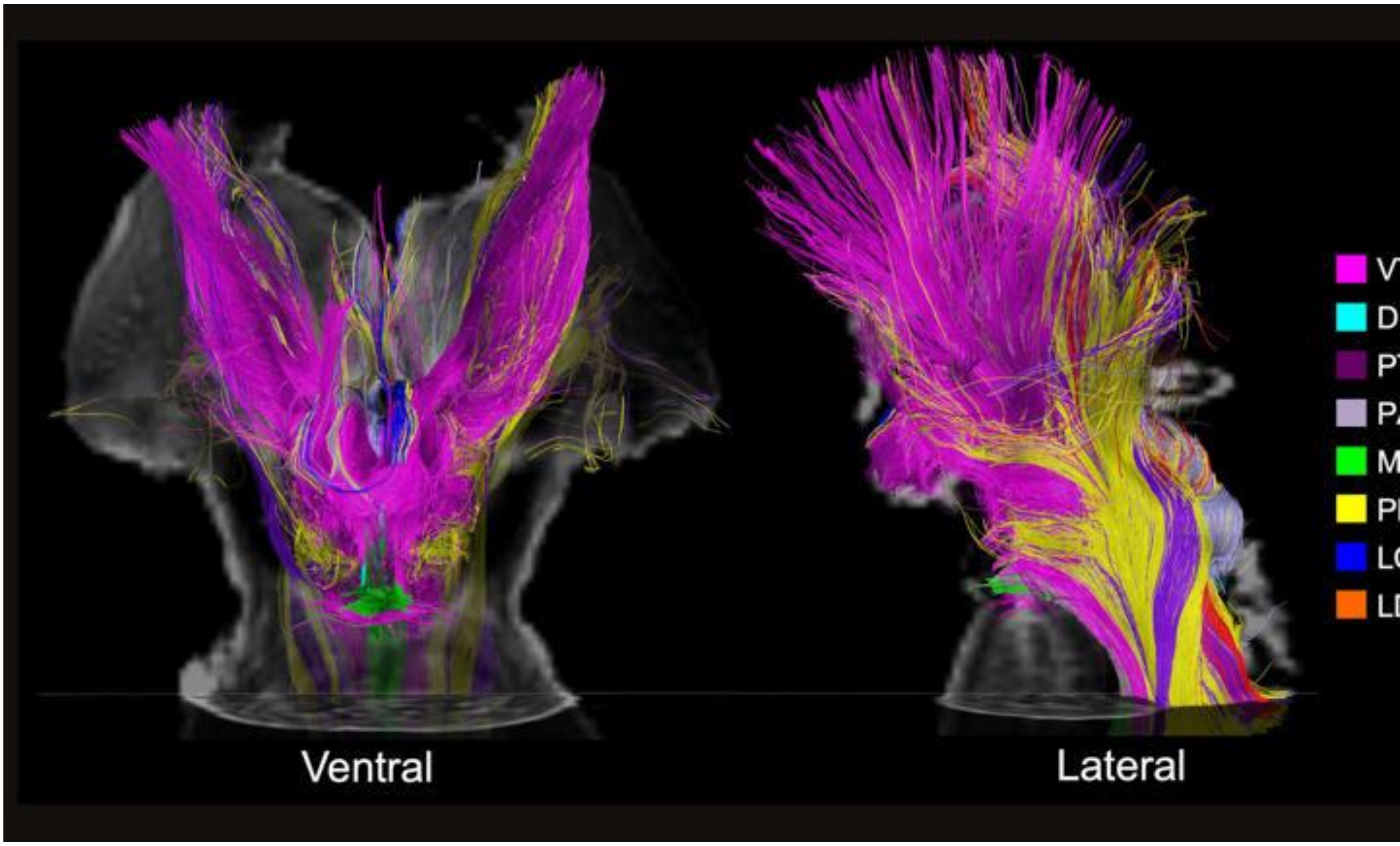

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Related: What happens in our brains when we 'hear' our own thoughts?

Do you sometimes talk to yourself in your head without actually speaking out loud? (Image credit: JGI/Jamie Grill via Getty Images)

If you've ever had an imaginary argument in your head, you may have "heard" two voices at once. Your own inner voice and that of the other person in the quarrel. You may even "hear" the other person's accent, or the timbre of their voice.

So what's happening in the brain when that inner monologue is running? How is it that you can "hear" your thoughts?
As it turns out, the brain undergoes similar processes when you're thinking words as when you're speaking out loud.

Inner monologues are thought to be a simulation of overt speech, said Hélène Loevenbruck, a senior neurolinguistics researcher and head of the language team in the Psychology and NeuroCognition Laboratory at CNRS, the national French research institute. When we're children, we're virtual sponges, soaking up new information from every angle. Children playing alone will often speak dialogue aloud, for instance between a toy truck and a stuffed animal. At around 5 to 7 years old, that verbalization moves inward, Loevenbruck said.

Related: Does everyone have an inner monologue?

Earlier studies have shown that the brain exhibits similar activity with inner speech as it does with verbalized speech. When study participants are asked to deliberately "speak" inside their heads while lying in a magnetic resonance imaging (MRI) machine, scientists can see parts of the brain that process auditory information activate as if the participant were actually hearing the words.

"Cerebral regions activated during inner speech are quite similar to those that are activated during overt speech during real speech," Loevenbruck told Live Science. Those regions include the left hemisphere frontal lobe and parietal lobe, which help in processing outward stimulation.

But when you're thinking of something like a fictional argument with another person, the brain goes one step further. During that inner argument, you're playing two roles: yourself, and the person you're arguing with. When you play yourself, the auditory centers on the left side of your brain activate, Loevenbruck said. But when you internally switch roles to play the person you're arguing with, "there's a sort of a shift of cerebral region activation to the right hemisphere," in the equivalent areas like the parietal lobe and frontal lobe, she continued. Seeing the situation from a different perspective, even if it's a perspective you're crafting in your head, shifts which brain regions are engaged.

Researchers have also observed this phenomenon when participants are asked to imagine movement, Leovenbruck continued. Dancers, for instance, use a different part of their brain to imagine themselves dancing versus someone else dancing, a study published in the August 2005 issue of the journal Cerebral Cortex found.

It's one thing to see those brain regions activate when a person is told to think something, but it's much less understood what happens in our brains when we let our minds wander, Leovenbruck said. Not all inner monologues are deliberate. Sometimes words or sentences just pop into your head, unprovoked.

This phenomenon might have something to do with the brain's "default mode network," (DMN) said Robert Chavez, a neuroscientist at the University of Oregon. The DMN is a network of areas in the brain that are active when it is not engaged in a specific task. The DMN is thought to be involved with aspects of internal thought, such as retrieving memories, imagining the future, or interoception — a sense or "feeling" of what's happening in your body, such as hunger or thirst.

"The default mode network seems to be more active when your mind is wandering," Chavez told Live Science. Because the default mode network involves

planning for the future by pulling from memories, recent experiences, and mental associations, it's thought that this combination of activities gives rise to an internal monologue while you focus inward.
A lot more research is needed to understand how inner thoughts arise spontaneously, Leovenbruck said. When taken to an extreme, inner thoughts can become dysfunctional, such as rumination after an uncomfortable or traumatic event, or in mental disorders, such as schizophrenia, in which people hear auditory hallucinations.

Originally published on Live Science.

What is consciousness?

The ancient Greeks dove into this question. But what do modern scientists think?

Is consciousness uniquely human? Or do other living things have varying degrees of it? (Image credit: Shutterstock)

Humans once assumed our planet was the physical center of the solar system, so it's no surprise that we also think highly of consciousness, the apparently unique quality that allows our species to contemplate such matters.
But what is consciousness? The topic has been extraordinarily controversial in the scientific and philosophical traditions. Thinkers have spent an immense amount of time and ink trying to unravel mysteries, such as how consciousness works and where it resides.

The short answer isn't very satisfying. Scientists and philosophers still can't agree on a vague idea of what consciousness is, much less a strict definition. One reason for that is that the concept is used to mean slightly different things. Many experts agree, however, that conscious beings are aware of their surroundings, themselves and their own perception.

Related: Can we ever stop thinking?
But the long answer leaves room for hope because researchers seem to be getting closer to an answer.

Something special?

Contemporary researchers have shown they can use a brain-scanning technique known as functional MRI to detect consciousness by indirectly measuring blood flow in the brain, a process that may indicate which areas of the brain are more active than others. But, for millennia, there was no way to collect evidence of this phenomenon. That made the topic challenging for thinkers who prized rationality and methodical experimentation.
In the Western world, the Italian astronomer Galileo Galilei tried to push anything to do with consciousness outside of the realm of scientific inquiry. A generation later, French mathematician and philosopher René Descartes brought consciousness into slightly sharper focus with his argument that mind (or soul) and body are two fundamentally different things. This position is called mind-body dualism.

"The vast majority [of thinkers] used to think that consciousness is very special," Susanna Schellenberg, distinguished professor of philosophy and cognitive science at Rutgers University in New Jersey, told Live Science.

But that attitude has fallen out of favor, thanks in part to people like 19th-century biologist Thomas Huxley, who helped usher in the view that what happens in the mind is a result of material events happening in the brain. It's a perspective that's grown in popularity.
"The idea I hold is a physicalist view, that consciousness isn't anything special in the world," Schellenberg said. That makes it a lot easier to imagine that humans aren't alone in possessing consciousness.

"We write poetry and rabbits don't, as far as we can tell," she said. "So, it's a difference of degree, not of kind."

Peering across the tree of life

"Almost everything you can say about [consciousness] is kind of BS," said Joseph LeDoux, a professor of neural science and psychiatry at New York University. "The only way to describe it is in terms of what it is and what it's not."

When comparing human consciousness to that of other animals, LeDoux finds it productive to look at neuroanatomy. For instance, humans are unique in having a highly developed frontal pole cortex, a part of the brain that researchers have connected with the ability to know what's on one's mind. That's an important aspect of consciousness by just about every definition. While non-human primates can't boast this late-model region of the brain, many of them do have other evolutionarily recent additions to the brain, such as the dorsolateral prefrontal cortex. It's been implicated in consciousness, and humans have one, too. For instance, this brain region is associated with working memory in humans, according to a 2015 review in the journal Frontiers in Systems Neuroscience.
"We know other animals probably have something [like consciousness], but they don't have what we have because we're different," because of these differences in neural anatomy, according to LeDoux, who wrote "The Deep History of Ourselves: The Four-Billion-Year Story of How We Got Conscious Brains" (Viking, 2019).

