CHAPTER 12

Finite Eventism

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In response to the discovery of a limiting velocity, Russell and Whitehead converged upon a doctrine known as 'eventism,' in which space-time is analyzed as a set of time-ordered moments, or "events." Eventism was well-founded by 1927, as exemplified in Whitehead's Gifford lectures at Edinburgh University, later published as *Process and Reality*, and Russell's *The Analysis of Matter*. The intent of eventism was to provide a simpler basis for physics, and at the same stroke, solve the mind-body problem. A human mental event is conceived as an individuated moment of pure phenomenal experience. It is situated in the causal order between its temporal predecessors and successors, placing it in the region of the brain. Whitehead inferred, in the manner of Leibniz, that *all* events which instantiate the causal order are monadic "occasions of experience." Russell teetered on the brink of that panpsychic generalization, but remained noncommittal.

I embrace Whitehead's panpsychic view of events, and the rationale for this is given below. 'Finite eventism' imposes a restriction that keeps infinities out of the theory: each event is restricted to a finite number of predecessors and successors. This makes it possible to construct exact diagrams of time-ordered events. Under the constraint of finite eventism, we shall find that 'less is more.' We can construct quantum theory from a bare-bones ontology of time-ordered events without employing any other primitives. This capability of eventism was unknown to Russell and Whitehead.

Physics Without Space

Whitehead acknowledged Henri Bergson as a major influence on his thinking. Bergson stressed the importance of time, and railed against "the spatialization of Nature." In this opening section, physics is reconstructed formally from *time sequence alone*, offering a de-spatialized account of the natural world that Bergson might have appreciated.

Until you formalize an idea, it cannot become a part of physics. In order to formalize what Whitehead calls "temporal succession," a temporal successor relation is required. A convention called *ordered-pair notation* suits our purpose. The expression (a,b) shall denote a primitive instance of temporal succession. The two arguments denote individual events or moments. The left-right order of arguments indicates the asymmetry of time order. Two pairs may have one argument in common. Such linking may connect any number of ordered pairs together, so that temporal structure of any finite complexity may be expressed by the use of ordered-pair notation.

First we use the ordered-pair to define a transitive relation, 'earlier than:'

> Definition: For any individuals a, b, and c,
> 1. If (a,b), then 'a' is also *earlier than* 'b.'
> 2. If 'a' is *earlier than* 'b,' and 'b' is *earlier than* 'c,' then 'a' is *earlier than* 'c.'

We then constrain the possibilities of time order with the following postulate:

> Postulate: No moment can be earlier than itself.

In mathematical parlance, the postulate imposes "acyclic order." As applied to physics, the constraint on time order is called "chronology protection." In terms of cause-and-effect, no event can be its own causal ancestor or descendant. In common parlance, there is no going backward in time.

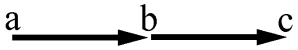
Finally, to complete the formal basis, we constrain eventism to a finite domain:

Finitude: Every moment has a finite number of predecessors and successors.

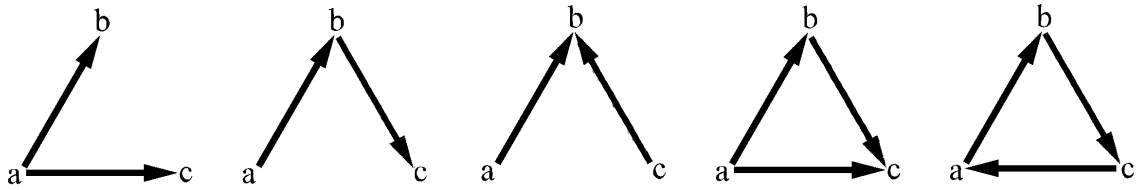
Surprising as it may seem, *the simple conditions given above are sufficient to construct a theory of physics from time alone*. Any construction we perform is confined to a finite number of ordered pairs. The analysis of whole-and-part arrives at logical primitives in a finite number of steps. The primitives are ordered pairings of moments. In consequence of this finitude, there is no infinite divisibility of a time interval, no continuous manifold, and no calculus in the theory.

A graphic arrow, with its directional asymmetry, serves just as well as an ordered-pair to depict a temporal transition from 'a' to 'b.' In the diagrams, each individual arrow represents a discrete and irresolvable step of time sequence. We can use the argument letters to label the endpoints of the arrow:

We can depict a time series of three moments, "(a,b) and (b,c)," as follows:



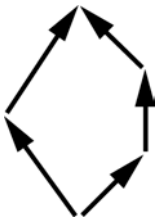
We can construct a time series of any finite length we like, but we can also construct time sequence possibilities that are not serial. There are four distinct ways that three moments can be arranged in chronological order. These are diagrammed below, along with one 'impossible figure' which violates chronology protection:



The offending diagram is the one on the far right, because each moment is earlier than itself. The first four diagrams are fine, and we assign them common names, from left to right: *fork*, *series*, *convergence*, *triangle*. Each diagram gives rise to variations if we swap the labels around while leaving the arrows undisturbed. It is 'structure' as defined by isomorphism that remains undisturbed by the label swapping. The variety of structure provides the variety of physical entities in this theory. The formal basis yields a limited variety of structural possibilities for a finite number of moments. That limited variety of natural kinds provides a basis for the application of probability theory. However, the theory is founded on the enumeration of all structural possibilities, starting with the simplest ones shown above, and probability has no part in this.

There is only one distinct diagram with exactly one arrow. There are three distinct diagrams of two arrows, counting the *fork*, *series* and *convergence*. The *series* surprises no one, since it is nearly an automatic assumption that time order is strictly serial. The *fork* and *convergence* contravene that assumption. Time order and causal order are conflated in this theory, such that "temporal succession" and "causal succession" are interchangeable terms. Any *fork* in the time diagrams thus depicts a single cause with multiple effects, and any *convergence* depicts a single effect with multiple causes.

