Article

Quantum Entanglement, Consciousness & Evolution

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Abstract

For physicists such as Bohm, Planck, Schrödinger, Heisenberg and others, consciousness, or potential consciousness, is an innate and inseparable aspect of the quantum immaterial realm which underlies the apparently material realm. Furthermore, as Bohm states, "every part of the universe is related to every other part but in different degrees;" this interconnection accounts for a deep level of the evolutionary interrelationships between creatures and environments. Because of the deeply connected nature of the quantum field there must be a quantum informational interconnection between environments and the creatures within them. The supporters of the hardcore materialist worldview tend to consider, without actually thinking too much (if at all), that anyone involved in scientifically investigating the nature of quantum reality and its relationship to the 'observer' as being so irredeemably infected with what these 'rationalists' call 'woo' that they should not be taken seriously. In this article we take a more in depth look at the crucial issues raised by the paper that Tsakiris unsuccessfully attempted to draw to the unwilling attention of a materialist.

Keywords: materialist, nonlocality, quantum gene, Bell's theorem, quantum entanglement, consciousness, evolution, Darwinism.

In this article we take a more in depth look at the crucial issues raised by the paper that Tsakiris unsuccessfully attempted to draw to the unwilling attention of Jerry Coyne. Figure 1 shows the upper half of the first page of the paper '*An experimental test of non-local realism*.' The paper, as can be seen, is written by seven physicists, physicists who make up a world renowned team of experimenters at the 'Erwin Schrödinger International Institute for Mathematical Physics' based in Vienna. Given the credentials of these physicists I think it is beyond dispute that, as Tsakiris says to Coyne, the paper in question can be considered as *not* being "too out-there, woo-wooish, fringy."

Unfortunately, however, the supporters of the hardcore materialist MUD (Materialist Ultra-Darwinian) worldview tend to consider, without actually thinking too much (if at all), that anyone involved in scientifically investigating the nature of quantum reality and its relationship to the 'observer' as being so irredeemably infected with what these 'rationalists' call 'woo' that they should not be taken seriously. Coyne, having managed to deflect any possibility of having to confront the evidence of 'quantum woo', posted to his blog associated with his WET (*Why Evolution is True*) book:

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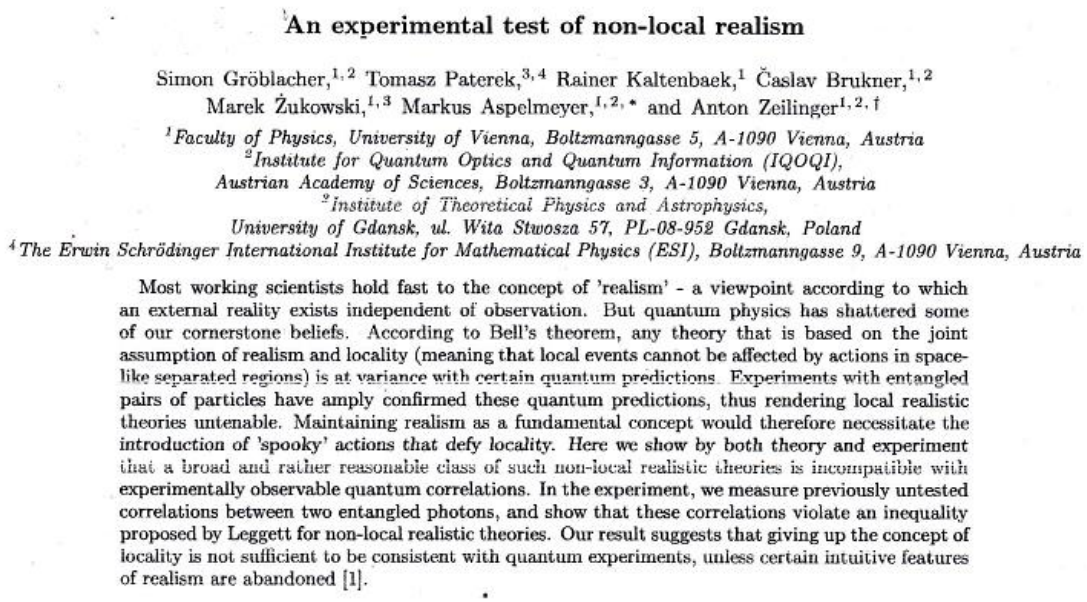

An experimental test of non-local realism

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Most working scientists hold fast to the concept of 'realism' - a viewpoint according to which an external reality exists independent of observation. But quantum physics has shattered some of our cornerstone beliefs. According to Bell's theorem, any theory that is based on the joint assumption of realism and locality (meaning that local events cannot be affected by actions in space-like separated regions) is at variance with certain quantum predictions. Experiments with entangled pairs of particles have amply confirmed these quantum predictions, thus rendering local realistic theories untenable. Maintaining realism as a fundamental concept would therefore necessitate the introduction of 'spooky' actions that defy locality. Here we show by both theory and experiment that a broad and rather reasonable class of such non-local realistic theories is incompatible with experimentally observable quantum correlations. In the experiment, we measure previously untested correlations between two entangled photons, and show that these correlations violate an inequality proposed by Leggett for non-local realistic theories. Our result suggests that giving up the concept of locality is not sufficient to be consistent with quantum experiments, unless certain intuitive features of realism are abandoned [1].