"People get all upset when you say that ... but no one confuses a chimpanzee with a human," he said. The cellular and molecular makeup of a chimp causes it to look and act differently from humans, so it stands to reason that the same kind of differences would cause chimpanzee consciousness to be different, too.

Some researchers take things a step further, holding that consciousness is a property of matter so fundamental that even an electron is conscious to a certain extent, a position known as panpsychism. Christof Koch, president and chief scientist of the Allen Institute for Brain Science in Seattle and a proponent of panpsychism, wrote in Scientific American that "any complex system ... has the basic attributes of mind and has a minimal amount of consciousness in the sense that it feels like something to be that system."

Could Danger Be the Reason?

Schellenberg said she thinks that a lot of animals have consciousness because "anything that feels pain ... is conscious," she said, noting the opinion is controversial.

Similarly, LeDoux thinks that avoiding danger is an important function of consciousness and possibly the reason it exists.

"All of our mental states, emotional states, are not inherited from animals. They're cognitively assembled, based on our knowledge of all we've learned about fear and danger through our life," he said. Human brains organize reams of information into schemas that serve as "the template of your conscious experience," he said.

For her part, Schellenberg doesn't think consciousness is the be-all, end-all question that it's made out to be.

"I'm one of the people who think consciousness isn't that interesting compared to why our mind and brain can do what it does," Schellenberg said. "The brain can, with multiple exceptions, do its job regardless of whether it's in a conscious state or not."

Originally published on Live Science.

Can We Ever Stop Thinking?

We often find ourselves in an endless thought loop. And every so often, we try to stop this endless flow of thoughts by telling ourselves to just stop thinking. But do we or can we ever really stop thinking?

It depends on how you define "thinking," said Michael Halassa, an assistant professor in the department of brain and cognitive sciences at MIT. A thought, which is the result of chemical firing between brain cells, can happen both on the conscious and unconscious level, he said.

The type of thinking we are aware of, such as the endless thoughts that pop up when we're trying to sleep, can, in theory, be silenced. That's presumably what meditation is all about, Halassa said.

But even though that's what meditators strive to do — it's not clear how much of a blank state they can actually achieve. "I don't know if [completely stopping thinking] is theoretically possible and if it is, I think that would be incredibly difficult to test," said Julia Kam, a cognitive scientist at the Knight Lab at the University of California, Berkeley.

But it's clear that "meditators are a lot more tuned into what their thoughts are," Kam told Live Science. "So when they're supposed to be focused on something and their mind shifts away, then they're just a lot better at picking up on that shifting of attention."

There's a difference between having a thought, and being aware that you're having a thought, she said. So if you ask someone what they're thinking about and they respond with "nothing," they could just not be aware that they're having thoughts, Kam said. For instance, you could be deeply in thought about a relationship or an upcoming test, and you only become aware of it when someone taps you on the shoulder and snaps you out of it, she said. People who are thinking about "nothing" could also be having stream of consciousness thoughts that don't tell a coherent story, Halassa said.

But the brain never actually stops "thinking" in a broader sense. Most thoughts are actually happening in the background without us being aware of them, and "there's not really a way to turn these things off," Halassa told Live Science.

If you see a familiar face in a crowd and think you know them, you might not be able to come up with how you know them right away, Halassa said. But maybe hours later, you'll suddenly remember. That's a result of your brain "thinking," in the background, he said.

Even making decisions happens mostly unconsciously. For example, some of this background "thinking" results in what we call a "gut feeling," Halassa said. "A lot of times our brains are crunching a lot of numbers and spitting out a gut feeling that we ultimately go with." We don't always have conscious access to our brain's decision-making process and sometimes we create a story to explain the decision — sometimes it's accurate, sometimes it's not, he added.
Kam agrees that how you define "thinking," changes the answer to the question. "If you mean thinking, as in having an inner dialogue with ourselves, then, yes, we can stop having that inner dialogue," Kam said. But if thinking means not focusing attention on anything in particular, "I think that would be a lot more difficult for the layperson."

Even sitting here reading this, thinking about thinking is sending messages across a chain of neurons in the brain. So if we somehow manage to stop ourselves from "thinking" consciously, or achieve a "blank state of mind" through meditation, the brain won't sign off. It will continue to have thoughts — we just won't be aware of them.

Can You Learn Anything While You Sleep?

There are only 24 hours in a day, and usually about a third of that is spent sleeping. So, the overambitious have always wondered: Is it possible to make use of this time and learn a new skill or even a language? In other words, is sleep learning possible?

The answer is yes and no, depending on what we mean by "learning."

Absorbing complex information or picking up a new skill from scratch by, say, listening to an audio recording during sleep is almost certainly impossible. But research shows that the sleeping brain is far from idle and that some forms of learning can happen. However, whether that's worth losing sleep over has yet to be determined.

Sleep learning: From sham to science

The concept of sleep learning, or hypnopedia, has a long history. The first study to demonstrate a memory and learning benefit from sleep was published in 1914 by German psychologist Rosa Heine. She found that learning new material in the evening before sleep results in better recall compared to learning during the day.

Thanks to many studies done since then, we now know that sleep is crucial for forming long-term memories of what we have encountered during the day. The sleeping brain replays the day's experiences and stabilizes them by moving them from the hippocampus, where they are first formed, to regions across the brain. Given that so much is happening to memories during sleep, it's natural to ask if the memories can be altered, enhanced or even formed anew.

One popular approach to sleep learning was Psycho-phone, a popular device in the 1930s. It played out motivational messages to sleepers, such as "I radiate love," supposedly helping the people absorb the ideas in their subconscious and wake up with radiant confidence.

At first, it seemed that research backed up the idea behind devices like Psycho-phone. Some early studies found that people learned the material they encountered during sleep. But those findings were debunked in the 1950s, when scientists began to use EEG to monitor sleep brain waves. Researchers found that if any learning had happened, it was only because the stimuli had woken the participants. These poor studies launched sleep learning into the trash can of pseudoscience.

But in recent years, studies have found that the brain may not be a total blob during sleep. These findings suggest that it is possible for the sleeping brain to absorb information and even form new memories. The catch, however, is that the memories are implicit, or unconscious. Put another way, this form of learning is extremely basic, much simpler than what your brain has to accomplish if you want to learn German or quantum mechanics.

Still, these findings have elevated sleep learning from the category of pipe dreams and put it back on scientists' radar.

"For decades the scientific literature was saying sleep learning was impossible. So, even seeing the most basic form of learning is interesting for a scientist," said Thomas Andrillon, a neuroscientist at Monash University in Melbourne, Australia. "But people are not really interested in this basic form of learning."

For scientists, the recent discoveries have raised hopes about possible applications, Andrillon told Live Science. For example, the implicit nature of sleep learning makes the phenomenon useful for people who want to shed a bad habit, like smoking, or form new good ones.

Multiple studies have found that a basic form of learning, called conditioning, can happen during sleep. In a 2012 study published in the journal Nature Neuroscience, for example, Israeli researchers found that people can learn to associate sounds with odors during sleep. The scientists played a tone to sleeping study participants while unleashing a nasty spoiled-fish smell. Once awake, upon hearing the tone, the people held their breath in anticipation of a bad smell.
"This was a clear finding showing humans can form new memories during sleep," said Andrillion, who was not involved in that study.

Although the memory was implicit, it could affect the people's behavior, researchers found in a 2014 study published in the Journal of Neuroscience. In that research, smokers used fewer cigarettes after spending a night being exposed to the smell of cigarettes paired with rotten eggs or spoiled fish.
ndrillon and his colleagues have found that learning in sleep can go beyond simple conditioning. In their 2017 study published in the journal Nature Communications, subjects were able to pick out complex sound patterns that they had heard during sleep.
Learning abilities in sleep may extend to the learning of words. In a study published in the journal Current Biology in January, researchers played pairs of made-up words and their supposed meanings, like that "guga" means elephant, to sleeping participants. After this, when awake, the people performed better than chance when they had to pick the right translation of made-up words in a multichoice test.
What all these studies have in common is that they show an implicit form of memory. "It's not some knowledge they'll be able to use spontaneously, because they don't know this knowledge is even there," Andrillion said. "The question is, 'Where do we go from there?'"
Learning a new language involves many different layers: recognizing the sounds, learning the vocabulary and mastering the grammar. So far, research suggests it may be possible to get familiarized with the tone and accent of a language or even the meaning of words while sleeping, but to a weaker level than what we already do all the time during the day without noticing

And then you have to consider the cost, Andrillion said. Stimulating the sleeping brain with new information likely disrupts the functions of sleep, negatively affecting the pruning and strengthening of what we have learned over the previous day, he said.

While losing quality sleep to potentially learn a few words is not a smart trade-off, researchers continue to study sleep learning because the compromise may be worth it in special cases. For example, sleep learning could be useful when people

need to change a habit or alter stubborn disturbing memories in cases of phobias and post-traumatic stress disorder.
And some forms of implicit learning that may help in those situation may occur more strongly during sleep. The conditioning that happened in the smoking and rotten egg study, for example, doesn't work well when done during wakefulness. If you smoke every day near a garbage bin, you know the two are unrelated, so you don't link them. We are not easily tricked when awake.

"But the sleeping brain is not so smart, and we can manipulate it for our own good," Andrillion said. "It sounds a lot like the 'Eternal Sunshine' [movie], and this is still ongoing work, but the possibility is there."

Until then, remember that a good night's sleep is already sleep learning at its best.

Why Can't We Remember Our Dreams?

You spend a third of your life asleep, a good chunk of which involves dreaming. But most often, you don't remember any of your dreams. And even on those lucky days when you wake up with a memory of the dream still floating in your mind, there's a good chance that in just a minute the memory will vanish into thin air and back to dreamland.

In waking life, such a case of quickly forgetting recent experiences would surely land you in a doctor's office. With dreams, however, forgetting is normal. Why?

"We have a tendency to immediately forget dreams, and it's likely that people who rarely report dreams are just forgetting them more easily," said Thomas Andrillon, a neuroscientist at Monash University in Melbourne, Australia. It might be hard to believe that you had a dream if you don't remember anything, but studies consistently show that even people who haven't recalled a single dream in decades or even their entire lifetime, do, in fact, recall them if they are awakened at the right moment, Andrillon said.

While the exact reason is not fully known, scientists have gained some insight into memory processes during sleep, leading to several ideas that may explain our peculiar forgetfulness.

You are awake, but is your hippocampus?

