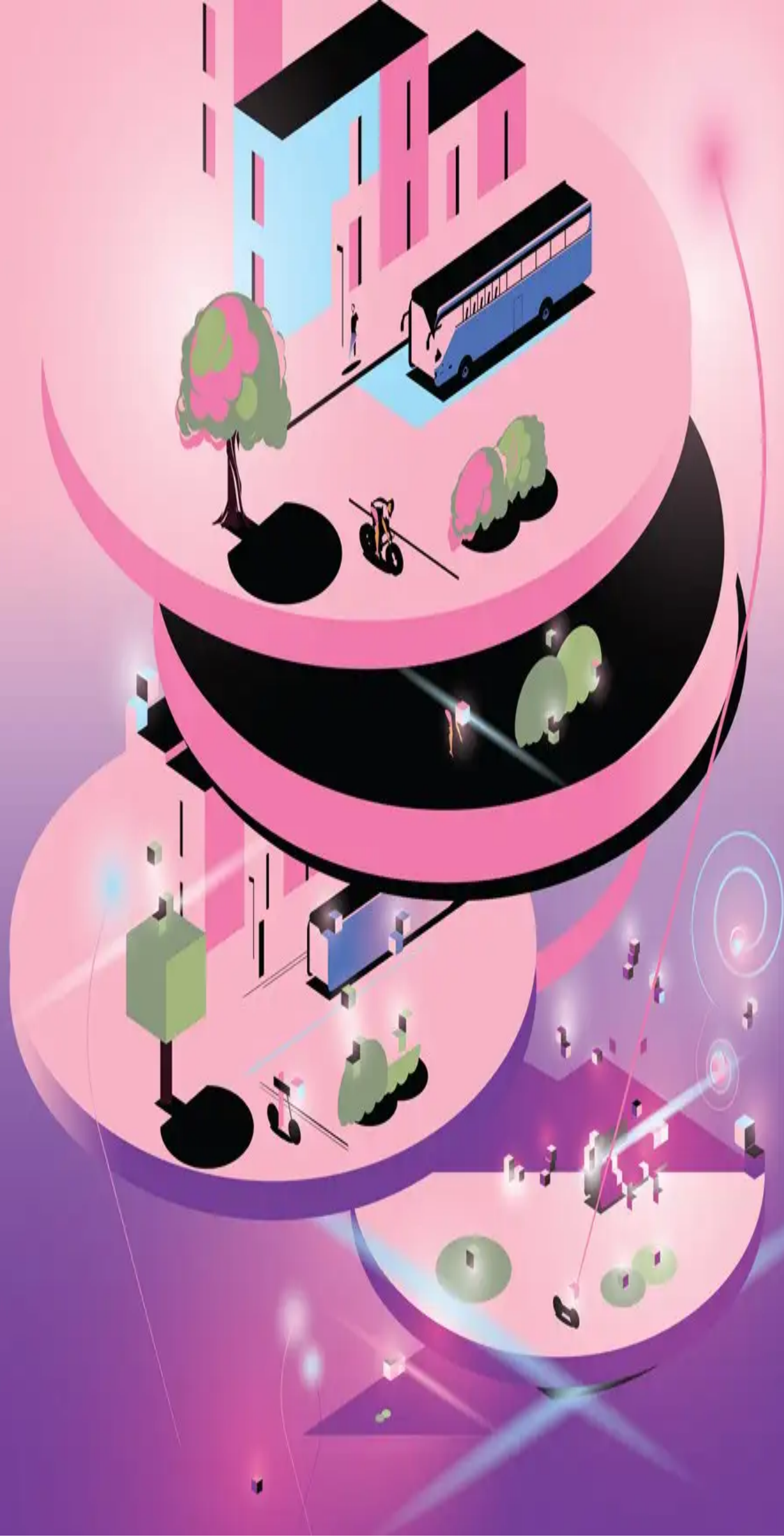


Is consciousness more fundamental to reality than quantum physics?