The *triangle* diagram consists of two locally separable paths that begin together and end together. A *relative frequency ratio* is formed, which compares a 2-step path and a single-step path that traverse the same time interval. We can construct a diagram of relative frequency for any rational number. The following diagram features a 2:3 relative frequency ratio:



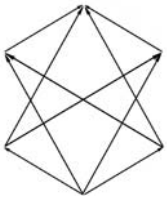
Relative frequencies serve this theory as relative energies in accord with Planck's equation E=hf. Planck's constant, *h*, is a scale factor that converts *units of frequency* to *units of energy*. This suggests that *energy is just frequency*. All we get from the latest diagram is a ratio of arrow-count for two locally separable time pathways. Suppose that the 2:3 ratio measures the relative *energy* of the two paths. The individual arrows are the countable units that yield the integer components of the numerical ratio. By that consideration, the individual arrows of our diagrams depict the individual quanta of quantum theory. Energy is 'packetized' in any account of quantum theory. In our theory, time itself is packetized into discrete transitions, and these serve the theory as energy packets.

The reciprocal of frequency is wavelength. Higher frequencies equate to shorter wavelength. In temporal terms, wavelength is a measure of duration, or time period. Higher frequency paths consist of shorter-period quanta. Frequency ratios and their reciprocals thus measure energy and wavelength respectively. We obtain the numbers that physics requires for frequency and wavelength without invoking waves or particles.

Our causally connected universe, we may suppose, corresponds to one elaborate arrow diagram. What are its highest and lowest frequencies? In a *bounded region* (to be defined shortly) the frequency range is capped at both ends. This ensures that energy density is everywhere finite. In the region of a high-energy experiment, we may hope to produce higher frequencies than those in the nuclei of ordinary matter under ordinary conditions. In an ordinary environment, the up/down quarks contain the quanta of highest frequency and least time period. That marks the high end of nuclear frequencies, which extend from there down to the somewhat lower frequency of a free electron. From there, the electromagnetic spectrum extends to lower and lower frequencies, finally fading out of detection due to increasingly feeble quanta. The low end is set, theoretically, by the age of the universe.

The diagram notation is interchangeable with the ordered-pair notation we began with. Any diagram can be labeled at its nodes and each arrow then translated to an ordered pairing of the labels at its endpoints. The theory can be expressed entirely as the combinatorics of ordered-pair expressions. That is the safeguard against over-interpretation of the diagrams. Shape and size of the diagrams are irrelevant artifacts of planar geometry that indicate nothing in the domain of reference. A diagram specifies nothing but time order. That said, we can streamline the presentation by relying on the diagrams for the more intuitive recognition of structure they provide.

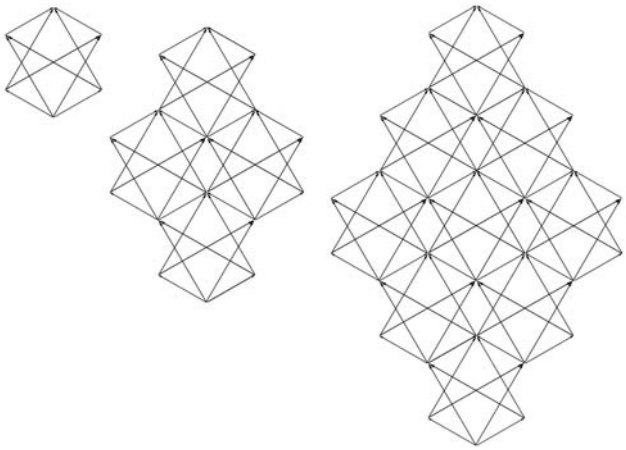
In my early explorations with paper and pencil, I drew the diagrams that have exactly three moments, then the diagrams with four moments, and then a great many diagrams with five moments. I was looking for a diagram that could be replicated to make a pattern of four-dimensional time. I did not find what I was looking for until I drew the following diagram (below), which I call the *hex cycle*. It is very likely the simplest template for constructing a pattern of four-dimensional time. The hex cycle diagram depicts a time sequence of 6 moments connected by 10 transitions.



The hex cycle has a single earliest moment and a single latest moment. Any diagram for which that is true is called 'closed.' A diagram that is not closed is 'open.' A closed diagram is the simplest way to specify a bounded or localized region of time. Such a region consists of all the quanta sandwiched between two moments, one earlier than the other. Such causal boundedness characterizes what can be learned by the scientific method. The causal factors that govern the runtime of an experiment are localized by two bounding moments of time: the moment of initiation, when the causal laws being tested are triggered into action; and the moment of completion, when the outcome of the experiment is known. Between those two moments, nature enacts a causal sequence that culminates either at the predicted outcome or at some other outcome.

We can build a series of ever more extensive closed regions by compounding hex cycles in a 'honeycomb' arrangement:

Figure 1: Honeycomb Series

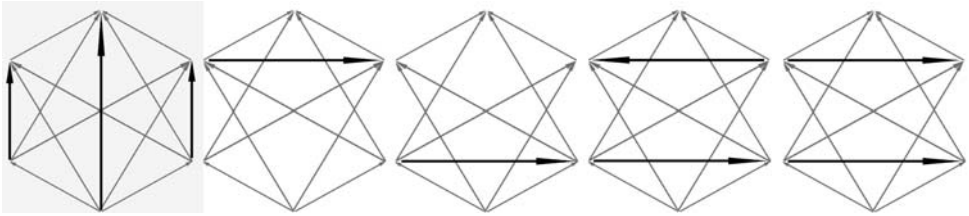


In the absence of a continuum, *dimensionality* is a matter of counting the arrows that meet at each node of a regular pattern. As the honeycombs develop appreciable interior, we see the growth of four criss-crossing time axes. Each interior node is at an intersection of the four axes. Every quantum belongs to one of the four time axes. I call these quanta 'lattice quanta,' because they compose a pattern I refer to as the '4-D time lattice.' That is to say, there are four axes of time in this theory, and they will account for the four-dimensional manifold of Special Relativity, that which Einstein called "space-time".[1] Choosing a sufficiently large 'n' as the n^{th} member of the above series, we can define a closed region of 4-dimensionality suited to span a cosmic scale. Such a 4-D manifold, like anything in this theory, is made of quanta. The 4-D *volume* of any subregion is measured in hex cycles. We now have a provisional account of space-time and energy. Given the energy and volume of a closed region, we can compute the *energy density* of that region.