When we fall asleep, not all the brain's regions go offline at the same time, according to a 2011 study in the journal Neuron. Researchers have found one of the last regions to go to sleep is the hippocampus, a curved structure that sits inside each brain hemisphere and is critical for moving information from short-term memory into long-term memory.
If the hippocampus is the last to go to sleep, it could very well be the last to wake up, Andrillon said. "So, you could have this window where you wake up with a dream in your short-term memory, but since the hippocampus is not fully awake yet, your brain is not able to keep that memory," Andrillon told Live Science.

While this might explain why dream memories are so fleeting, it doesn't mean that your hippocampus has been inactive throughout the night. In fact, this region is quite active during sleep, and appears to be storing and caring for existing memories to consolidate them, instead of listening for incoming new experiences. "Some data shows that [during some sleep stages] the hippocampus is sending information to the cortex, but not receiving any," Andrillon said. "This unidirectional communication would allow sending memories from the hippocampus to the brain's cortex for long-term storage, but new information wouldn't be registered by the hippocampus."

Upon awakening, the brain may need at least 2 minutes to jump-start its memory-encoding abilities. In a 2017 study published in the journal Frontiers in Human Neuroscience, researchers in France monitored sleep patterns in 18 people who reported remembering their dreams almost every day, and 18 others who rarely remembered their dreams. The team found that compared with low-dream recallers, high recallers woke up more frequently during the night. These middle-of-the-night awakenings lasted an average of 2 minutes for high recallers, whereas low-recallers' awakenings lasted for an average of 1 minute.

Neurochemical soup

Our poor ability to encode new memories during sleep is also linked to changes in the levels of two neurotransmitters, acetylcholine and noradrenaline, which are especially important for retaining memories. When we fall asleep, acetylcholine and noradrenaline drop dramatically.

Then, something strange happens as we enter the rapid eye movement (REM) stage of sleep, where the most vivid dreams occur. In this stage, acetylcholine returns to wakefulness levels, but noradrenaline stays low.

Scientists have yet to work out this puzzle, but some suggest that this particular combination of neurotransmitters might be the reason we forget our dreams. The boost in acetylcholine puts the cortex in an aroused state similar to wakefulness, while low noradrenaline reduces our ability to recall our mental escapades during this time, according to a 2017 study in the journal Behavioral and Brain Sciences.

Sometimes your dreams are just not memorable

Do you remember what you were thinking about this morning when brushing your teeth? Our minds wander all the time, but we discard most of those thoughts as nonessential information. Dreams, especially mundane ones, may be just like daydreaming thoughts and deemed by the brain to be too useless to remember, the late dream researcher Ernest Hartmann, who was a professor of psychiatry at Tufts University School of Medicine, wrote in Scientific American.
But dreams that are more vivid, emotional and coherent seem to be better remembered — perhaps because they trigger more awakening, and their organized narrative makes them easier to store, Andrillon said.

If you are intent on improving your dream recall, there are a few tricks to try. Robert Stickgold, an associate professor of psychiatry at Harvard Medical School, suggests drinking water before bed, because it will make you wake up at night to use the bathroom. These "middle-of-the-night awakenings are frequently accompanied by dream recall," Stickgold told The New York Times.
Once in bed, repeatedly reminding yourself that you want to remember your dreams may increase your chances, and so does keeping a dream journal, some studies have suggested. Upon waking up, hang on to that fragile dream memory: Keep your eyes closed, stay still and replay the dream memory, until your hippocampus catches up and properly stores the memory.
Original article on Live Science.

Can I Control My Dreams?

Lucid dreaming — that is, being aware of and able to control your dreaming state — may sound like a typical nocturnal experience to some, and just a pipe dream to others.

Whatever your opinion, the phenomenon of lucid dreaming has been observed in the laboratory. Subjects have been able to communicate to the waking world from their dreams using agreed-upon signals: namely, patterns of eye movement. Much dreaming seems to accompany a sleeper's rapid eye movement (REM), which

occurs at a specific stage in the sleep cycle. Eye muscles are exempt from the paralysis that prevents other muscles in the body from acting out one's dream-movements. A lucid dreamer can shift eyes downward in a dream and the sleeping body will duplicate the action.
Several books and films (notably "Waking Life") have dealt with the notion of controlling one's dreams, but in the scientific world the study of lucid dreaming has remained peripheral to sleep research.

Scientists discover the maximum age a human being can attain

In a groundbreaking discovery, Dutch researchers believe they've uncovered the elusive "ceiling" of the human lifespan. As modern life expectancy continues to rise due to advances in nutrition, improved living conditions, and progressive medical care, there's been heightened interest in understanding just how old humans can potentially grow.

The new study offers a startling perspective.

Utilizing a comprehensive dataset that tracked the exact age at death for approximately 75,000 Dutch individuals, expert statisticians from Tilburg and Erasmus universities in Rotterdam have posited a maximum age limit for women at an astonishing 115.7 years.

The male counterpart, interestingly, nudges slightly below at 114.1 years. This invaluable data stretches over a remarkable three decades, providing a solid foundation for the researchers' claims.

Professor John Einmahl, one of the leading scientists behind the study, shared some insight into the findings. "On average, people live longer, but the very oldest among us have not gotten older over the last thirty years," he remarked.

Einmahl's observations underscore a fascinating paradox. He elucidated, "There is certainly some kind of a wall here. Of course, the average life expectancy has increased."

Related Stories

These findings further highlight that the number of individuals in The Netherlands celebrating their 95th birthday has almost tripled in recent times. "Nevertheless, the maximum ceiling itself hasn't changed," Einmahl emphatically noted.

For clarity, it's essential to differentiate between 'lifespan' and 'life expectancy'. The former relates to the duration of life for an individual, while the latter represents the average expected life duration for individuals within a specific age group. Life expectancy typically serves as a metric indicating societal wellbeing.

This recent Dutch exploration resonates with findings from US-based researchers last year. While they too identified a similar age ceiling, they posited that those exceptionally aged weren't living quite as long as their predecessors.

However, Einmahl and his team challenge this notion. Employing a unique statistical approach known as the "Extreme Value Theory", they concluded that the maximum lifespan has exhibited almost negligible fluctuations.

For those unfamiliar, the Extreme Value Theory is a sophisticated statistical methodology primarily utilized to interpret data and address questions related to extreme events – think lifespans, natural disasters, and other outliers.

Still, like every rule, there are exceptions. Einmahl cites the case of Jeanne Calment, the French supercentenarian, who defied all odds by living to the remarkable age of 122 years and 164 days. To date, she remains the oldest verified woman.

As the scientific community awaits further validation, Einmahl announced that their pioneering findings are enroute for submission to a peer-reviewed journal. He anticipates its publication "within the next month or so".

As we look to the future, studies such as these are more than mere statistics. They prompt profound questions about the human condition, the nature of our existence, and the interplay of biology and environment. The "ceiling" might be set, but the conversation about human potential is limitless.

The Illusion of Death

Our current way of thinking goes on to assume that the world has an objective existence independent of the observer. However, numerous experiments have suggested otherwise. We view life as the activity of carbon and other molecules: we live for a while and then decay into the ground. This belief leads us to accept the concept of death, primarily because we identify ourselves with our physical bodies, which eventually perish. However, biocentrism, a theory proposed by Dr. Robert Lanza, argues that if we incorporate life and consciousness into the equation, many scientific puzzles can be explained, including why the universe appears fine-tuned for life.

Death

Biocentrism states that space and time are not the solid entities we perceive them to be. Instead, they are constructs of our consciousness. For example, consider the famous two-slit experiment: when a particle is observed, it behaves like a particle and passes through one slit. Without observation, it acts like a wave, passing through both slits simultaneously. This indicates that reality is shaped by our consciousness.

Also, Heisenberg's uncertainty principle (not THAT Heisenberg) suggests that we cannot measure a particle's exact location and momentum simultaneously. This phenomenon, along with the understanding of particles being entangled over vast distances, further supports the notion that space and time are tools of our mind.

Death in a Timeless World

In a timeless, spaceless world, the idea of death does not hold. In this context, immortality wouldn't imply a perpetual existence in time but rather an existence outside of time altogether. This idea aligns with recent experiments showing that light particles can communicate instantaneously as if there were no space or time separating them. Such findings suggest that our understanding of time and space-and, by extension, life and death-is deeply flawed.

Quantum Mechanics and Multiple Universes

Quantum mechanics challenges our current understandings of reality. The "many-worlds" interpretation, for example, states that every possible observation corresponds to a different universe. In this multiverse, all possible outcomes occur simultaneously, implying that death, as we perceive it, does not exist in any real sense, since we are still alive and death will have already taken place. This theory resonates with the principles of biocentrism, where consciousness plays a central role in shaping reality.

Philosophical and Psychological Perspectives

The fear of death is a major influence on many human behaviors and beliefs, which is something covered by terror-management theory. This theory suggests that our existential dread drives us to cling to beliefs that connect us to something greater than our mortal selves.[3] For physicists, grappling with the implications of quantum mechanics and the potential for an observer-dependent reality can be both unsettling and comforting. Consciousness influencing our universe can provide a sense of purpose and continuity beyond physical death.

The Future of Biocentrism

Dr.

Robert Lanza's biocentrism theory remains controversial, blending elements of science and philosophy to make something new. Critics argue that it lacks a solid mathematical foundation and veers into speculative territory, which is both a fair critique and completely true. However, Lanza continues to refine his ideas, and aims to bridge the gaps between biotechnology and physics. His work suggests that understanding consciousness could revolutionize our perception of life, death, and the universe.

Conclusion

Death, as traditionally understood, maybe an illusion shaped by our consciousness. Quantum physics and biocentrism have challenged the notion of an objective, observer-independent reality, suggesting that life and consciousness are central to the universe's fabric. As Einstein implied and Lanza elaborates, our understanding of existence is limited by our linear (and limited) perception of time and space. Embracing these new perspectives could profoundly impact how we understand life and the afterlife.

Lifechanging senolytic drugs could extend human lifespans by 30%

Though the quest for the fountain of youth may remain elusive, scientists continue to uncover methods to prolong human lifespans.

Though the quest for the fountain of youth may remain elusive, scientists continue to uncover methods to prolong human lifespans. In the future, guarding our cells against aging could be as simple as ingesting a tablet.

Researchers at the Mayo Clinic have discovered that senolytic drugs can enhance the production of a crucial protein, potentially shielding the elderly from the effects of aging and various illnesses. Their findings, featured in eBioMedicine, demonstrate this through experiments on mice and humans.

The senolytics developed at the Mayo Clinic, when administered, effectively purge the bloodstream of senescent or "zombie" cells. These cells are implicated in numerous diseases and detrimental aging aspects.

The study reveals that the elimination of senescent cells leads to a significant increase in the production of a protective protein known as a-klotho.

