

## Is Reality Digital or Analog? A Worldview

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To avoid talking past one another we need to agree on terms: What do physicists mean by reality? Few would go as far as Stephen Hawking and declare that reality is “model-dependent.”<sup>i</sup> Perhaps more representative of the mainstream is Stephen Weinberg, who, in his review of Hawking’s recent popular work, confesses that he cannot help believing “*that there is something out there, entirely independent of us and our models.*”<sup>ii</sup> The physicist David Deutsch concurs: Building on Samuel Johnson’s rock-kicking refutation of Bishop Berkeley’s skepticism, he establishes a criterion for reality that he believes many scientists would accept: “*If something kicks back,*” he writes, “*it exists.*” Dr. Johnson, of course, was concerned with refuting solipsism, with countering the idea that material reality could be completely illusory—a disturbing possibility that at different times seems to have occupied both Weinberg and Deutsch as well as other philosophically inclined scientists. But Johnson’s criterion for reality is not a criterion for reality per se, not reality in general, and not even, as David Deutsch assumes, “*the criterion for reality that is used in science,*”<sup>iii</sup> but rather more modestly, a criterion for the *existence* of a reality external to our consciousness, the existence of a “*something out there*” that Weinberg wisely accepts as a given. But reality, as the proto-solipsist in each of us knows, is more inclusive than external reality. If we hope to discover a deep, foundational reason why reality—or perhaps a qualified portion of reality, such as the physical universe of spacetime—must be either purely analog or purely digital, we should begin with a concept of reality that views physical reality as part of a grander whole.

In an effort to establish a working definition of reality we start with a common-sense statement that, as a first approximation, is difficult to deny: If we have to deal with something—whatever that something turns out to be—it is real. We then assert the converse: if we can, with impunity, ignore that something, then that something is not real. In other words, reality is what we have to deal with. That, we assert, is what reality *is*. In this view, reality is found at the level of the steaming bowl of chowder and the frosty mug of beer in front of you rather than in the quarks and electrons into which your meal may be analyzed.

Note that saying something is not real is not at all the same thing as saying it is an illusion. Illusions are quite real; we have to deal with them on a daily basis. The problem we have with illusions is not that they are not real, but merely that they are not what they seem to be. Nor does the fact that something is illusory preclude its existence. Illusions exist. They are complex mental constructs involving the active participation of a knowing subject. Matter itself, when examined closely by physicists, reveals its illusory nature, dissolving into mathematical abstraction as insubstantial and observer-dependent as a rainbow or a mirage.

Despite the illusory nature of physical reality, Deutsch’s criterion for its independent existence fits comfortably within our criterion for reality. We have to deal with a hot stove when it *kicks back* at us by burning our hand. We note that *all* Darwinian strategies, from those employed by the simplest single-celled life forms to the phenomena of human culture, have evolved in response to the fact that nature responds to life’s initiatives. It kicks back. There is no action without a reaction. All technology is based on the fact that external reality kicks back in regular ways. All of science is based on the fact that nature always appears to respond

faithfully to well-posed yes-or-no questions—to the crucial experiments of the scientific method.

The external reality probed by the physical sciences, of course, is not the only thing we are forced to deal with. Recognizing the reality of an objective world external to our consciousness does not blind us to the reality of our rich subjective lives. To the contrary, by denying solipsism we acknowledge the reality of *other* conscious entities, much like ourselves, whose hopes and dreams we also have to deal with. There are also significant aspects of reality which may not be characterized as exclusively objective or exclusively subjective. There are the immutable statements of mathematics and the perhaps imperfectly knowable laws of nature. Mathematical facts and scientific laws have a subjective dimension in the sense that we can call them up and hold them in our mind's eye without any external reference, but we are nevertheless incapable of contemplating them without at the same time perceiving their objective nature.

There are also aspects of reality that share the objective/subjective duality of mathematical statements and the laws of physics that are historically contingent. The rate of inflation of a national currency is real by our criterion. And there are subtle, difficult to quantify aspects of reality that are nevertheless readily perceptible to millions of interested observers, such as a change in momentum in televised sporting events. Birth is real. Death is real. Growth and decay are real. Intelligence is real. Memories are real. False memories are also real. Reports of out-of-body experiences, encounters with angels and religious rapture are real. Instincts are real. Dreams are real. Mathematical and scientific intuition is real. Our susceptibility to the force of logic, to music, to poetry and to beauty in general is real. Love and compassion are real. Irrational faith is real.