There is no necessity to devote all the hex cycle energy to a perfectly uniform 4-D lattice. A less uniform lattice of fewer hex cycles and less energy can feature gaps or holes which delineate particle-like sequences. These separable sequences are the propagation modes of neutrinos and electrons. That is to say, the neutrino/electron formations, delineated by gaps in the uniformity, *constitute* the 4-D time lattice we call 'space-time.'

It is *charge quanta* that distinguish electrons from neutrinos. See the following figure, which shows the additional quanta locations afforded by the hex cycle:

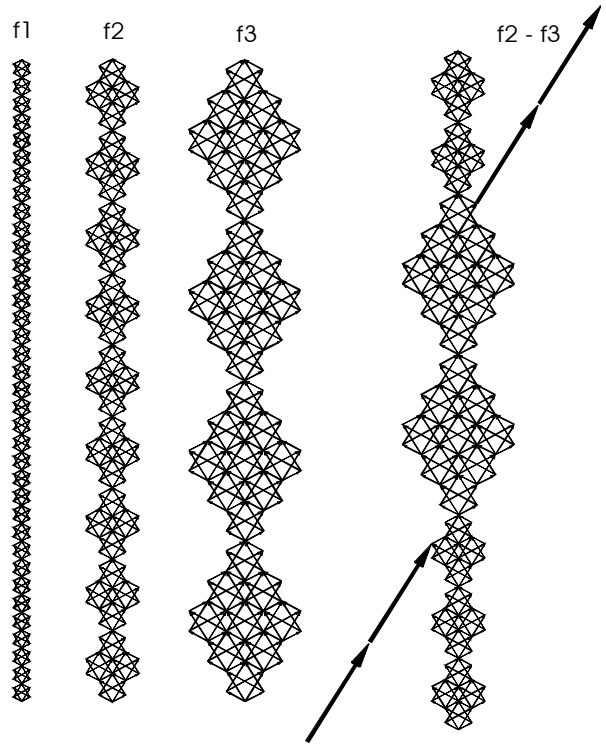
Figure 2: Quanta of momentum and charge



Placing the greatest importance on the hex cycle as the basis of our four-dimensionality, I have preserved its integrity as the template of all five diagrams. Variations are obtained by selective inclusion of the additional quantum possibilities afforded by the six moments of the hex cycle. In the leftmost diagram, I have drawn *quanta of forward momentum*. That hex cycle has a major axis quantum—the center arrow—which transitions directly from the earliest to the latest moment of the cycle. Such a quantum has the greatest duration and the least energy of any quantum in its cycle. It occupies the axis of bi-lateral symmetry inherent in the hex cycle. I have also drawn both of the other 'vertical' quantum possibilities, thereby preserving the bi-lateral symmetry. The "parallelism" of those three quanta is a topological feature of the hex cycle, and not just an artifact of the geometry of regular hexagons that I've employed in my drawings. The major axis and its parallels define the *axis of proper time* intrinsic to the hex cycle.

The other four diagrams include either or both of the *charge quanta* possibilities. The presence of any charge quantum breaks the bi-lateral symmetry of the cycle. Flipping or rotating an entire diagram does not affect its structure, so the four diagrams above exhaust the charge possibilities of a single hex cycle. If we were to include all three verticals plus two horizontals (two charge quanta) in one hex cycle diagram, the diagram would be *full*. More moments would be needed to accommodate more quanta within the region of such a cycle.[2]

The *chained repetition* of a closed diagram will serve to replace the notion of 'a particle persisting through time.' Chained repetition means that the last moment of one cycle serves as the first moment of the next. At this point, the term 'cycle' acquires its usefulness, as in 'cycles per second.' The *series* is a chained repetition of a single arrow, and this will serve as the *photon* of radiant energy. The hex cycle, if it contains charge quanta, will serve in chained repetition as a *free electron*. Electron *clouds* will also consist of hex cycle formations in chained repetition. The motivation for these claims is to be found in the next illustration, which yields Bohr's formula for the 'spectral fingerprints' of the atoms.



I have drawn the hex cycles as *neutrino* cycles, without any charge quanta. As drawn, they depict modes of neutrino propagation. If we populate the hex cycles with *charge quanta*, we get electron clouds. In that case, we would have, from left to right, a *free electron*, a *hydrogen cloud*, a *helium cloud*, and finally, a hydrogen cloud sequence disturbed by an encounter with a photon. The first three diagrams mark the start of a progression that continues in step with the periodic table. The stable clouds feature uniform cycles of uniform frequency. The cloud disturbed by the photon exhibits a modulation of cycle-pattern and frequency. The frequency of the photon, either incident or emitted, is the difference in frequency of the two cycles involved in the modulation. This scenario, generalized to the whole series of cloud possibilities, yields Bohr's formula for the spectral wavelengths of photons absorbed and emitted by the atoms.

Attached to periodic nodes of an electron cloud sequence is a *nuclear* sequence of higher frequency.[3] This constitutes a synchronization of nuclear and electronic frequencies. That is what gives the nucleus its location in the 4-D lattice. Larger clouds form around larger nuclei, which correlates greater cloud size to greater nuclear mass. On this theory, Einstein's 'curvature of space-time' is a global consequence of the local 'slowdown of time' correlated to local mass density. Such slowdown is depicted in the diagram by the stepped-up scaling applied to each successive cloud formation. The progressive expansion of hex cycles, from left to right in the series of cloud formations, constitutes a stepwise inflation of the underlying space-time metric. This relates the inverse square law of gravity to the inverse squares of Bohr's formula.

Counting the hex cycles of a sequence gives a reasonable measure of the total energy. Each time sequence is scaled so that 36 hex cycles span the height of the diagram. Thus the same amount of energy plays out in the same amount of time for any of the cloud formations. The result is a departure from the linear incrementing that one expects from an independent time axis. But proper time is not an independent axis. The hex cycles establish a proper time axis in conjunction with four axes of lattice quanta. We measure time along a proper time axis that increments as an integral component of local 4-D lattice propagation, such that cycles of equal energy transpire in equal time periods. If we don't take that into account, we misinterpret the non-linear growth of the proper time component as the deflecting work of forces that obey an inverse square law.