What are zombie cells?

Senescent cells, colloquially known as "zombie cells," are cells within your body that stubbornly persist and do not die.

Usually, a cell starts out as a healthy, functioning component of the body. However, it may encounter various stressors such as oxidative stress, a viral infection, or other factors. In response to this stress, the cell has three possible outcomes: undergo self-repair, undergo cell death, or transform into a senescent, or "zombie," cell.

While zombie cells may have some advantages, they are not entirely detrimental. A 2017 study indicates that cellular senescence, the process by which normal cells transform into zombie cells, can actually be a positive response to tumor development.

Instead of uncontrollably multiplying and contributing to tumor formation, a cell will turn into a zombie cell and halt its growth.
On the other hand, zombie cells can also have negative consequences in different situations. As we age, these zombie cells accumulate within our bodies. This accumulation can impede the body's ability to repair damaged tissue and may cause the release of harmful chemicals that affect nearby healthy cells.

Research has connected the presence of zombie cells to numerous age-related diseases such as atherosclerosis (a type of heart disease), diabetes, and lung disease.

The impact of senolytic drugs

Senolytics (or senolytic drugs) are a specific class of drugs that help clear out zombie cells. "We show that there is an avenue for an orally active, small-molecule approach to increase this beneficial protein and also to amplify the action of senolytic drugs," says James Kirkland, M.D., Ph.D., a Mayo Clinic internist and senior author of the study.
The researchers first showed that senescent cells decrease levels of a-klotho in three types of human cells: umbilical vein endothelial cells, kidney cells and brain cells.

The researchers demonstrated that by using senolytics desatinib and quercetin in three different mouse models, a-klotho levels were increased. Following the administration of desatinib and quercetin in clinical trial participants with idiopathic pulmonary fibrosis, a-klotho levels were also found to increase.

Yi Zhu, Ph.D., a Mayo Clinic physiologist and biomedical engineer, and the study's first author, states, "We are the first to establish a connection between the potential influence of fat-resident senescent cells on brain a-klotho. This could provide another path to explore the effects of peripheral senescent cells on brain aging."

The protein a-klotho plays a crucial role in maintaining overall health. Its levels tend to decline as people age and are particularly reduced in various diseases such as Alzheimer's, diabetes, and kidney disease.

Research on animals has revealed that reducing a-klotho in mice results in a shorter lifespan, while increasing a-klotho levels by inserting a gene that triggers its production can extend their lifespan by 30%.

Increasing a-klotho levels in humans has been a significant objective in research; however, achieving this has been challenging due to its large size and instability. Direct introduction poses issues, as it necessitates intravenous administration rather than oral consumption.

The current research demonstrates that senolytics, which can be taken orally, boost a-klotho levels in individuals suffering from idiopathic pulmonary fibrosis, a condition linked to senescence that results in frailty, severe breathing problems, and death.
This study received support from various organizations, including the National Institute of Health, the Translational Geroscience Network, Robert and Arlene Kogod, the Connor Group, Robert J. and Theresa W. Ryan, and the Noaber Foundation.

Where can you get senolytic drugs?

The senolytic drug dasatinib isn't available as an over-the-counter drug. But quercetin is available in supplement form.

You can also ramp up your quercetin intake by eating more onions, apples (with the skin!), citrus fruits, and parsley. It can't hurt, and these delicious foods are easy to find at your grocery store or local farmer's market.

Reality Is Just a Bunch of Hallucinations We Collectively Agree On

When we think of hallucinations, we think of phenomena that are not real-created, in a way, by an aberration in our minds. But from one perspective, these visual illusions are just as real as anything else we might see.

Anil Seth, a neuroscientist and director of the Sackler Centre for Consciousness Science at the University of Sussex, researches the biological basis of the otherwise ethereal topic of consciousness, which he defines as the state when there is "something it is like to be" an organism. (For example, there is something like the way it is to be a mouse, but not a coffee mug.) And he wants to understand how this shapes how we experience the world.

"Most ambitiously, we want a unified theory of perception," Seth said about the goal of the lab. "Time, vision, hearing...we want to explain that."

The Sackler Centre is home base for Seth's world of neuroscience, but also philosophers, physicists, computational scientists, and artists-creating a multidisciplinary tableau through which to look at questions about the mind and brain. Seth and his team are applying a range of methods and tools-from computational science and virtual reality to brain imaging-to identify the mechanisms that compose consciousness.

The way Seth explains it, our perceptions are a combination of electrical impulses and prediction. The brain combines sensory signals, processes it in the context of what it knows from the past, and guesses what is happening in real time. For example, we might see an object through the visual cortex, but what helps us identify said object is the past compendium of information we have accumulated until that point.

Which is why he says our conscious reality is so similar to hallucination-the only difference is that we collectively agree on these particular hallucinations and deem them reality. "We don't just passively perceive the world, we actively generate it," he said in a 2017 Ted Talk.

Seth, who grew up in Oxfordshire, England, became fascinated by consciousness around the age of 19 through the lens of math and physics. At Cambridge University, he started to absorb books on the topic while studying natural sciences. In *The Emperor's New Mind*, Roger Penrose, a mathematical physicist, posited that some parts of the human mind would never be replicated by a machine. In *Consciousness Explained*, cognitive scientist Daniel Dennett described consciousness as a cluster of brain activity, rather than a centralized entity. But Seth wasn't satisfied.

"I said, ‘something is missing here'," Seth told me. "I think that gave me the motivation to think I want to know more."

Seth continued to study the brain after university. He received a Masters of Science in Knowledge-Based Systems at the University of Sussex in 1996 and said academia provided the resources and professors to help him explore different avenues of addressing consciousness and how it determines what we perceive, from psychology to brain imaging data. He started to look at behavior and the brain, and how they were influenced by someone's environment.

But he didn't think it was possible to specifically study the core idea of consciousness until 2001, when he flew across the pond to the Neurosciences Institute in San Diego, California to work with Gerald Edelman, a Nobel Prizewinning biologist who argued that the mind and consciousness were purely biological. Explained in his book *Neural Darwinism*, Edelman's theory is focused on how genetics and the environment influence the way neurons in the brain interact and reproduce to create consciousness.

"Here was the first time people were not only studying consciousness but studying the brain [in that context]," Seth said.

His role in San Diego was multifaceted. Seth spent his time building robots with brain architecture that mimicked the human brain. The robots were tasked with solving visual perception problems, or mazes. Afterward, Seth needed to find a way to continue his exploration of consciousness.

In 2006, Seth moved back to England and arrived at the University of Sussex. He slowly found support for his new laboratory and built out a team to study how the brain constructs the concept of the self and world around it.

"It required professional philosophers to actually learn some of the neuroscience, and scientists like me to become literate with philosophy," he said of the process.

The lab's methodologies run a huge spectrum, too. They conduct VR experiments to understand hallucinations and how we know if an object exists. There are computational models to test the beast-machine theory, put forth by French philosopher Rene Descartes, that says animals differ from humans in that they are unthinking, unfeeling machines.

The philosophy of consciousness, of course, also intersects with faith and culture. And that has continued to play a role in Seth's work as well. He has spoken with Buddhists, Hindus, Christians and members of other religious groups to further understand how consciousness has been defined. That definition varies: in Buddhism, for example, consciousness is defined loosely as *skandha*, five factors that contribute to mental and physical existence. Much of this conversation also has to do with the concept of a soul, which can sometimes been seen as the embodiment of consciousness.

"The concept of the soul, in Western religions, is like a little me that's made of stuff jumping from body to body," Seth said. "In Eastern traditions, it's a little more sophisticated."

But Seth said he's also frustrated by the lack of neuroscience and data in the larger understanding of consciousness. Given the nature of his work, Seth has been active in speaking and writing about consciousness for an audience outside of academia.

He sees the subject matter as both an academic and intellectual pursuit, as well as a personal one. Seth, who has dealt with depressive episodes for many years, says his study of the emotional experience and how it is constructed has helped him understand his own mind. He can tell himself a different story and break his cycle of thoughts by acknowledging how reality is created.

Seth said he hopes there will be an even larger application of his work when it comes to mental health. Understanding consciousness, he said, could help uncover some of the mechanisms of complex disorders like schizophrenia and delusions. Right now, he said, psychiatry can often fall short of this kind of treatment. "You can suppress people's symptoms, but you don't get to the cause."

But Seth is also careful to avoid seeing his discoveries as prescriptions. There are still huge questions to be answered, he said, and the team has a long way to go. Why is consciousness part of the universe at all? Why do some have some experiences and others don't? This is the stuff, he said, that impacts every single person, and the machines we continue to make.

"I do feel a sense of connectedness to the world around me that derives from studying consciousness," he said. "It's the kind of job where even if there are points that are satisfying, there's always another thing waiting."

Written by: Anita Rao

Human consciousness may come from another dimension, scientist suggests

Despite consciousness being the centre of studies and discussions for years, it remains one of the world's biggest mysteries. A new mind-boggling theory has suggested the brain's consciousness could derive from other dimensions – not just brain activity.

Michael Pravica, a professor of physics at the University of Nevada, shared a concept deep-rooted in hyperdimensionality, the idea that the universe has more dimensions than the ones we perceive. He believes we should be exploring hidden dimensions to explain consciousness.

"The sheer fact we can conceive of higher dimensions than four within our mind, within our mathematics, is a gift... It's something that transcends biology," the scientist told *Popular Mechanics*.

While hyperdimensionality and string theory are widely accepted by physicists, his belief of their ties to consciousness is a controversial one.

Pravica, an Orthodox Christian with a PhD from Harvard, used hyperdimensionality to create a bridge between science and his religious beliefs, exploring his idea that Jesus may have been a hyperdimensional being.

"According to the Bible, Jesus ascended into heaven 40 days after being on Earth. How do you ascend into heaven if you're a four-dimensional creature?" Pravica asked.

His theory ventures outside the realm of neuroscience and into theoretical physics with one scientist slamming it as bordering "on science fiction".

Stephen Holler, PhD, an associate professor of physics at Fordham University in New York, chimed in on the action, telling the publication: "Gaps in scientific knowledge are attributed to divine intervention, rather than being seen as opportunities for further inquiry and understanding."

He went on to suggest it was a "poor explanation mechanism that arguably stifles the inquisitive nature required for good science and teaches that it's not okay to say, 'I don't know'".

Scientist says human consciousness comes from another dimension

A baffling new theory to explain human consciousness has suggested it comes from hidden dimensions and is not just brain activity.

A physicist claimed that we plug in to these invisible planes of the universe when making art, practicing science, pondering philosophy or dreaming, and this could explain the phenomenon that has evaded scientific understanding for centuries.