Reality, it seems, is rich.

Given the richness of experience, should we despair of finding a simple definition of reality that comprehends this abundance? Or does the very richness of this world suggest that such a statement is necessary, as a kind of acknowledgement or confession of faith? If so, what kind of constraint would the richness of experience place on any attempt to define its existential basis?

At a minimum, a foundational statement would have to be consistent with the fact that any reality to which we can have access, any reality which we can explore scientifically—any reality into which we can launch our theoretical and experimental probes—that is, *any knowable reality*, is, by default, experienced reality. We can imagine a reality beyond our experience, a reality that is unknowable, perhaps for being hostile to the emergence of consciousness, but we could never experience such a reality—we could never probe it with our bodily senses or our scientific instruments to test our theories about it. If we could, it would not be a reality that is external to our experience. After escaping the logical weir of solipsism to recognize an aspect of reality external to our consciousness we discover that we remain trapped by our experience. This stubborn fact, the wellspring of solipsism's maddening logic, will be encountered by anyone attempting to formulate fundamental statements about reality. A world that does not accommodate the peculiar needs of knowers for experience is not objectively knowable. Such a world might exist or be imagined, but it could not be known. This is not a rhetorical tautology but a logical constraint on any fundamental theory or statement about the reality of *our* knowable world.

At the most rudimentary level, for something to be knowable there must be a separation or a boundary between the knower and the knowable, with the potentially knowable existing externally to the knower. Knowledge would be some structure interior to the knower that is correlated with some structure in the external environment that motivates and conditions a response on the part of the knower to external developments. Knowledge—which need not be conscious knowledge—is fundamentally different from information. Information exists in the environment external to the knower, whereas knowledge is an internalized representation of that information, a model that abstracts from fine-grained details, and which is therefore necessarily incomplete. In principle, physicists can represent the complete information about a physical system, such as a drop of water, by describing the rotation of a vector in infinite-dimensional Hilbert space, but this representation of a real system, which defines what is knowable about the system, is external to the system it describes, existing only in the consciousness of a relatively small number of scientists who have abstracted a vast amount of information from external reality.

When the system under consideration includes not only a physical environment, but also knowers enmeshed in that environment—the physical universe as a whole, for example—it is necessary to consider what the boundary might be that separates the knowers from the potentially knowable. Our scientific and philosophical intuition fails us when we try to imagine a boundary or membrane that does not delimit what we commonly refer to as consciousness, a vantage point from which we view ourselves in the context of a reality that is not merely physical. It is imperative to recognize that this vantage point, which places the observer in the position to view him- or herself in the context of evolving social and physical relationships, is external to physical reality. Religiously inclined thinkers will think of it as the divine perspective, imagining a god who “looks down upon” his creation from without, monitoring and judging the actions of his creatures. Sober-minded thinkers who find no need to posit a god external to creation nevertheless assume a perspective that is similarly above or separate from the spacetime of our experience. The Standard Model of particle physics, for example, *associates* each dimensionless point in the four-dimensional spacetime of Einstein’s General Theory with a number of smooth geometric objects that are not contained physically within these dimensionless points but somehow external to them and to spacetime, or even “above them.” The model itself is an abstraction to which no spacetime coordinates may be attached.

Theoretical physicists attempting to view physical reality as an object are in the situation of an imagined artist somehow confined to and co-substantial with the object of his study. Embedded in physical reality the scientist cannot begin to comprehend it objectively anymore than a visitor to the Louvre could comprehend the Mona Lisa if he were trapped behind the bullet-proof glass in the oil on wood of Leonardo’s masterpiece. Imprisoned within physical reality, buffeted by experience, one’s perspective is irredeemably subjective, little different in kind from that of a photon on a random walk in the opacity of the sun’s interior. To view reality *objectively* you must consciously remove yourself from it so, looking back, you can view it *as an object*, from without.