Quantum mechanics employs a set of four integers to specify the "electron state" of an atom. The four integers are associated with four concepts tied to Newtonian physics: orbit number (Bohr orbit,) sub-orbit number, angular momentum, and up/down spin. If we set out to populate our cloud formations with quanta of charge and momentum, we foresee a limited range of available 'fill patterns.' The isolated hex cycle offers two 'slots' for charge and four alternative fill patterns, as shown previously. The number of fill patterns grows systematically with increasing cloud size. Such fill patterns provide an interpretation for the 4-tuples of raw numbers in Quantum Mechanics.

The topology of discrete time sequence is rich enough to formulate physics, simplify it, unify it, and endow it with the consistency of whole number arithmetic. Taking this theory as provisionally correct, we can then explore its consequences for philosophy and the scientific outlook.

Physicalism Decommissioned

I shall use the term 'physicalism' to refer to the widespread belief that the world is mainly composed of non-mental entities. Physicalism is rooted in the common sense belief that physical objects such as rocks consist of inert matter. Such matter is not thought to depend for its existence on human minds, nor is it thought to have any mental characteristics of its own. The common sense belief in matter was incorporated into physics by Newton, who gave it rigorous definition and fundamental status in his system of matter-in-motion. This reinforced the common sense belief in matter, and insofar as matter-in-motion seemed to provide a sufficient conception of the physical world, such belief was called 'materialism.' Newton's physics proved to be defective in the long run, and his characterization of matter was part of that defect. Physics then shifted its dependence from matter to various substitutes, such as *fields* and *mass-energy* and *probability waves*. These substitutes served to redefine such objects as rocks without disturbing the gut-level conviction that such objects have no mental characteristics. The widespread acceptance of this *modified materialism* I am calling 'physicalism.'

The physicalist thinks of the physical world as extended in space, just as Descartes characterized it. Without recourse to such extension in space, he is unable to formulate any physicalist ideas. The inventory of spatially-conceived entities is wiped out by the brute reduction of physics to pure time sequence. There is nothing wrong with geometric conceptions in themselves—they just don't apply to a purely sequential physical world. Thus we may say that the geometric conceptions are 'decommissioned from service' in the theory of physics.

According to Richard Feynman, quantum physics is "crazy," and we need to become accustomed to that fact. Trying to make sense of physics is a quixotic goal that has brought human understanding to the end of its tether. Presumably, Newtonian physics was less crazy—a standard for comparison. The notion of matter-in-motion encapsulates Newton's theory nicely and presents little challenge to the layman. Now consider the theory of time sequence, which is even less challenging. It has but one concept that must be mastered—that of 'earlier-and-later.' We specified the logic of earlier-and-later on the first page of the physics section, and there was nothing "crazy" about it. There is nothing crazy about time not going backward. The concept of 'time order' is presupposed in the concept of 'motion,' so one cannot be comfortable with the latter concept and uncomfortable with the former. There is not a single new concept in the theory of time sequence, nor any non-standard logic, nor any novel mathematics. What defines and distinguishes the new theory is its *retention of time order to the exclusion of everything else*.

We all 'know the mind of the physicalist' because we all know how to conceive a rock as 'a lump of stuff.' Descartes made use of a piece of wax in order to bring his notion of physical existence into stark focus.[4] I have a rock in front of me right now, which fits nicely in the palm of my hand. As a physical object, it will serve just as well as Descartes' piece of wax. My rock is made of quanta. The constituent quanta of the highest frequencies connect to form the quark cycles of my rock. The quark cycles combine to form cycles of protons and neutrons, and these combine to form nuclei. The nuclei are interlaced with electron clouds to form complete atoms, which in turn combine to form molecules. The molecular patterns connect to form the rock. An arrow diagram of my rock would show how all its quanta are connected into a single elaborate sequence. The quanta themselves, I should emphasize, are not

undefined. Each quantum is an irresolvable step of time sequence. My rock is a propagating time sequence, made of temporal transitions from one moment to another. As it is with the rock, so it is with my hand that holds the rock, my body, physical objects in general, and the universe as a whole.

The foregoing account rests upon the notion of quanta, which are unperceivable. The theory of quanta is *conjectural* in nature, as is the "crazy physics" of Feynman, or string theory, to take another example. Conjecture carries with it the risk of error. The craziness of contemporary quantum physics could be wrong, as could any theory that ventures to account for the unperceivable causes of our sensory data. The physicalist is under the innocent impression that he knows the essential nature of a rock in his hand from direct sensory perception *without having made any conjecture at all*. That innocent impression gives the physicalist a 'head start' in his pursuit of understanding the physical world. He is pre-equipped with the certainty that geometric shape and size are primary features of physical existence. But he is pre-equipped with the wrong topology, and his certainty is only psychological. He gets this wrong topology—spatial topology—from his own sensory data, which he cannot distinguish from the physical world, which he thinks he perceives. Thus he is stuck with a spatial conception of the world. It will take the dramatic and incontrovertible collapse of spatial states and spatial configurations in the theory of physics to make him rethink his assumptions about what is perceivable and what is not.

That which is perceivable is detailed in the study of *phenomenology*. Here we find everything that is missing from the theory of physics. There is no qualitative color in the theory of physics, but in phenomenology we find a description of the color solid, the gray scale, hue circles, primaries, complements, saturation, and so on. We find color instantiated in the spatially extended regions of a well organized two-dimensional visual field. We find visual size and shape. We find sound, with auditory qualities of pitch, loudness, tonality, and tempo. We sometimes find these sound qualities organized into melodies and music. We find the somatic feelings of touch, pressure, motion, and rhythm, organized into the relative locations of a "body plan," which is the body-as-felt. We also find temporal coordination among these discriminable sensory modes. We find intentions and ideas being entertained. We find odor and flavor. We find a lot.