The idea that everything that exists can be built from the bottom up has long held sway among physicists. Now, a new kind of science is under construction that centres conscious experience – and might unravel the universe's biggest mysteries



Imagine you could take a cosmic mixing bowl and cook up reality from scratch. It would be a strange kind of baking, with the end results including everything from space-time and satellites to cats and the cosmic web. But here's the question: what would be the basic ingredient you'd need to use?

I first got introduced to this kind of question in seventh grade, sitting in a class I had never taken before: physics. Although this introductory class was mostly about balls rolling down hills, I was taught that the methods of physics ought to have limitless reach – an idea called reductionism. Physics should be able to identify the essential ingredients of reality and show how to combine them from scratch into anything and everything.

Immediately, I decided to become a physicist. But now, many years and several degrees later, I am less sure that physics holds all the answers. Take something like my sense of self: is that really a consequence of some equation that we haven't yet derived? If I think about questions like these hard enough, I am left feeling rattled, wondering whether I have become a bad physicist.

[Rethinking reality: Is the entire universe a single quantum object?](#)

So, I decided to engage with these doubts and work out what I really think about the essence of reality. I was inspired by two recent books that come at these questions from opposite ends of the spectrum. One argues that all reality is built from nothing more than quantum fields. "Everything else is just in our minds. All our concepts are illusions," says its author, [Liam Graham](#). The other insists that the most essential ingredient of reality is conscious experience. "That's what is fundamentally real," says [Adam Frank](#) at the University of Rochester in New York state, one of the book's co-authors.

Deciding whether either of these stances – or something in between – is correct matters for more than just my own peace of mind. Assumptions about what is fundamental undergird how all science is done and may have long been confounding our attempts to answer some of the most stubborn scientific mysteries.

The power of physics

Historically, turning messy and subjective human experience into neat and abstract mathematics has been the one weird trick that makes science, and especially physics, powerful. [Galileo Galilei](#) and [Isaac Newton](#) made revolutionary contributions to the world by observing objects on Earth and in the heavens, then quantifying their motion with equations – although mathematics and reason existed in other forms long before their time. Other physicists turned experiential notions such as hot and cold into the numerical system of temperature. Mathematical models allowed us to predict the future, drove our understanding of the universe and led to myriad technologies. We got a better view of the stars and a working steam engine.

With the advent of [quantum theory](#) in the 1920s and 30s, physicists began to grasp the as-of-now smallest parts of the physical world. The [standard model of particle physics](#), which is rooted in quantum theory and tabulates all known fundamental particles and forces, is the most precisely tested scientific theory. Remarkably, even though phenomena such as quantum entanglement – where particles maintain a quantum link across extreme distances – still escape most people's intuition, we have harnessed them to build working [quantum computers](#).

Frank says all this gave physicists a sense of unbridled power. "You start off with this idea that physics is going to answer all your questions, just give me the laws of physics and I'll be able to

build everything up – kangaroos are no problem! I can explain it all,” he says. He disagrees with this view, and his most recent book, [*The Blind Spot*](#), co-written with astronomer [Marcelo Gleiser](#) and philosopher [Evan Thompson](#), argues that even the most successful scientific theories ought not to lose track of the role of experience and the way it informs where the limits of their explanatory power may be.

Graham has the opposite view, as may be evident from the title of his book, [*Physics Fixes All the Facts*](#). He believes that even incredibly complex problems, such as what [consciousness](#) is and how it arises, can, in principle, be explained starting with the most basic physical building blocks. In fact, he goes further, arguing that anyone who rejects the ability of physics to eventually describe consciousness is essentially invoking ghosts and spirits. His philosophical stance is called austere physicalism, which you can think of as the most uncompromising flavour of reductionism. “All that there really is, is whatever physics says there is down at the bottom,” he says.