Michael Pravica, a professor of physics at the University of Nevada, Las Vegas, has based the wild idea on hyperdimensionality, the idea that the universe is made up of more dimensions than just the four we perceive: height, length width and time.

But his theory is highly controversial, with one scientist saying that the cornerstone of Pravica's theory 'borders on science fiction.'

'The sheer fact that we can conceive of higher dimensions than four within our mind, within our mathematics, is a gift... it's something that transcends biology,' Pravica told Popular Mechanics.

Scientists have been attempting to explain human consciousness and its origins for hundreds of years - and the theories run the gamut.

One leading theory suggests that consciousness is related to how much information is integrated between the different parts of the brain. The more information is connected and integrated, the more conscious a being is thought to be.

Another posits that conscious mental states are driven by top-down signaling in the brain. Top-down signaling refers to the process by which higher-level brain regions send information, expectations or context to lower-level brain regions.

But Pravica's theory ventures outside the realm of neuroscience and into theoretical physics.

He suggested that in moments of heightened awareness, like when we enter a dream state or use our brains for deeply creative or intellectual tasks, our consciousness could transcend our physical dimension and enter a higher plane.

In these moments, our consciousness syncs with hidden dimensions and receives a flood of inspiration, Pravica said.

To better understand the controversial theory, consider the following scenario.

Imagine you're a two-dimensional being living in a two-dimensional world, like a character in a comic book. Now, imagine that a sphere passes through your plane of view.

The sphere would look like a dot that grows into a larger and larger circle as it comes closer, then gradually shrinks until it's out of view. You would have no way of knowing that it's actually a three-dimensional shape.

Pravica sees us as a version of these 2D characters. Although we exist in a four-dimensional world, we can only perceive matter and energy that is of those four dimensions, just like how beings in a 2D world cannot perceive a 3D object.

Thus, the limitations of our world prevent us from detecting higher dimensions that could, in theory, exist all around us.

This is the foundation of hyperdimensionality - the idea that the universe is made up of many dimensions, some of which are hidden because they are beyond the reach of our physical realm.

Hyperdimensionality ties into string theory, which states that reality is made up of infinitely small vibrating strings that are smaller than atoms, electrons or quarks.

As the strings vibrate, twist and fold, they produce effects in multiple unseen dimensions that give rise to all the particles and forces that we can observe, from particle physics to gravity.

'String theory is essentially a theory of hyperdimensionality,' Pravica said. 'It's looking at how the universe is put together on a sub-quantum scale.'

Pravica believes that our brains can tap into higher dimensions when in a dream state or performing deeply creating or intellectual tasks

Although we can observe the effects that these vibrating strings have on the physics of our dimension, we can't observe the hidden dimensions that they're vibrating in.

That is - we can't physically observe them.

But our consciousness may be able to tap into them, Pravica says.

Hyperdimensionality and string theory are widely accepted by physicists, but Pravica's idea of their relationship with consciousness is more controversial - especially because it blurs the lines between science and spirituality.

As an Orthodox Christian with a Ph.D. from Harvard, Pravica has found hyperdimensionality to be a way to bridge his scientific background with his religious beliefs.

For example, he believes Jesus may be a hyperdimensional being.

'According to the Bible, Jesus ascended into heaven 40 days after being on Earth. How do you ascend into heaven if you're a four-dimensional creature?' Pravica asked.

But being hyperdimensional could, theoretically, have allowed Jesus to move between our world and heaven - which may be a world of higher or infinite dimensions, he said.

Pravica's theory is based on a 'God of the gaps' perspective, where gaps in scientific knowledge are explained by divine intervention, said Stephen Holler, associate professor of physics at Fordham University.

He believes that this type of thinking is insufficient, and hampers the scientific inquiry needed to truly understand and explain ineffable phenomena like human consciousness.

'It's a poor explanation mechanism that arguably stifles the inquisitive nature required for good science and teaches that it's not okay to say, 'I don't know,'' Holler told Popular Mechanics.

He points out that our ability to mathematically manipulate higher dimensions is not proof that they actually exist, or that our consciousness can interact with them.

What's more, exploring these higher dimensions is impossible due to the limitations of our current technological capabilities.

Not even the most powerful particle accelerator in the world - the Large Hadron Collider (LHC) at CERN - can provide real proof that these dimensions exist.

The LHC smashes particles together at incredibly high speeds - up to the speed of light.

This allows physicists to study the fundamental building blocks of matter and energy and access infinitesimally small dimensions - even smaller than a single proton.

But even the LHC isn't able to reveal the high-dimensional strings that quantum physics predicts. To get that granular, physicists would need a much more powerful collider.

Without that concrete evidence, Holler says that hyperdimensionality 'borders on science fiction.'

But Pravica is optimistic that such technology could exist within his children's lifetime.

Until then, he will continue to support hyperdimensionality and his theory of how it relates to our consciousness.

'I see no point otherwise,' he said. 'Why study? Why live?'

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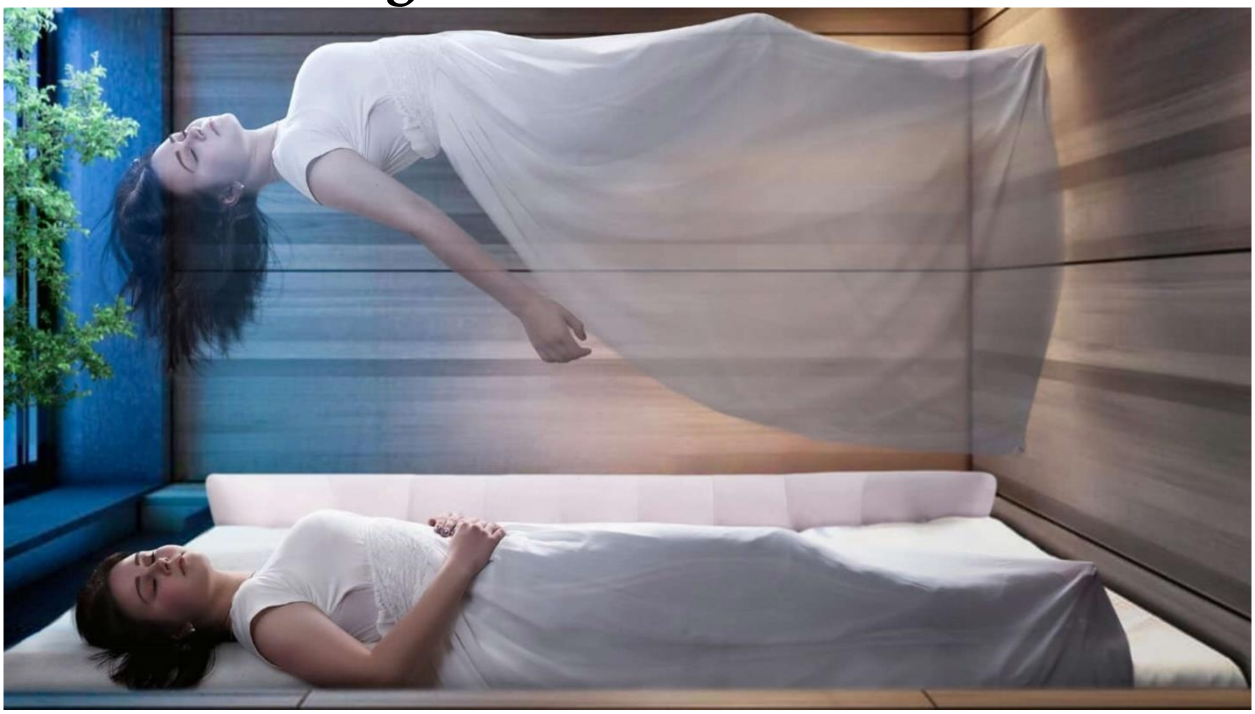
Beyond the Final Breath: How Consciousness Persists During Death



Death has long been shrouded in mystery, often seen as the ultimate end. But what if death is not the final chapter but rather a complex process? Research by Dr. Sam Parnia, a leading expert in resuscitation science, challenges our understanding of death.

His work suggests that death is not an absolute endpoint but a gradual process involving unique cognitive experiences.

Redefining Death

Traditionally, death has been defined as the irreversible cessation of heart function, known as death by cardiopulmonary criteria. However, advances in intensive care medicine have allowed doctors to artificially maintain a patient's heartbeat, even when the brain has suffered irreversible damage.

This has led to the concept of brain death, where the brain has died, but the heart continues to beat with medical intervention.

Dr. Parnia's research reveals that death is not an instantaneous event, but rather a process that unfolds over time. (ref) After a person's heart stops, the cells in their body, including the brain, begin their own gradual death process.

Contrary to previous beliefs, brain cells do not die within minutes of oxygen deprivation. In fact, it can take hours or even days for irreversible damage to occur.

The Paradox of Consciousness during Death

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One of the most intriguing aspects of Dr. Parnia's research is the study of near-death experiences. (ref) Many patients who have been resuscitated report vivid and lucid cognitive experiences during the time when their brain function was severely compromised or even absent.

These experiences often involve a sense of leaving the body, observing the resuscitation efforts, and feeling a profound sense of peace.

The fact that patients can have well-structured thought processes and form memories during a time when their brain is highly dysfunctional challenges our understanding of consciousness.

It raises the possibility that consciousness may not be solely produced by the brain, but rather that the brain acts as an intermediary for a yet undiscovered scientific entity.

Implications for the Nature of Consciousness

Dr. Parnia's research has significant implications for our understanding of consciousness and its relationship to the brain.

If consciousness can persist even when brain function is severely impaired, it suggests that the mind may not be entirely dependent on the physical brain. This opens up new avenues for scientific exploration and philosophical inquiry.

Could consciousness be a fundamental aspect of reality, existing beyond the confines of the brain? Are there layers of reality that we have yet to discover which may shape our perception and experience?

The Future of Resuscitation Science

As resuscitation science continues to advance, we may gain a deeper understanding of the processes that occur during death and the potential for intervention.

Dr. Parnia's research highlights the importance of developing strategies to combat the accelerated cell death that occurs when oxygen and blood flow are restored to organs after resuscitation.

By understanding the mysteries of death and consciousness, we may not only improve medical outcomes but also gain profound insights into the nature of life itself.

The exploration of near-death experiences and the frontiers of resuscitation science hold the promise of transforming our understanding of what it means to be human.