All that we find in phenomenology, as I say, is missing from the theory of physics. The theory of time sequence shows just how 'thin' the subject matter of physics really is. Its subject is the time order of what happens in the universe. Physics sheds no light on the intrinsic nature of the discrete happenings, which are sorted into individual moments and relational transitions by sheer dialectical necessity. That sorting is enough to define time order, in terms of which, hypothesis and prediction are used to model and refine the temporal/causal structure of the universe. The predictions of physics must lead to perceivable results to do any good. 'Perceivable results' means sights and sounds in the phenomenology of a sentient human mind. Physical theory is concocted to improve the predictability of such sights and sounds. It has proved vital to incorporate theoretical, *unperceivable* entities into physics, to better predict the qualitative sensory data that we *do* perceive. With that development, physics becomes partially *non*-phenomenological. What begins as the supplemental addition of theoretical entities into physics, ends up as a theory referencing *nothing but* theoretical entities. The non-phenomenological component becomes all, so that physics and phenomenology end up with mutually exclusive domains of reference. This all began in earnest with Galileo and Newton, when the so-called secondary qualities were marginalized from physics. Now it is clear they are gone altogether. It is wrong, therefore, to speak of 'physical phenomena.' Physics is a hard-won predictive model for our sensory data. It is still in the making, proceeding by experiments that test the predictive power of this or that hopeful conjecture pertaining to the existence and arrangement of unperceivable entities.

The unperceivable entities of physics are either mind-like or not. Panpsychism holds that they are, and physicalism holds that they are not. Given the reduction of physics to just two primitive types of entity—temporal *moments* and temporal *transitions*—the question is narrowed as to whether these are mind-like or not.

The paradigm case of a mind-like entity is the human mind, which we can characterize as a temporal stream of phenomenological experience—the 'stream of consciousness.' To Descartes, it seemed clear

that all things physical are spatially extended, while the mind subsists in time without being spatially extended. The mind is thus set apart from the physical world, *except for the common element of time itself*, which is native to both mental experience and the dynamics of physical bodies.

With the physics of time sequence as one's hypothesis, the seriality of human mental experience can be incorporated into the physical world as an integral part, since time is compatible with time. This was the gist of eventism for both Russell and Whitehead, inasmuch as the mind-body problem would be overcome. In that case, we would have moments of human experience implicated in the temporal/causal order with other moments, as yet uninterpreted, that serve the modeling needs of physics. Russell's term for the human moments is "mental events." Whitehead migrated to the term "occasions of experience." For either one of them, the question of panpsychism versus physicalism turned on whether or not *all* moments are like human moments—mental and experiential. Whitehead says yes, while Russell remains firmly noncommittal.

The key argument for panpsychism concerns the compatibility of human mental events with their immediate causes and effects. It has been a standing argument against mind-like entities that they are *unlike* the spatial entities of physics, so that causal interaction between the two is unintelligible. But now 'the shoe is on the other foot.' A time series of human moments is well suited to instantiate the causal order, while the remaining moments of physical theory have no specified attributes whatsoever. It is these latter moments that now stand in need of causal compatibility with mind.

The foregoing argument rests upon the validity of the proposed reduction of physics to time sequence. The reduction to time is best understood as a continuation of Newton's enterprising reduction to *space*, *time* and *matter*. Consider how Newton's theory accomplished the reduction of 'heat' to the motion of molecules. The physical theory of heat had first developed in accord with the assumption that heat is a primitive quantity without definition in terms of anything more basic. When Newton's theory was used to reformulate the physics of heat, it was eliminated as a primitive entity, replaced by the average kinetic energy of molecules in motion. That same type of reductionism—eliminate and replace—is carried further, and taken to the limit, in the reduction of the molecules and their motions to sheer time-ordered sequence.

Common sense realism in regard to the existence of the physical world is not jeopardized by the reduction to time. The electrons and photons, the rock, the brain, the planets, the galaxies—all these have their quanta and their mass-energy. None of it has any spatial extension, because the chaining of temporal transitions provides all the extensiveness that is needed. There can be no such thing as a physical *state* of instantaneous organization. What exists all-at-once is only each individual moment. Since each moment is generic and primitive, there is no specification of its 'state.' To make reference to a 'physical state,' such as a 'brain state,' is to 'freeze out time' and immerse oneself in the illusion of spatial extension.

Science today thinks in terms of 'big' and 'small.' Galaxies are big and quanta are small. These are assessments of spatial extent. They constitute a nasty distortion of the facts. Physical size and measure pertain to quanta, which have greater or less *duration*, which means they are relatively slow or quick. The quicker quantum has the greater energy, and the slower quantum has the greater time span. In a vast closed region, a single quantum could connect the earliest moment to the latest, spanning an eon of time. Such a quantum has feeble energy, but to think of that quantum as 'small' is to miss the fact that it spans a galaxy.

'Magic numbers,' 'God-particles,' and 'dark energy' are among the hopeful terms that physics uses to mark the holes in its understanding. The physicists admit that they do not know what a particle is, what mass is, or why particles have the masses they do. Feynman was one who strived to understand physics in terms of logically primitive concepts. Accordingly, he was bothered by the 'fine structure constant,' a raw number needed to make quantum electrodynamics work.[5] It is a magic number because it has no known derivation or interpretation. To have such a number listed among the ultimate constituents of the temporal world is tantamount to number mysticism, which is what bothered Feynman. The inclusion of even one magic number in a theory is enough to wreck any ontological interpretation of that theory. String theory requires many such numbers, perhaps an infinity of them. There are no magic numbers in the theory of time sequence, and no mystery as to how numbers apply to the physical world. Everything in the theory is

countable, and any numbers are integers or ratios of integers. A non-rational number like *pi* is extraneous to the theory, as the theory has no circles or continuous curves.

Another magic number, one that Einstein called "my biggest mistake," is the Cosmological Constant of gravitation. That 'constant' is now known to shift in value as the universe ages. Physicist Rafael Sorkin has given an explanation of that shift in terms of "causal sets."[6] The theory of causal sets is formally identical to the theory presented here. Every diagram in this article is a diagram of a causal set. Sorkin and his group at Syracuse University have used causal sets to reformulate most of General Relativity. Causal sets are useful for calculating the Hawking radiation given off at the boundary of a black hole. Taken together, the quantum theory presented here, and the work accomplished in cosmology with causal sets, are complementary advances on two fronts of a single reductionism.