Our ability to form abstract mental pictures of the world around us is a familiar fact, but we should not allow this familiarity to breed contempt. Our ability to look back on spacetime from a vantage point that we cannot locate *in* spacetime is of such significance that it cannot be without bearing on fundamental questions. One is reminded of Bohr’s quip that the opposite of

an ordinary truth is a falsity, whereas the opposite of a profound truth may be another profound truth. In Bohr's spirit we pursue a superficially ill-posed question—Is reality digital or analog?—that overlooks the possibility that the best answer might be “neither” or “both,” or possibly even “neither *and* both.” But before proceeding we must commit ourselves to a definition of reality that cannot be other than a hypothesis, one that must be subjected to the test of usefulness:

**Reality is what exists potentially in the present.**

To view physical reality objectively, to go beyond the unavoidable starting point of immediate experience, we project ourselves mentally to a vantage point that is outside spacetime. As individual consciousnesses we hover above the physical world, our personal vantage point being *associated* with a unique three-dimensional volume of spacetime and a segment of the single time dimension of spacetime that we share with other consciousnesses. This particular vantage point, the vantage point from which we view physical reality, has a familiar name. It is called the present. The present has no objective existence within our models of physical reality, although it can be *associated* conceptually with the spacetime coordinates of these models. Note that in this view, the present is not seen as a dimensionless point or even an extended region on the single time dimension of spacetime but rather a place outside of spacetime that is associated with a four-dimensional volume. This understanding of the present merits restating: The present is *not* a subjective experience of the single time dimension of four-dimensional spacetime, but rather a place outside of spacetime that is associated with various three-dimensional spatial volumes unique to individual foci of consciousness and with lengths of the single time dimension of spacetime that these foci share with each other.

It might be objected that this view of the present is an abstraction without connection to reality, but the opposite is the case. Look around. The present is real. It is the past and the future which are abstractions, mental constructs that enable us to deal with the reality of the present. The present, moreover, despite its unphysical nature, is the only platform from which we can launch our probes of physical reality, whether they be as simple as laying our hand on a hot stove, or as complicated as designing an experiment for the LHC. And the present is the only place to which probes of physical reality can return their reports.

The tyrannical control that the present exerts over our access to reality is not in any sense ‘reasonable.’ The brute fact that our access to that portion of reality that forms the traditional subject matter of the physical sciences invariably passes through the portal of the present cannot be overthrown by rational argument or undermined by empirical findings, which could only be epiphenomena compared with its foundational essence. Nor does the fact that the present is not accounted for in any of our theories of physical reality diminish *its* reality. It is, rather, the failure of our best theories of physical reality to locate or accommodate the present within spacetime that exposes their incompleteness. Theories of physical reality that do not begin with the observation that our only access to it is through our experience of the present are obviously abstracting away from something truly fundamental.

Given that physical reality can be viewed only from the present, it is imperative that we take a closer look at the ground on which we are standing.

**Things we can say about the present:**

The present is real: We cannot avoid dealing with the present.

The present has objective existence: Although we cannot locate it in our models of spacetime, the present is not a purely subjective phenomenon. The present is the place where we meet and interact with other foci of consciousness, each of which we associate with unique spacetime coordinates.

The present is not an illusion: *The present is what it seems to be*. It is the place where we interact with physical phenomena as well as things that appear to exist outside our models of spacetime, such as the propositions of mathematics and the laws of science.

### **Things we can say about physical reality:**

Because physical reality can be viewed objectively only from without, four-dimensional spacetime of the General Theory is not a model of reality as a whole.

Physical reality recognizes our independent existence by responding to the probes we launch from the present. This acknowledgment of our independent existence is the converse of Deutsch's criterion for the existence of a material world independent of our consciousness. It is important to note the mutuality of the relationship: We poke, and physical reality pokes back; we pose the question, and physical reality answers.

In its relationship with us, physical reality is law-abiding and of unimpeachable integrity. If physicists could not presume the probity of nature, they could not justify using mathematical consistency as a guide in constructing models of physical systems.

Physical reality is an illusion in the straightforward sense that it is not what it appears to be.

Physical reality is non-local. This recently discovered aspect of reality is further evidence of the illusory nature of physical reality. Spatial separation is clearly not what generations of physicists presumed it to be.

Mathematical models of physical systems, while indispensable as a basis for technology, lead to unintuitive conclusions that conflict with each other and with experienced reality. For example:

According to Einstein's General Theory, *at the macro level* there is *no becoming, only being*: Change is an illusion in the block universe of four-dimensional spacetime.

According to the mathematical formalism of quantum theory, *at the micro level* there is *no objective being, only becoming*, in the evolution of the wave equation.

### **The relationship between physical reality and the present:**

The present controls the macro-states of the past, allowing some, denying others. Only pasts macro states that could have evolved according to the laws of physics into the macro state of the present are permitted.

The given micro state of the present allows conflicting macro-states in the future, such as Schrödinger's alive/dead cat.