Currently, that means quantum fields, which are fundamental quantum objects that permeate all space. But cutting a path from those at the bottom all the way up to human consciousness isn’t exactly straightforward: we have to find a way through the thorny terrain of [emergence](#). This is the idea that a whole can have profoundly different properties from its component parts. For example, water is wet, but individual water molecules are not. If you can, in principle, predict these higher-level properties from the equations that describe the parts, then the system is said to be weakly emergent. However, if these predictions are impossible, then the whole is truly more than the sum of its parts, and the system is strongly emergent.

[What 350 different theories of consciousness reveal about reality](#)

Emergence seems to naturally explain why science is compartmentalised into distinct subjects – biology, chemistry, physics and everything in between – each with their own institutions. “While everything is physical, I don’t think you should look to the physics department to help you predict and understand systems like human beings,” says philosopher [David Papineau](#) at King’s College London. Psychology has, so far, worked well without having to reference what every electron in the brain is doing.

My experience of academia reflects this. I studied physics in college and graduate school, and almost never shared a class with peers who focused on plant biology or medicine. They became successful in their respective fields without ever having to know what a quantum wave function is, which was the bread and butter of my work. But does this actually reflect the nature of reality, rather than just being how humans, with our limited brains and a penchant for bureaucracy, decided to chunk it up?

Graham regards these separations as false. In fact, he reasons that they put a damper on scientific progress. Having too many overly specialised branches, each speaking its own language, allows scientists to be less honest about what they do and do not know, he says. What’s more, he sees the concept of emergence as misleading – if not entirely useless. Emergence simply hides the bits of physics that we don’t yet know, he says. When a property like “wetness” emerges, the only real understanding of this is in terms of the balance of cohesive and adhesive forces among molecules, which can be further boiled down to fundamental particles and fields. The experience of wetness, meanwhile, is an illusion – as are all emergent concepts.

In this austere physicalist view, phenomena that seem strongly emergent, such as consciousness or the origins of life, can also be built from the bottom up – even if we aren’t entirely there yet. “Believing in strong emergence is equivalent to believing in pixies in your garden,” Graham writes in his book.

[Forget the multiverse. In the pluriverse, we create reality together](#)

Consciousness remains a contender for strong emergence among some philosophers, but an austere physicalist must reject the idea. To see why, consider a thought experiment set in an imagined future in which we finally understand consciousness so well that we can build artificial consciousnesses. Imagine a scientist in this future who has spent their life learning all there is to know about what colours are and the purely physical mechanisms that underlie subjective experience. They can record the precise physics of what happens inside an artificial consciousness when it is shown a red tomato, but, through some odd set of circumstances, the scientist has never actually experienced redness themselves. Then, one morning, they wake up and, for the first time, look at a tomato and suddenly experience its colour.

Have they learned something new? If all there is to reality is physics, the answer ought to be “no”, as the experience of red is created in a physical process that the scientist already understands from their studies of artificial consciousness. But if consciousness is more than a sum of some physical processes and parts, that leaves room for the scientist to have learned something new.

Limits of imagination

In Graham’s view – the austere physicalist view – the scientist doesn’t lack knowledge, just a mental capacity called imaginative understanding. “A more capable entity would be able to take all the information, use it to run an internal simulation and experience red without ever seeing it,” writes Graham. Humans can’t do this because of the limitations of our evolved minds and bodies; the same lack of imaginative understanding explains why we can’t intuitively understand quantum physics, he says.

When I looked at the richly red tomatoes in my grandfather’s garden as a child, were they just tomato-shaped quantum fields that my brain evolved to give the illusion of sumptuous vegetables? The idea feels joyless to me. Yet Graham argues that it is being aware of the limits of our comprehension that makes him appreciate the intricacy and complexity of our physical world all the more. “[It] makes everything seem even more extraordinary, rather than [adding] some sort of magical spirit,” he says.

Can the redness of a red tomato ever be truly conveyed as a scientific equation?

Mira/Alamy

For Frank, accounting for experience is neither magical nor a problem. “I have no access to the world except through experience,” he says. What could then be more real than experience? This school of thought is called phenomenology. First developed by philosopher Edmund Husserl, it became enormously influential, reasoning that the world’s essence cannot be captured just by abstract ideas like quantum fields because experience is the pre-condition for creating those abstractions. “The physicalist world is an unexperienced and unexperienciable world. It is a very useful abstraction, but one that only comes after the actual world that scientists live and practise in,” says Frank.