Fortified with confidence in the reduction of physics to time sequence, we can complete the decommissioning of physicalism. The entities of physics—moments and transitions—are *all time-like*. Human moments of sentient experience are well suited to instantiate the causal order, and they provide the crucial sensory data required for empirical confirmation of physics. The remaining moments of the causal order thus stand in need of causal compatibility with the human moments, *so all moments must be mind-like*. That leaves the transitions to be considered. Each transition connects one moment to another. Since the moments are mind-like, direct relations between them are *also* mind-like. To suppose otherwise would be to inject incompatibility for no reason. Since all the primitive entities of this physics are best considered mind-like, panpsychism emerges as the more plausible doctrine, and physicalism drops out of contention.

The Dominant Monad

Regarding 'human minds,' I consider them to be discrete, countable, and each one serial. There is normally one human mind per human body. A notable proponent of discrete human minds, in the philosophical tradition, is Berkeley, who believed only in human minds and the mind of God, with no further minds involved, and no physical world. I shall treat one human mind as a series with a definite frequency. There are other series that are not human, and they might well have the same frequency as a human mind, but that alone does not make them 'human.'

If one person's sentient mind be considered a temporal series, then its analysis into momentary parts can take one of two paths. In a *continuous* series, there are an infinite number of moments between any two in the series, and with respect to any one moment in such a series, there is no *next* moment. On the other hand, a *discrete* series has a finite number of moments between any two, and the connection of moments is characterized by next-to-next succession. I argue for the latter, in order that a human series of moments be compatible with the discrete type of order that belongs to the physical world. Human moments can then be identified with selected moments in the theory of physics, appearing as normal junctions in the arrow diagram of the universe.

Our sentient experience of time seems to be smooth and without breaks. The best we can do to account for that smoothness, using discrete time analysis, is to model the human series as an unbroken alternation of 'moment, transition, moment, transition.' We then have a typical serial structure, constituted by moments and transitional quanta, which I nominate as 'human moments' and 'human quanta,' respectively. By itself, such a series is just like a photon of unknown frequency, and it represents a disembodied human mind. We are interested in the embodiment of such a mind in the immediate environment of its brain. This requires that the human series be joined by forking and convergence to other quanta of the brain.

The first order of business is to determine the frequency of the human series with respect to the other frequencies of physics. The free electron lies at the high end of electromagnetic frequencies. It is superseded only by the frequencies of the nucleus. Mind-brain interaction is electromagnetic activity, which ranges in frequency from that of the free electron at the high end, to frequencies as low as several cycles per second and perhaps lower. Psycho-physical experiment indicates that 10 Hz is the frequency of human mental states. Let us consider the experimental data.

The closest physical correlate to human sentient awareness is the brain wave activity at the cortical surface, recorded by EEG. Alpha frequencies in the neighborhood of 10 Hz accompany both the waking state of awareness and the state of active dreaming. Dreamless sleep is accompanied by slow rolling waves of several cycles per second. A brain dead patient is flat-lined, with no EEG activity. In the late stages of ALS, a patient can reach a 'locked in' stage, having lost the last vestige of voluntary motor control. The patient's mind is stranded, without even an eye-blink to communicate to the outside world. In such a case, the EEG is the only means by which a doctor can determine whether or not the patient's brain is still host to a sentient human mind.

The alpha frequencies are typically out of phase with one another, making a jumbled mess on the EEG record. A good meditator can bring the alpha frequencies into synchrony, producing a steady rhythm of coherent oscillation at 10 Hz. This is a remarkable clue to the frequency of mind-brain interaction. When we ask the meditator for an 'inside report' as to how the psycho-kinetic feat was accomplished, we hear that meditative practice is a progressive calming operation, effected phenomenologically and intentionally. This leads to a state of mind characterized by calm alertness and clear sensory awareness.

The concert of alpha rhythm measured by the EEG apparatus cannot be identified with the lone human series, which is too weak to be measured. Nevertheless, there must be some 'pacemaker' at work in the brain to orchestrate the alpha activity into a common beat or rhythm. The human series might serve as the pacemaker, or it might simply join in when the opportunity arises. In either case, it seems likely that the human series of moments transpires at a rate of 10 per second, connecting with other cycles of the brain that are nearby in frequency.

A stimulus probe on the visual cortex produces a spot in the subject's visual field. A *pulsing* stimulus, repeated at one location, produces a pulsing spot for the subject, *until the pulse rate exceeds 10 per second*. As that stimulus frequency is approached, the sensory spot loses its frequency altogether and becomes steady. Testing the frequency response of the other sensory modalities reveals the same 10 Hz limitation. The implication is that we cannot register changes faster than ten per second. The likely explanation: moments of human sentient awareness transpire at that rate and no faster.

A rate of 10-per-second for human moments is also appropriate to the delays involved in the conduction of efferent nerve signals from the brain to the muscles, and in the reverse direction, the conduction of afferent signals from the sense receptors to the brain. *Reaction time*—to avert a driving collision for example—is not reducible to less than one tenth of a second. Reliable motor control of the body requires patience for the feedback, which is subject to the propagation delays of neural transmission. The human series is well qualified for central control of the human body, equipped at 10 Hz with the ideal frequency for the job.

Strobe lights at 10 Hz bother people, and epileptics are prone to seizure when they see such strobe lights. All in all, given that we are seeking a finite frequency for the human series, a regular frequency of 10 Hz seems to be it. We are not aware of this frequency by introspection. It is ascertained only by reference to scientific hypotheses concerning a world that lies beyond the reach of anyone's introspective powers.