Chilling Facts About the End of Life

Each year, the world bids adieu to roughly 60 million individuals. Death, a universal yet often misunderstood happening, inspires a combination of fear, fascination, and deep curiosity. It's a concept clouded in mystery, inspiring questions that have echoed through the ages. While definitive answers to some of the questions remain elusive, we can shed light on some truly bone-chilling facts surrounding the end of life.

This exploration isn't intended to be morbid or fear-inducing. Rather, it aims to provide a peek into the lesser-known aspects of a universal human experience. By exploring these chilling truths, we may come to a deeper understanding and perhaps lessen the sting of the inevitable. Death is an unavoidable reality, and knowledge can be a powerful tool in facing its mysteries.

So, prepare to be both intrigued and unsettled as we consider 14 facts that could reshape your perception of death.

Rigor Mortis’ Transient Embrace

In the hours following death, a chemical reaction within the muscles causes them to stiffen, a phenomenon known as rigor mortis. This stiffness typically peaks around 12 hours postmortem and gradually subsides over the next day or two. This temporary state offers forensic investigators valuable clues about the time of death, helping them piece together the timeline of events if they’re unknown.

The onset and duration of rigor mortis can be influenced by various factors, including ambient temperature, body mass, and the cause of death. This information helps investigators estimate the time of death with greater accuracy.

Death’s Instant Replay

In rare and often traumatic deaths, an immediate and intense form of muscle stiffening called cadaveric spasm can occur and continue into rigor mortis. This phenomenon may preserve the last action a person took before dying, such as clutching a weapon or an object related to their demise. This macabre “snapshot” can offer crucial evidence in investigations, shedding light on the circumstances surrounding the death.

Cadaveric spasm is a fascinating yet chilling example of how the body can sometimes retain a haunting echo of its final moments. It’s a reminder that death can be both a mystery and a source of crucial information.

The Dance of Decomposition

The human body undergoes a series of distinct stages as it decomposes. These stages, including autolysis (self-digestion) and putrefaction (breakdown by bacteria), unfold in a predictable pattern. Forensic scientists analyze these stages to estimate the time since death and gain insight into the surrounding environment.

This morbid ballet of decay, while repulsive to some, is a fascinating process that reveals the intricate interplay of biology and environmental factors. It’s a crucial tool in forensic investigations, helping to unravel the mysteries surrounding suspicious deaths.

Body Farms

In certain research facilities known as “body farms,” scientists study the intricate process of human decomposition under various conditions. These outdoor laboratories provide invaluable data that helps forensic experts understand the factors influencing decomposition rates. This knowledge aids in criminal investigations and the identification of human remains.

Body farms, while seemingly gruesome, are essential for advancing our understanding of death and decay. The data collected from these unique facilities has far-reaching implications for forensic science and criminal justice.

The Body's Cellular Afterlife

Even after the heart stops and the brain ceases activity, certain cells within the body can continue to function for hours or even days. These include skin cells, which can be harvested and used for grafts, and stem cells, which hold the potential for regenerative medicine.

This postmortem cellular activity has led to advances in organ transplantation and tissue donation, offering hope and healing to those in need. It's a reminder that even in death, the body can continue to give life.

The Bone Collector

After soft tissues have decomposed, the skeletal remains can persist for centuries or even millennia. Forensic anthropologists study these bones to identify individuals, determine the cause of death, and reconstruct past events.

Bones serve as a lasting record of our existence, offering clues about our ancestry, lifestyle, and the circumstances surrounding our demise. They provide a tangible link to the past and a reminder of our own mortality.

The Death Mask

In some cultures, death masks were created to preserve the likeness of the deceased. These masks, often made of wax or plaster, served as mementos or were used in funeral rituals.

Death masks offer a glimpse into the past, capturing the facial features of historical figures and everyday people alike. They are a poignant reminder of the fragility of life and the importance of preserving memories.

The Science of Embalming

Embalming, the process of preserving the body after death, has a long and fascinating history. The ancient Egyptians were masters of this art, using a combination of natural resins and spices to mummify their pharaohs and prepare them for the afterlife.

Modern embalming techniques involve replacing bodily fluids with preservatives to delay decomposition and restore a more lifelike appearance. This practice is often used to allow for viewing of the deceased before burial or cremation.

The Coffin Birth

Also known as "postmortem fetal extrusion," coffin birth is a rare phenomenon that occurs when gases build up inside the decomposing body of a pregnant woman, causing the fetus to be expelled. This gruesome event has been documented throughout history and often fueled superstitious beliefs.

While the scientific explanation for coffin birth is straightforward, the historical accounts often include embellishments and folklore, reflecting the deep-seated fear and fascination surrounding death and the unknown.

The Death Rattle

The "death rattle" is a rattling or gurgling sound that can occur in the final stages of dying. It's caused by the accumulation of fluids in the airways and the relaxation of the throat muscles. While distressing to witness, this sound is a natural part of the dying process.

The death rattle is often a sign that death is imminent, and it can be emotionally difficult for loved ones to hear. However, understanding its cause and recognizing it as a natural part of the process can help to alleviate some of the anxiety and fear associated with it.

Some People See a Light at the End

As life's curtain begins to fall, some individuals report experiencing the "deathbed phenomenon." They describe visions of radiant lights, encounters with deceased loved ones, or a profound sense of peace. While skeptics attribute these experiences to oxygen deprivation or other physiological factors, others believe they may offer a fleeting glimpse into the afterlife.

The deathbed phenomenon raises profound questions about the nature of consciousness and the possibility of a realm beyond our earthly existence. It's a reminder that even as our physical bodies fade, the human spirit may continue to seek connection and meaning.

Theory About the Multiverse Suggests That it May Even Hold the Key to Immortality

In 1979, physicist Alan Guth proposed 'cosmological inflation' as one of the most developed multiverse models to answer questions about the existence of a parallel universe that had been discussed since the early 1900s. He suggested that after the Big Bang, the universe expanded rapidly for a brief moment, creating a huge zoom effect that affected the cosmic microwave background and the distribution of galaxies.

Elaborating on the same, Neil Turok, a physicist at the University of Edinburgh, UK, toldBored Panda, "It was an approach that was born out of a certain sense of frustration with previous approaches. In my view, they had all become rather complicated and contrived, including my own approaches." He added, "I thought we could be on the verge of the next big revolution in theory. It would be inspired by the data, and by the failure of traditional paradigms. It would change our view of the universe."

Following Guth's proposal, many theories emerged including one from physicist Andrei Linde, who introduced chaotic inflation in 1983. This suggested that rapid expansion possibly occurred in different ways due to chaotic early conditions in the universe. Knewz.com noted that in 2013, the European Space Agency’s Planck satellite map of the cosmic microwave background challenged inflation theory.

Since then, scientists have been inventing new methods to prove that there were parallel universes. Some argued in favor of the cyclic universe, which proposed that the universe went through endless cycles of formation and destruction. Additionally, Turok himself suggested a mirror universe theory in 2018, explaining that our universe had a twin where time moved backward.

According to theoretical physicist Alexander Vilenkin of Tufts University in Massachusetts, inflation didn't stop everywhere at the same time. Writing in Scientific American, he explained that when inflation stopped in one area, a new bubble universe was formed. He further wrote, "This picture of the universe, or multiverse, as it was called, explained the long-standing mystery of why the constants of nature appeared to be fine-tuned for the emergence of life. The reason was that intelligent observers existed only in those rare bubbles in which, by pure chance, the constants happened to be just right for life to evolve. The rest of the multiverse remained barren, but no one was there to complain about that."

Another theory that gained attention was Hugh Everett's 'Many-Worlds theory.' According to his theory, whenever an event had several possible outcomes, the universe split with every action. The theory surfaced more in the late 1990s through a thought experiment called 'quantum suicide,' which suggested that the Many-Worlds idea was theoretically possible. It was first suggested by physicist Hans Moravec in the 1990s and later expanded by Max Tegmark.

The experiment was created to test the idea of the 'many worlds' interpretation of quantum mechanics. Furthermore, the trials suggested that the person involved in the experiment would never experience death. This was because there would always be a version of the universe where they survived, making them 'quantum immortal.' Since then, physicists and mathematicians have continued to explore its implications. However, Many-Worlds was just one of several theories about the universe, and scientists were exploring more in search of a logical explanation.

Some researchers have suggested that consciousness is a fundamental property of the universe. Panpsychism takes this idea further and proposes that **everything in the universe is conscious**. However, despite our familiarity with consciousness, it remains a mystery. When we contemplate the universe, part of the universe becomes conscious of itself.

Does Consciousness Pervade the Universe?

Philosopher Philip Goff answers questions about "panpsychism"

One of science's most challenging problems is a question that can be stated easily: Where does consciousness come from? In his most recent book, *Galileo's Error: Foundations for a New Science of Consciousness*, philosopher Philip Goff considers a radical perspective: What if consciousness is not something special that the brain does but instead is a quality inherent to all matter? It is a theory known as panpsychism. He answered questions from former longtime Mind Matters editor Gareth Cook.

Can you explain, in simple terms, what you mean by panpsychism?

In our standard view of things, consciousness exists only in the brains of highly evolved organisms, and hence it exists only in a tiny part of the universe and only in very recent history. According to panpsychism, consciousness pervades the universe and is a fundamental feature of it. This doesn't mean that literally everything is conscious. The basic commitment is that the fundamental constituents of reality—perhaps electrons and quarks—have incredibly simple forms of experience, and the very complex experience of the human or animal brain is somehow derived from the experience of the brain's most basic parts.

I should clarify that by "consciousness," I don't mean self-awareness or the capacity to reflect on one's own existence. I simply mean "experience": pleasure, pain, visual or auditory experience.

Human beings have a very rich and complex experience; horses less so, mice less so again. As we move to simpler forms of life, we find simpler forms of experience. Perhaps at some point the light switches off, and consciousness disappears. But it's at least coherent to suppose that this continuum of consciousness carries on into inorganic matter, with fundamental particles having unimaginably simple forms of experience.

What does panpsychism seek to bring to physics?

Philosophers of science have realized that physical science, for all its richness, is confined to telling us about the *behavior* of matter, what it does. Physics tells us, for example, that matter has mass and charge. These properties are completely defined in terms of behavior—things like attraction, repulsion, resistance to acceleration. Physics tells us absolutely nothing about what philosophers like to call the *intrinsic nature* of matter: what matter is in and of itself.

PHILOSOPHY

Is the Universe Conscious?

Could consciousness be a fundamental property of the universe?

Posted September 22, 2024 | Reviewed by Jessica Schrader

- Consciousness remains a mystery with no satisfactory scientific explanation.
- Some researchers have suggested that consciousness is a fundamental property of the universe.
- Panpsychism takes this idea one step further and suggests that everything in the universe is conscious.