The concept of [temperature](#) illustrates this argument well. The physical definition of temperature is based on the average speed at which air particles jiggle. But physicists only developed mathematical equations for temperature because they had different experiences first. The concept of temperature couldn’t have arisen had someone not noticed the difference between a warm room and a cold one.

Temperature (and steam engines) would never have been invented without the experiences of hot and cold

DEEPOL by plainpicture/Fredrik Schlyter

Useful and insightful concepts like temperature are part of physics' historical ascent up the "spiral of abstraction", says Frank. But that spiral is always rooted in the experiential world. To say that the equations of quantum theory are more real than that world is a case of mistaking the map for the territory, he writes.

This metaphor helps me understand why questioning the essential truth of physics left me feeling strained. On the one hand, the ascent up the spiral of abstraction towards ever more elegant and clean mathematical ideas is immensely satisfying. On the other, it is palpably fulfilling to keep my feet in the experiential muck, where the juicy tomatoes grow.

Perhaps the truth is that it isn't a black-and-white situation where either quantum fields or conscious experience have to be fundamental. [Jessica Wilson](#), a non-reductionist philosopher at the University of Toronto Scarborough in Canada, has certainly suggested that there might be a middle way between only reading the map and only traversing the territory. "[Experience] is part of the data to be explained," she says. We don't perceive quantum fields, but things that we do perceive and experience have the sort of stability, integrity and causal power that ought to imbue them with a kind of reality. Wilson is building a different framework for reality's structure, aiming to accommodate both the micro and the macro, without infusing one with more reality than the other.

There are other schools of thought that strike more of a middle ground too. For philosopher [Carl Gillett](#) at Northern Illinois University, the answer is a mutualist view where neither can be discarded. A living cell, for instance, is a complex whole defined by its membrane. It is composed of atoms, which are simple parts that do not themselves have membranes, but can form one through physical interactions. But the atoms don't undertake those membrane-producing processes unless the conditions that transcend them are just right. Physics alone isn't enough: the parts are influenced by the emerging whole.

Theories of reality aren't the same as reality. Have we been mistaking the map for the terrain?

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So, having exposed myself to some heady ideas about the true essence of reality, where do I ultimately come down? To be honest, I still haven't decided whether I am a true physicalist, like Graham. Something about my grandfather's tomatoes still feels a little transcendent to me. But even when I doubt my relationship with the deepest layers of physical reality, my training as a scientist implores me to look to the world of experiments as a way to afford peace of mind.

Much of my rumination has been in the realms of philosophy, but Wilson also suggests that empirical tests may one day be decisive. For instance, austere physicalism is clear about its disdain towards the concept of strong emergence. But if experiments can demonstrate a facet of consciousness that violates a known law of physics, which, in turn, leads us to find some new kind of non-physical interaction within the brain, then strong emergence still stands a chance.

[The physicist who argues that there are no objective laws of physics](#)

[Daniele Oriti's pursuit of a theory of quantum gravity has led him to the startling conclusion that the laws of nature don't exist independently of us – a perspective shift that could yield fresh breakthroughs](#)

Ultimately, where we come down on these questions could influence how science is carried out. Frank wants nothing less than a new kind of science that includes more than inanimate objects obeying mathematical models. He is collaborating with biologists and information scientists to develop a framework that acknowledges the [active role that agents, who have goals and desires](#), play in the world. In this “physics of agency”, he says, there is an entirely new range of scientific questions to go after.

Physicalists, mutualists, phenomenologists, whatever they want to call themselves, they are all still betting on science and its most basic tenets to give us a better grasp on what is real. “There’s a sense in which science is just a matter of letting evidence influence your beliefs. And basing your beliefs on evidence, I think everybody should do that,” says Papineau. That’s certainly a view I can subscribe to.