Location of the human series in the brain sequence

Brain scientists have mapped out a set of functional locations on the cortex called *projection areas*. These serve to pinpoint the location of the human series in the brain. The first two projection areas to consider are depicted by the 'motor homunculus' and the 'sensory homunculus,' which represent human-like forms that were first mapped out by Wilder Penfield.[7] The topology of the human body is preserved in these shapes, but geometric distortions of the 'little man' give him the appearance of a malformed fetus. You can stimulate the motor homunculus with a probe and get the corresponding part of the body to twitch into action, like operating a puppet. You can stimulate the sensory homunculus to shortcut the more remote stimulus that is normally needed on the surface of the body to achieve the same sensation.

Each moment of a human series has additional predecessors and successors that belong to the brain but not to the human series. Forking and convergence connect the human series to other cycles of the brain.

Quanta that fork off from the human series to the motor homunculus provide control of bodily movement. Quanta from the sensory homunculus converge upon the human series, updating the body-image of somatic awareness. At cycles of 10 Hz, the sequence of cause-and-effect is as follows:

1. One human moment forks off to many moments of the motor homunculus.
2. Effects are propagated along efferent nerve routes to the muscles.
3. Muscle action causes feedback signals along afferent nerve routes to the sensory homunculus.
4. Many moments of the sensory homunculus converge upon the next moment of the human series.

During the tenth of a second between the two bounding moments of the above cycle, one human quantum also transpires, propagating the human series. Compare the above with the following passage from Russell (1948):

> Consider now a single causal sequence, beginning with an external stimulus, say to the eye, continuing along afferent nerves to the brain, producing first a sensation and then a volition, followed by a current along efferent nerves and finally a muscular movement. This whole series, considered as one causal sequence, must, in physical space-time, occupy a continuous series of positions, and since the physiological terms of the series end and begin in the brain, the "mental" terms must begin and end in the brain. That is to say, considered as part of the manifold of events ordered in space-time by causal relations, sensations and volitions must be located in the brain. A point in space-time, following the theory to be developed in a subsequent chapter, is a class of events, and there is no reason why some of these events should not be "mental." Our feeling to the contrary is only due to obstinate adherence to the mind-matter dualism.

Both accounts describe the causal location of human mental events in the brain. My account is quantum-specific in locating a human mental event between immediate causal predecessors and successors. Neither account makes any sense if the brain and its cortical surface are conceived geometrically. The standard conception of a brain is one of instantaneous extension in space, with no earlier-and-later involved in its composition. That is a brain without quanta. Such a brain has no place in our physics. Taking Special Relativity into account, the cortical surface is a set of contemporaries—'causal cousins,' related only by their causal ancestry. Such contemporaries are also poised to beget common causal descendants. The 'location of the mind in the brain' is resolved by tracing the causal lineage of human mental events to and from the homuncular regions. The homunculi on the cortex are the key causal locators of human mental events. This interpretation is *inconsistent* with the concept of a cortex as a surface of instantaneous spatial extent. Hence, prevailing wisdom attributes no significance to the homunculi.

Other projection areas on the cortex have also been mapped out, which correspond to other sensory fields of human phenomenology. Patterns of excitation at the retina are reproduced at the visual projection area. Auditory experience also has a patch of cortical surface devoted to it. A mental event typically involves all the sensory modes at once. The distinct phenomenal sensory modes correspond to the distinct patches of cortex devoted to the organs of sight, sound and touch. As with the sensory homunculus, the visual and auditory projection areas are home to causal predecessors of the human series. From those cortical sites, the afferent system converges to a human percept, at which point the efferent phase of causal sequence is renewed.

Let us consider visual experience and its patch of cortex. In phenomenal vision, we have a spatially extended field of colored patches. The colorful visual field is part of a human mental event. As is the case with color, the inherent geometry of the visual field is given to the subject of experience. We can judge with remarkable precision the size and shape of colored patches given in our visual experience. A good example is the extraordinary precision by which we can judge a rectangle to have height-width proportions of the 'golden mean.' This is pure phenomenology. The ancients could judge with the same

accuracy. It owes nothing to science. It is a type of ratio measurement that involves no physicalistic conceptions or assumptions.

The visual projection area has a space-time metric based on *the second* as the standard unit of duration. Supposing the patch of visual cortex to be roughly circular and one inch in diameter, its space-like extent is approximately one-tenth of a nanosecond. The full spread of the subject's phenomenal visual field correlates to the full diameter of the cortical patch, so that half the visual field corresponds to half the cortical patch, or one-twentieth of a nanosecond. Proportionate size in the visual field is thus correlated to the metric unit of physics. This correlation is critical for an epistemological account of physical measurement, which requires sentient mental events in the laboratory, and sensory data that is phenomenally given to them.

The correlation of phenomenal measure to the nanosecond span of this or that cortical projection area is reliant on psycho-physical experiments. Perceivable sensory fields are correlated to the unperceivable domain of physics. In the case of hearing, it is *pitch* that correlates to the nanosecond span across the auditory cortex. We do not expand the domain of the perceivable by arriving at such correlations. They belong exclusively to the field of psychophysics, which correlates the qualitative data of subjective experience to the conjectural model of theoretical physics.

The human series has direct access to vision, hearing, and tactile information at the cortical projection areas. Such *direct access* to information is unambiguous in our theory of physics. It means that select moments of the projection areas are immediate causal predecessors of a human moment. Each such predecessor connects to the human moment by a single quantum. Conversely, *direct action* by a human moment upon some moment in the region of the motor homunculus means that a single quantum connects the human moment to the homuncular moment. The homunculi are situated on the cortical surface as if to provide convenient test points for a technician to troubleshoot the sensory and motor systems. In normal operation, they serve as staging areas for perception and control by the human series.

The stable brain is a propagation of synchronized time cycles, featuring a great range of frequencies and great variety of cycle topologies. The stability of human experience and its dependence on the brain means that the human series must be embedded in supportive cycles of 10 Hz frequency. These cycles provide a base of causal routine for the human series, and connect the 10 Hz series to the ladder of higher frequencies involved in brain function.

Conclusion

'Panpsychism' is a broad term for divergent doctrines as to the mind-like character of physical existence. I have argued that the reduction of physics to time sequence improves the prospects for panpsychism in general, over and against the default physicalistic view that predominates today. That is my main point in this article, and I am less concerned with discrepancies between competing versions of panpsychism. I will close with a summary of my own interpretation, which may serve as an example, and a foil for opposing views.