Everything we experience is linked to our consciousness. Despite this familiarity, consciousness remains a mystery.

Source: Caleb Frith | Unsplash

How do you feel right now? Happy? Sad? Excited? Do you feel hot or cold? Maybe hungry? Everything we experience—our thoughts, feelings, and sense impressions—comes to us through our own consciousness (Pang, 2023a). It is what we are most familiar with and the only way our minds can access the world (Pang, 2023b). Despite this intimate familiarity, consciousness remains one of the greatest mysteries. We lack any good scientific explanations for it and even struggle to accurately define or measure it (Zhao et al., 2019). We have good evidence that consciousness is linked to the brain because changes to the brain—whether chemically through medication, alcohol, or psychoactive drugs, through brain damage, or through targeted brain stimulation—impact consciousness (Yaden et al., 2021; Damasio, 2006; Riedel et al., 2016). At the same time, there are baffling phenomena—like blindsight, amnesia, or split-brain patients—where people can respond correctly to a cue while denying ever perceiving this cue (LeDoux et al., 2020). Even without these complications, it is not clear how a specific brain state would give rise to a subjective experience. The Australian philosopher David Chalmers (1995) labeled this *the hard problem of consciousness*. Even if we could map every experience to a specific brain state, it is not clear why such a biological configuration should result in a subjective experience.

The quest for answers

Scholars have been trying to solve this conundrum for a long time. Myriad suggestions and explanatory theories have been proposed, ranging from suggesting that brain states and experiences simply are the same thing (Smart, 2022), through the notion that consciousness is the integration of information within a system (Tononi et al., 2016), to more exotic suggestions, like it being a relativistic phenomenon linked to a specific frame of reference (Lahav & Neemeh, 2022).

These theories are intriguing, and many have advanced our understanding of specific aspects of consciousness, but none seems to satisfactorily answer the most fundamental questions about consciousness. That is why some experts have taken a completely different approach by asking if consciousness could be a fundamental aspect of the universe.

Getting down to the foundations

Scientific knowledge is a bit like a high-rise building, where every new level relies on the ones below. Any explanation is based on previously established facts and principles. However, there needs to be a starting point: fundamental facts that cannot be explained by anything underlying. For a long time, atoms were believed to be the fundamental building blocks of matter (the name *atom* comes from the Greek word for “indivisible”). We now know that atoms are made up of smaller particles called quarks, leptons, and bosons (Close, 2004). Some have suggested that these subatomic particles are made up of vibrating strings, a theory with ardent supporters and passionate critics (Ritson & Camilleri, 2015). We may also find something else that is underlying what we now call *fundamental particles*. However, this is just kicking the can further down the road. Ultimately, if we want to understand the universe, we need to accept that there are fundamental entities that we can use to explain other things, but that cannot themselves be explained further.

Consciousness is a mystery that seems qualitatively distinct from anything else we know. That is why some scholars have suggested that it is a fundamental aspect of the universe. According to this view, asking why there is consciousness is akin to asking why there are laws in physics. It is not a wrong question; it is just not scientifically answerable. Fundamentalism is no longer just a fringe theory but has some respected supporters (Hoffman et al., 2022; Schurger & Graziano, 2022). Just to be clear: This is still a controversial notion and neither proven nor established doctrine among experts. However, it is a view that is gaining traction and has profound implications if found to be true.

A conscious universe?

We still don't know what gives rise to consciousness, but if it is a fundamental aspect of the universe, it may not be limited to human minds. Many researchers believe that many (or even most) animals are conscious (Pang, 2024). If consciousness is woven into the fabric of the universe, it may arise outside of the wet organs we call brains. *Panpsychism* is the view that everything in the universe has at least an element of consciousness in it (Goff, 2001). This view holds that even a grain of sand has a minuscule amount of consciousness—nothing comparable to our experiences, but not zero. Panpsychism has a long history in both Western and Eastern philosophy, and while there are some strong contemporary defenders, it seems a bridge too far for many scholars (for example, Frankish, 2021). This view also has many problems: Why do we have a single, united conscious experience and not a fractured one constructed by the many parts of our brain (and body)? How can we perceive our own consciousness but not others? These are just some of the problems panpsychism faces.

If consciousness permeates the universe, it is unclear whether (and how) this is either united or separated. We could be part of a larger conscious structure. Alternatively, the whole notion of panpsychism could be complete nonsense. We simply don't have enough evidence or understanding yet to truly know. Consciousness could be fundamental; it could be a purely physical process; it could be in a category of its own; or it could be something entirely different from all these options. For now, consciousness remains a mystery but given the importance it has to us and the possible implications if any of these theories were true, it is worthwhile investigating further.

Facebook image: Jaem Prueangwet/Shutterstock

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Is the Universe Conscious?

Humans evolved and the universe woke up

Take out a piece of paper and draw a vertical line right down the middle. On one side of the page, make a list everything in the world that you're sure is conscious; on the other, make a list everything that you're sure is not. Unless you're one of those people who pretends that consciousness doesn't exist, it's a safe bet that you'll have human beings on the conscious side; probably you'll have at least some other animals there to keep them company too. Unless you're a New Ager or mentally unbalanced, it's a safe bet that you'll have things like rocks and potato peelers on the other side, the unconscious side.

One thing you probably won't have on your list of conscious things is: the universe. To most people (myself included), the idea that the universe might be viewed as a conscious entity is outlandish in the extreme - the kind of view that most scientifically-minded people (myself included) would be unwilling to admit to, at least around their scientifically-minded friends and colleagues. But as outlandish as it might sound, it actually turns out to be a straightforward implication of evolutionary theory.

This is the case, at least, if we assume that not only the body but also the mind is a product of evolution. And this is a view that really everyone should hold today. We know that the mind is dependent on the activity of the brain, and we know that the brain is a product of evolution; thus, we know that the mind is a product of evolution. Furthermore, if you look at some of the core components of the human mind, they have clear links to survival and reproductive success: fear motivates the avoidance of danger; sexual desire motivates behaviours that lead to the production of babies; etc. The case that the mind is a product of evolution is strong.

As soon as we recognize that the mind is a product of evolutionary processes, our view of the mind and its place in nature is radically altered. A recurring idea in the belief systems of the world is the notion that human beings are composed of two separate and separable parts: a physical body and an immaterial mind or soul. Not everyone has held this view, but it's not (as commonly claimed) unique to the Western tradition. Many people have believed that the mind stands outside nature; it is a part of us that transcends the material world and our biology.

Evolutionary theory completely overthrows this view. From an evolutionary perspective, it is impossible to maintain that the mind stands outside nature. Instead, it is a tiny fragment of nature, valued only by those tiny fragments of nature that possess it. Mind is not something separate from matter; it is a process embodied in matter.

Now here's the point: When we fully digest that the mind is the activity of an evolved brain, it radically transforms our view of the mind's place in the universe - and our view of the universe itself. The physical universe ceases to be an unconscious object, observed and explored by conscious minds which somehow stand above or outside it. Conscious minds are *part* of the physical universe, as much as rocks and potato peelers. Our consciousness is not simply consciousness *of* the universe; our consciousness is a part of the universe, and thus the universe itself is partially conscious. When you contemplate the universe, part of the universe becomes conscious of itself.

Similarly, our knowledge of the universe is not something separate from the universe; it is a part of the universe. Thus, for humans to know the universe is for the universe to know itself. As Carl Sagan put it, ‘humans are the stuff of the cosmos examining itself'. And Darwin's theory of evolution explains how this could be so - how clumps of matter could come to be organized in such a way that they are able to contemplate themselves and the rest of the cosmos.

The history of the universe looks very different from this perspective. For billions and billions of years, the universe was here and no one knew about it. More to the point, for all that time, the universe itself had no idea that it existed. But then, around 13.82 billion years after the Big Bang, and almost four billion years since life first evolved, something strange began to happen: Tiny parts of the universe became conscious, and came to know something about themselves and the universe of which they are a part. Eventually, some of these tiny parts of the universe - the parts we call ‘scientists' and ‘scientifically-informed laypeople' - came to understand the Big Bang and the evolutionary process through which they had come to exist. After an eternity of unconsciousness, the universe now had some glimmering awareness that it existed and some understanding of where it had come from. This might sound like a strange thing for a universe to do, but perhaps it's not; perhaps many possible universes would become conscious of themselves given sufficient time.

So much for the history of the conscious universe; what about its destiny? There are many competing suggestions on this topic, some more optimistic than realistic. Pierre Teilhard de Chardin, a French Jesuit palaeontologist, suggested that the universe will continue to expand into greater and greater degrees of awareness, finally coalescing into an integrated, universal consciousness, which he dubbed the Omega Point and identified with Christ. Modern cosmology indicates that such suggestions are more interesting than they are plausible. Although the universe is conscious of itself at present, the projected heat death of the universe makes it all but certain that the time will come when the lights go out and the universe slips back into unconsciousness.

For how long will it remain in its present semi-conscious state? The answer depends on how prolific the universe is at producing conscious life. If consciousness is widespread throughout the universe, then the odds are that at least some pockets of consciousness on some planets will survive for a reasonable length of time. For all we know, though, ours may be the only planet in the universe hosting mind and consciousness. If so, then our decisions and our conduct will determine whether the universe has a long future as a conscious entity or will soon lapse back into unconsciousness.

That said, one might wonder whether, in the grand scheme of things, it really matters. It may be pure anthropocentrism to assume that a universe with consciousness is better than one without. Conscious beings are often disgruntled and sometimes simply miserable, and maybe on balance an unconscious universe would be the more desirable. But although it's possible to entertain such thoughts in principle, it's hard in practice to duck the conclusion that it would be a terrible shame if the universe were not to remain conscious for as long as possible. Nonetheless, it may be the fate of the universe to spend an eternity in darkness, save one brief flash of self-awareness in the middle of nowhere.

Can our brains help prove the universe is conscious?

As humans, we know we are conscious because we experience and feel things. But we are still unable to explain exactly what consciousness is or where it comes from.

"Consciousness — or better, conscious experience — is obviously a part of reality," Johannes Kleiner, a mathematician and theoretical physicist at the Munich Center For Mathematical Philosophy, Germany, shared in an interview. "We're all having it but without understanding how it relates to the known physics, our understanding of the universe is incomplete."

With that in mind, Kleiner is hoping math will enable him to precisely define consciousness. Working with colleague Sean Tull, a mathematician at the University of Oxford, U.K., the pair are being driven, to some degree, by a philosophical point of view called panpsychism.

If the researchers can answer how our brains give rise to subjective experience, there's a chance their mathematical model could extend to inanimate matter too, they said.