The present resolves apparent paradoxes, conflicts and inconsistencies that arise when the physical universe is modeled objectively—that is, when it is modeled *as if* it were mere *information*, independent of our immediate experience of it. For example:

The frozen *being* of the four-dimensional block universe of the General Theory dissolves in the warm *becoming* of the present.

The whirling *becoming* of quantum theory resolves into the sharpness of *being* of the present.

### **The relationship between physical reality and life forms:**

Life is the starting point of all knowledge of physical reality.

There is an implicit contract between physical reality and life as a collectivity.

According to this contract, organisms that invest successfully in acquiring knowledge of their environment are rewarded, whereas life forms that are less successful in making this investment are penalized. Note that knowledge of the world—like a tree knowing that days are getting shorter or an amoeba sensing the salinity of its environment—need not be intentional.

The implicit contract between physical reality and life is enforced by the Second Law of Thermodynamics. Any successful life form begins its encounter with physical reality by carving out a volume of space from which entropy may be exported and interior to which structure may be created. Some life forms leverage their ability to organize inanimate matter into biomass by creating structures in their environment that offer shelter from the relentless dissipating forces in the world around them, permitting an accumulation and safekeeping of knowledge. The evolution of human culture, with its elaborate physical and social structures and burgeoning store of internalized information—knowledge—must be understood as movement along the same developmental vector that passes through social insects, vertebrates and other life forms.

All fundamental laws governing physical systems except the Second Law are indifferent to the struggle of individual life forms to survive and reproduce.

The indifference of physical law to life has led many scientists to conclude that the universe is indifferent to human aspirations. This view does not withstand scrutiny. It is the very indifference of physical law to life that makes these laws available to support life's struggle. Human culture is able to scale up life's power to organize physical reality by exploiting the terms of trade established by the Second Law of Thermodynamics whereby the potential contained in the relatively low-entropy state of the present may be harnessed to produce structure.

The universe appears poised to accept any quantity of entropy that life processes generate.

Recent evidence that the expansion of the universe is accelerating suggests that the universe may never reach thermodynamic equilibrium. Immersed in an ever-cooling thermal bath, life may face no theoretical limit to the creation of structure via the exportation of entropy. The so-called heat death of the universe that troubled so many late-19<sup>th</sup> Century thinkers, and which provided generations of pessimistic philosophers with the apparent backing of hard science, appears to have been an exaggeration. We must look now, *not* at what the Second Law of Thermodynamics might say about the universe some  $10^{100}$  years in the future, but what it means for life's relentless push to create structure in the world today.

#### **The problem with anthropic reasoning:**

The foregoing analysis nudges the discussion in the direction of anthropic reasoning, a line of thought that seeks to explain improbable cosmic coincidences that conspire to make the universe congenial to life. The problem with most forms of anthropic reasoning as employed by working scientists is the fact that scientists who employ it usually do so as a last resort, apologetically, and at the wrong explanatory level, where it plays the role of a kind of ersatz god-of-the-gaps. But anthropic reasoning reveals its full explanatory power only when applied boldly as an Aristotelian final cause for the universe as a whole. Science has been described as the search for the maximum compression of information, but compressed information is knowledge, and knowledge is quite different from raw information.<sup>iv</sup> Knowledge is information

purposefully stripped of unnecessary detail as the situation may dictate. Knowledge, moreover, involves knowers, entities whose independent existence is acknowledged by the physical universe in an ongoing dialogue. The problem with knowers is that they come with free will. Although nobody doubts that we make real choices that have real consequences, making this assumption explicit imposes conditions that are impossible to satisfy in purely objective models of the cosmos, to wit:

- i. Such a universe would have to be knowable:
- ii. Available options would have to be real:
- iii. There would have to be some mechanism to compel choice:
- iv. Agents exercising free will would have to make decisions without knowing ultimate consequences. Free will is incompatible with complete knowledge of the future.

Our world, apparently unconstrained by our models of it, conforms to these constraints:

- i. The universe *is* knowable, as per the earlier discussion.
- ii. We *do* make choices among real options. Our ongoing dialogue with Nature—the scientific method—is based on this assumption. The superposition of events in the wave equation of quantum physics reflects this reality.
- iii. The universe, despite its abundant internal energy, does in fact compel choice by establishing the terms of trade between various options.
- iv. The ultimate consequences of any act are unknowable in our world.