I think of each moment in the physical scheme as an 'occasion of experience,' to use Whitehead's term. Each occasion is host to its own phenomenological data. The arrow diagram of the universe is an 'inheritance map' or 'family tree,' showing the causal ancestry and lineage of each occasion with respect to the others. A human stream of awareness is a 'personal series,' forming a dominant line of inheritance. The chained repetition of human cycles propagates the dominant line of inheritance, accounting for the relative constancy of human experience over a modest span of time. The other moments and quanta of the human cycle are connected to the human series, but they are not parts of it. No moment is part of any other moment, and no quantum is part of any other quantum. Whole and part are unambiguous, and the primitive parts combine to make sequential structure. The overall connected structure is merely a history or genealogy of moments. All experience is localized in the moments—there is no 'group mind' to be ascribed to any structured whole. Neither is there any 'mind stuff' which coagulates to compose an occasion. Occasions are the only units of experience.

The patterned regularities of temporal succession are the laws of physics. Departures from regularity constitute the limits to law-like determinism. I see no 'necessity' attaching to the contingent patterns of time. Physics relies utterly for any success it might have on projected continuation of propagating patterns. Why do specific patterns persist and not others? The physicist describes *how* time progresses, making purely structural claims about patterns of time sequence. In asking *why* time makes the patterns it does, we are thirsting for a teleological explanation. Whitehead looks first to why human beings form societies, and he finds that societal organization leads to greater satisfaction of the members. Generalizing that insight to the relations that bind all occasions, moments form cyclic patterns of repetition for the same reason—to reap more satisfaction from a sharing arrangement with like-minded individuals. Just as *experience* is entirely localized within individual moments, so is the teleological element of *satisfaction*. The teleology of pattern formation is thus wholly attributed to the teleological nature of the individual moments and their direct inheritance relations to contiguous moments.

No moment is 'bigger' or 'smaller' than any other. I have ascribed a privileged role to human moments in the control of bodily behavior, but the cooperation of a great many non-human moments is presupposed. We are apt to take a parochial view of our own native frequency as 'just right' for the enjoyment of sane, coherent experience. We have trouble granting experience to the moments of an electron because of their nanosecond quickness. But that pace is strictly relative to other frequencies. There is no absolute measure of duration. The pace of experience is 'just right' for the constituent occasions of any sequence, regardless of its frequency ratio to other sequences.

NOTES:

[1] In the diagrams, the four axes all look alike. "Space-time" is really "time-time" in this theory. Why then do we experience it as three spatial and one temporal? We don't. We don't experience the physical world at all. We experience phenomenal sights and sounds, just as Berkeley described in his account of vision. The visual field, with its coloration and geometry, belongs to the phenomenology of an individual human mind. The ontology of an individual mind begins there. The elaboration of further ontology—to include God, or other minds, or a physical world extended in space—proceeds by faith. Russell prefers the term "inference." Russell was just as convinced as Berkeley of the inference required for "knowledge of the external world." As he says repeatedly, no one can perceive physical objects. He derides the so-called "perception of physical objects" as "the Immaculate Perception." Nevertheless, we can, and do, make vigorous inferences about an external world. In light of this 'shot-in-the-dark' character of scientific ideas, we are free to reformulate Special Relativity with four time axes all alike, rather than three of space and one of time. All coordinates are then real-valued, and we dispense with imaginary numbers. The limiting velocity becomes a consequence rather than an axiom of the theory. Everything is simplified, minimizing the complexity of the hypothetical scheme in accord with Ockham's principle of parsimony.

[2] The limited capacity of the hex cycle for charge quanta serves the same function as the Pauli exclusion principle. Also, symmetries of the hex cycle correspond to CPT (charge-conjugation, parity, time reversal.) For example, a hex cycle of 10 arrows has mirror symmetry about its major axis (parity). Furthermore, if we reverse the direction of every arrow (time reversal), we get the same diagram we started with (orientation on the page being meaningless).

[3] The cloud sequence diagrams do not show any nuclei. The quantum structure of the proton must be worked out in order to diagram, for instance, a complete hydrogen atom. Nevertheless, much can be learned about electromagnetism without knowing about the nucleus, as the historical development of physics testifies. I have found the likely structure of the nucleus, based on a time lattice with a different topology than the 4-D time lattice. See my paper "The Structure of Quarks," online at: http://step-in-time.spaces.live.com

Secondly, you can't count electrons in the cloud diagrams. Why is that? In the reduction to time, there are no particles, strictly speaking, but only quanta arranged in particle-like sequences. Conservation of electron-count is not an empirical law in the first place, and no one will ever *see* an individual electron. The inviolable identity of individual particles is lost in the reduction. The same holds true for the quarks and nucleons of the nucleus. What's gained is a consistent breakdown into quanta. For more details see my books *The Mind-Body Problem and Its Solution* (2004), and *A Theory of Everything for Physics* (2005).

[4] *Meditations* II, Part 11.

[5] The fine structure constant, once thought to be an integer, is now thought to be 137.036. The 'Honeycomb Series' of Figure 1 shows three cycles that are subsequently employed in chained repetition to diagram the cloud sequences. The smallest cycle of Figure 1, the single hex cycle, has 10 lattice arrows and can hold (as shown in Figure 2) up to 3 quanta in its proper time axis. The largest cycle of Figure 1, the helium cloud cycle, has 78 lattice arrows, and can hold up to 59 quanta in its proper time axis, for a total of 137. That is likely the fine structure constant in this theory, and I suggest that the discrepancy of .036 be re-evaluated in the native context and units of the new theory.

[6] Read about causal sets at: http://www.einstein-online.info/en/spotlights/causal_sets/

[7] The drawing below appears in Penfield and Rassmussen, *The Cerebral Cortex of Man* (1950). The image is available online, courtesy of WikiMedia Commons, at the following URL: http://en.wikibooks.org/wiki/Image:Homunculus-de.svg#filehistory