"A mathematical theory can be applied to many different systems, not just brains," Kleiner told All About Space via email. "If you develop a mathematical model of consciousness based on data obtained from brains, you can apply the model to other systems, for example, computers or thermostats, to see what it says about their conscious experience too."

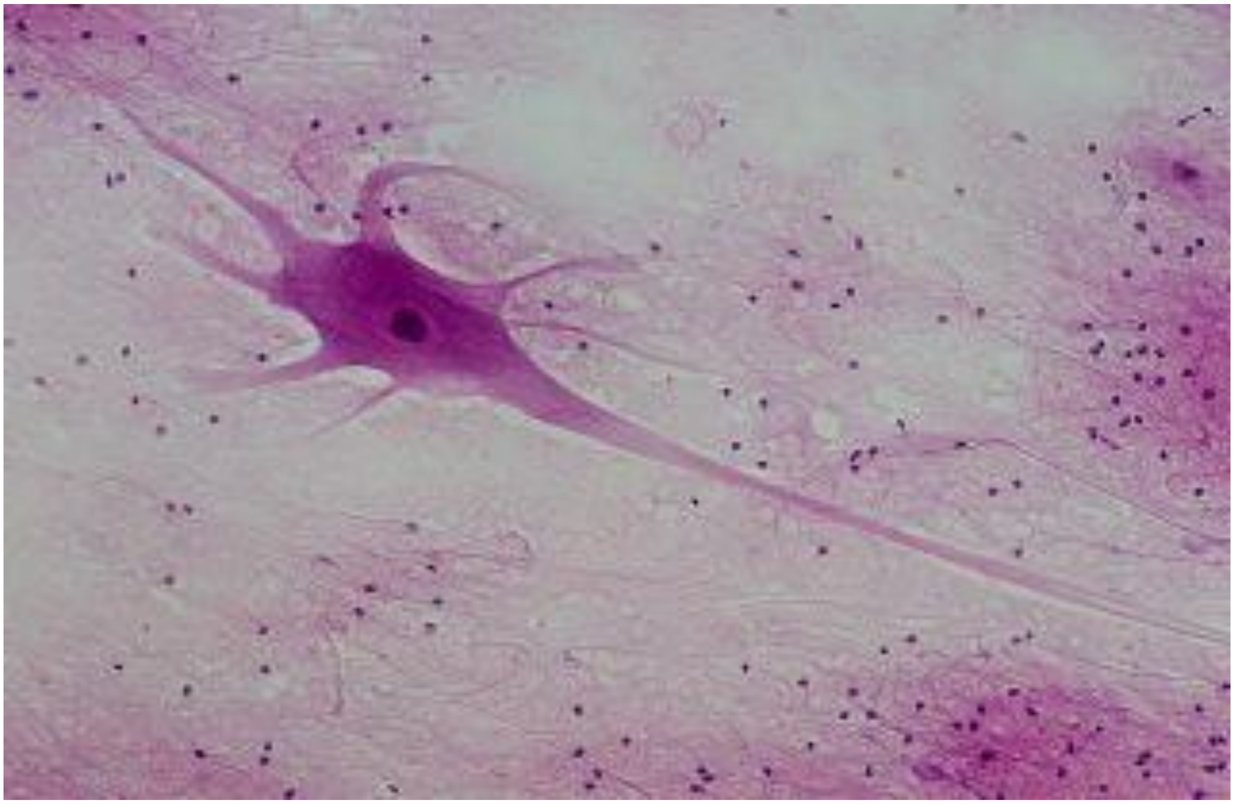
Some prominent minds lend weight to the view of panpsychism, not least renowned Oxford physicist Sir Roger Penrose, who was among the first academics to propose we go beyond neuroscience when looking at consciousness.

He says we should strongly consider the role of quantum mechanics and in his book published in 1989 "The Emperor's New Mind: Concerning Computers, Minds, and the Laws of Physics" he argued that human consciousness is non-algorithmic and a product of quantum effects.

This idea evolved in collaboration with anesthesiologist and psychologist Stuart Hameroff into a hypothesis called Orchestrated Objective Reduction (Orch OR).

It claims consciousness is likely due to quantum vibrations in microtubules deep within brain neurons as opposed to the conventionally held view that it is due to connections between neurons.

Importantly, however, "Orch OR suggests there is a connection between the brain's biomolecular processes and the basic structure of the universe", according to a statement published in the March 2014 paper "Consciousness In The Universe: A Review of the "Orch OR" Theory", written by Penrose and Hameroff in the journal Physics of Life Reviews.
And it's on this basis that Kleiner and Tull are working. They are also inspired by neuroscientist and psychiatrist Giulio Tononi, distinguished chair in Consciousness Studies at the University of Wisconsin.



A neuron. Orchestrated Objective Reduction (Orch OR) claims consciousness is likely due to quantum vibrations in microtubules deep within brain neurons. (Image credit: Getty Images)

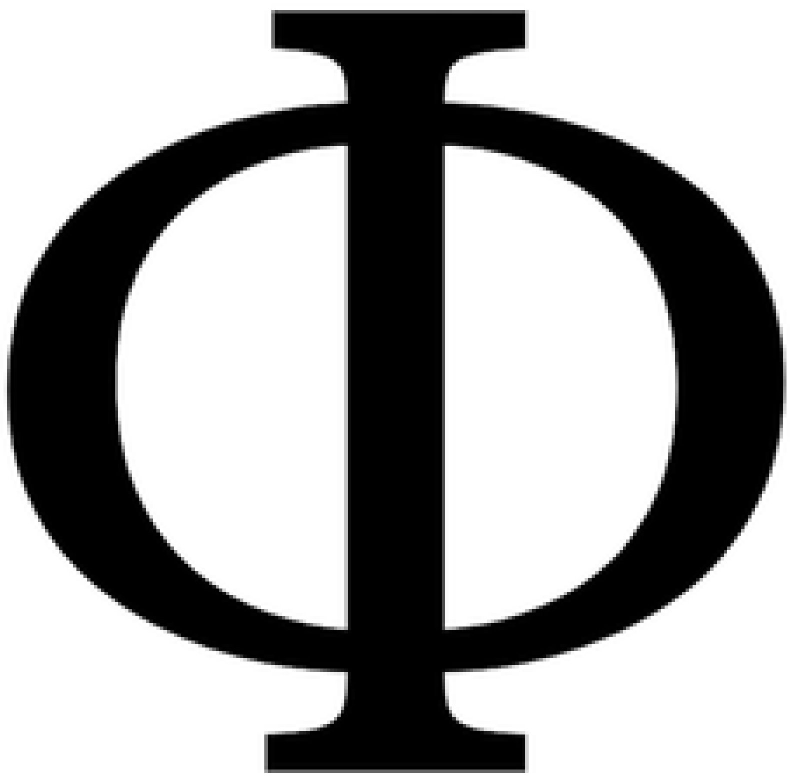
Tononi's theory of Integrated Information Theory (IIT), published in the journal BMC Neuroscience, is one of a small class of promising models of consciousness. “IIT is a very mathematical theory,” Kleiner said.
IIT says consciousness is a fundamental aspect of reality; that it exists and is structured, specific, unified and definite. A core idea suggests consciousness will emerge when information moves between the subsystems of an overall system: to be conscious, an entity has to be single and integrated and must possess a property called "phi" which is dependent on the interdependence of the subsystems.

In other words, you could have a bunch of coins on your desk, on top of each sits a bunch of neurons. If information which travels along those pathways are crucial for those coins, then you've got a high phi and therefore consciousness.

If those coins could operate perfectly well as subsystems without information flowing to and from other coins, then there is no phi and there is no consciousness. The greater the interdependency between subsystems, the more conscious something will be.

"Integrated information is an abstract quantity which you can calculate if you have a good detailed description of the system," Kleiner said, adding that the system does not have to be biological.

"The result is a number, denoted by phi, so if you have an apple, you can ask how much integrated information is in there, just as you can ask how much energy is in there. You can talk about how much integrated information is in a computer, just like you can talk about entropy."



Phi, the symbol used to represent the Integrated Information Theory.

IIT backs panpsychism to a great extent because even a proton can possess phi, according to the theory. And just as an apple, thermostat and computer can possess it, so can your chair and your desk all manner of other things across the universe.

"When it comes to experimental evidence, there are several independent studies which point at a correlation between integrated information and consciousness," Kleiner said.

So do the subsystems have conscious experience? No. Are all systems conscious? No.

"The theory consists of a very complicated algorithm that, when applied to a detailed mathematical description of a physical system provides information about whether the system is conscious or not, and what it is conscious of," said Kleiner.

"The mathematics is such that if something is conscious according to the theory, then the components which make up that system can't have conscious experiences on their own. Only the whole has conscious experience, not the parts. Applied to your brain, it means that some of your cortex might be conscious but the particles that make up the cortex are not themselves conscious."

WHAT IS REAL IN THE UNIVERSE?

"If there is an isolated pair of particles floating around somewhere in space, they will have some rudimentary form of consciousness if they interact in the correct way," said Kleiner.

So according to IIT, the universe is indeed full of consciousness. But does it have implications for the physical part of the universe? The math of the theory says it does not. A physical system will operate independently, whether it has a conscious experience or not.

Kleiner gives a computer as an example, saying that IIT's math shows it may have consciousness but that won't change the way in which it operates.

"This is at odds with the metaphysical underpinning of the theory which is strongly idealist in nature," Kleiner said. "It puts consciousness first and the physical second. We might see some change in the mathematics at some point to take this underpinning more properly into account."

This is what his and Tull's study seeks to resolve. Emergentist theories of consciousness tend to claim physics is all there is.

The Integrated Information Theory shows that consciousness could be found within the universe. (Image credit: Getty Images)

"They would reject the idea that consciousness is separate from or more primary than the physical and they would say consciousness is nothing but a specific physical phenomenon which emerges from the interaction of the fundamental physical quantities in certain conditions," said Kleiner.

His and Tull's math version of IIT, on the other hand, is intended to be what could be called a fundamental theory of consciousness. "It tries to weave consciousness into the fundamental fabric of reality, albeit in a very specific way," said Kleiner. And if it's shown that the universe is conscious, what then? What are the consequences?

"There might be moral implications. We tend to treat systems that have conscious experiences different from systems that don't," said Kleiner.

Yet if it is proven that consciousness plays a causal role in the universe, it would have huge consequences for the scientific view of the world, said Kleiner. "It could lead to a scientific revolution on a par with the one initiated by Galileo Galilei," he said.
And that really is something to bear in mind.