The fact that our world accommodates the ability of conscious agents to project the force of their wills onto events to create structure without apparent limit can be explained by letting anthropic reasoning rise to the explanatory level of an Aristotelian Final Cause. The Perfect Anthropic Cosmological Principle (PACP)—a radical hypothesis suggested by an emerging worldview—is an effort to formulate such a cause. The PACP asserts that the universe is purposeful—its purpose being to engender independent conscious beings capable of participating in true love relationships. The PACP is scientific in the sense that it makes falsifiable predictions about what can and what cannot be observed in the physical universe. According to the PACP, empirical facts, such as the non-locality of the universe, together with the laws, constants and principles of physics in their knowable or approximate form—Newton’s gravitational constant, Planck’s constant, the speed of light, fine structure constant, the Second Law of Thermodynamics, the Pauli Exclusion Principle, and so forth—can all be shown to occupy logical niches that conform to the mandate that they serve the overriding purpose. The PACP underwrites a compelling narrative that establishes a meaningful connection between our most cherished human qualities and the uncanny ability of the physical universe, not only to connect cause with effect, but to connect individuals, who are seen as indivisible and fundamental, with the consequences of their actions.

Of central importance in the elaboration of the PACP is the assumption that free will is not an illusion but a real physical force. This force is understood to exert a tug on events in much the same way that the force of gravity exerts an attractive force on energy, with the power of one’s will being an increasing function of one’s level of consciousness and a decreasing function

of one's distance from the event in some as-yet poorly understood sense. The more knowledge an individual accumulates—the more aware he becomes of the potential residing in the present—the more power he has to structure events that, from his point of view, are located in the future.

The will is understood to operate on superimposed macro events located in the future through its effect on actual micro events, which are sensitive to its directive. In a world characterized by free will there are perforce no completely random events: The universe constantly monitors itself to maintain maximum sensitivity to the shaping force of our wills, an activity facilitated its non-locality. According to the PACP, the universe attends upon us. The mysterious ability of physical systems to seek maxima and minima of state variables—exemplified, for example, in the path of a lightning bolt—is a reflection of this fundamental fact.

Note that one person's will may cancel the force of another's. For example, if two individuals will their lottery number to be drawn, the net force of their wills on the event will be zero. In general, however, the direct opposition of wills is an inefficient way of producing effects in the real world. It is much more effective to use the force of one's will to create structure in the external environment that will cause other wills to support rather than oppose that force. Our susceptibility to reason and beauty and our willingness to accept leaders and teachers reflects the power of conscious knowledge to direct the course of history and the readiness of the universe to calculate and respond to the net force of different wills.

According to the PACP, the universe is balanced between opposing forces that conspire to engender beings endowed with free will. On the one hand, for consciousness to emerge, the universe must drive developing foci of independent action—life forms—to experience the consequences of their actions as a means of becoming aware of their situation in the universe. This mechanism is so finely tuned that it leads conscious beings to contemplate the moral dimension of their actions. The doctrine of karma represents an intuitive grasp of this aspect of reality. Such a finely tuned mechanism suggests that reality may be modeled by continuous mathematics. On the other hand, since conscious beings are elemental, and since they engage physical reality in a dialogue based on up-or-down answers to carefully posed questions, models of reality must also be able to capture this discreteness. But our models of physical reality do not mirror reality per se, which involves conscious individuals making decisions, but only the information-processing power of the physical universe to connect decision makers with the consequences of their decisions. When we look at reality we say, with Bohr's blessing, that it is neither analog nor digital, and that it is both. The fact that our foundational theory of physical systems can be expressed equivalently in both digital and analog form may be the closest that science may get to a Zen-like statement about ultimate reality.

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<sup>i</sup> Quoted by Stephen Weinberg, The New York Review of Books [P. 32].

<sup>ii</sup> Ibid.

<sup>iii</sup> David Deutsch, The Fabric of Reality [p. 87]

<sup>iv</sup> One could argue that computer memories contain compressed information and therefore knowledge, but the analogy does not hold up. The array of electric potentials on a memory chip constitutes information, not



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knowledge, information reflecting a structure external to a knowing entity created by a knowing entity for its own purposes. A given state of a computer memory is analogous to the structures wasps create to provide shelter from the dissipating forces of rain, wind, ultra-violet radiation, and so forth. The apparently random array of 1's and 0's that mirrors the state of a memory chip is a reflection of the mysterious ability of life to structure portions of its environment for its own purposes. Computers and computer systems, hardware and software, are cultural artifacts, analogous to styles of architecture, to the shape of tools, to research libraries, particle accelerators, and so forth. They do not contain knowledge but merely information; they are structures that serve the purpose of the life forms that created them.

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