Figure 1

Alex Tsakiris: woomeister and coward

> Well, after my fractious interview at Skeptiko with Alex Tsakiris, in which he failed to get me to admit to the existence of any number of woo-ish phenomena, he got lambasted in the comments, something he's not used to from his usual gaggle of ESPers, near-death-experiencers, and quantum wowsers. What does he do when faced with an onslaught of rationalism?[1]

The charge that Tsakiris is a 'coward' is based on the claim that, according to Coyne, he closed off the online discussion too early in order to avoid the massed ranks of 'rationalists' who wanted to give him what they mistakenly consider to be the 'true' facts. When I went to the site to have a look it appeared that this was not the case, there seemed to be a reasonable length of opinion. It might be the case however, that Tsakiris reopened the discussion.

One of the first comments from a Coyne supporter is:

> One of the worst interviews I ever wasted my time listening to. It's clear the host has an agenda and is only interested in forcing everything to fit it. You had as your guest one of the most renowned evolutionary biologists in the world, and all you can do is push your own wacky pet theories about consciousness? … What a disgrace.[2]

Tsakiris, of course, was actually asking Coyne to take into account the possible implications of the quantum discoveries which have been made by Zeilinger and his team, experimental results which confirm remarkable quantum metaphysical insights about the ultimately *immaterial* nature of reality. This is a conclusion that has been increasingly inescapable since the inception of quantum physics. So it seems appropriate to consider whether Zeilinger might have been infected with the dreaded 'woo', whatever that might be. According to Wikipedia Anton Zeilinger (fig.2):

> …has held positions at the University of Innsbruck, the Technical University of Munich, the Technical University of Vienna and at the Massachusetts Institute of Technology (MIT) and distinguished visiting positions at Humboldt University in Berlin, Merton College of Oxford University and the Collège de France in Paris. Zeilinger received many awards for his scientific work, among the most recent being the King Faisal Prize (2005), and the first Newton Prize of the IOP (2007). He is a member of six Scientific Academies. Anton Zeilinger is currently Professor of Physics at the University of Vienna and Scientific Director of the Institute of Quantum Optics and Quantum Information of the Austrian Academy of Sciences. Since 2006, Zeilinger is the vice chairman of the board of trustees of the Institute of Science and Technology Austria, an ambitious project initiated by Zeilinger's proposal. … In 2005 Anton Zeilinger was among the "10 people who could change the world", elected by the British newspaper *New Statesman*. In 2010 he received the Wolf Prize in Physics. Anton Zeilinger's achievements have been most succinctly described in his citation for the Isaac Newton Medal of the Institute of Physics (UK): "For his pioneering conceptual and experimental contributions to the foundations of quantum physics, which have become the cornerstone for the rapidly-evolving field of quantum information."[3]

One would have thought, then, then Zeilinger would be safe from being infected with 'woo'! Whatever that might be.

Figure 2 – Zeilinger with some experimental apparatus.[4]

The abstract to the '*An experimental test of non-local realism*' paper begins:

> Most working scientists hold fast to the concept of 'realism'- a viewpoint according to which an external reality exists independent of observation. But quantum physics has shattered some of our cornerstone beliefs.

Already we have an extraordinary and disturbing intimation. It seems that the most precise and delicate experiments carried out at the quantum level of reality, experiments which have been carried out in different variations over and over again, indicate that *an "external reality" which is "independent of observation" does not exist!* And, furthermore, if this should turn out to be correct then it must be the case that the consciousness or consciousnesses of 'observers' are

interconnected in some way with the production of what appears to be an external reality. In fact Zeilinger has elsewhere referred, in his discussion of the importance of the work of the twentieth century physicist John Wheeler, that we must appreciate Wheeler's:

> …realisation that the implications of quantum physics are so far-reaching that they require a completely novel approach in our view of reality and in the way we see our role in the universe. This distinguishes him from many others who in one way or another tried to save pre-quantum viewpoints, particularly the obviously wrong notion of a reality independent of us.[5]

In other words we must now conclude that quantum theory, the most fundamental level of the physical investigation of the process of reality, has proved that there is no external reality which is entirely independent of consciousness. Another important and highly regarded physicist and philosopher, Bernard d'Espagnat, has indicated the situation in clear terms:

> The doctrine that the world is made up of objects whose existence is independent of human consciousness turns out to be in conflict with quantum mechanics and with facts established by experiment. [6]

The majority of significant physicists have reached similar conclusions.

The paper Tsakiris refers to concerns an experiment which sets out to test 'non-local realism', which means that it tests the notion that there are 'real' 'hidden' connections between every part of reality which are independent of mind and minds. In other words if we allow 'reality' to be such that all points of reality are instantaneously interconnected by 'real' external links we can then also assume that there is an external reality which is independent of observers. And the answer is that such an objectively 'real' external world, independent of observation, does not exist. This means accepting a thoroughly and spookily interconnected world and we must abandon "certain intuitive features of realism." One aspect of this situation is that there are no definite properties of quantum systems prior to measurement. The experiment confirms spooky instantaneous quantum non-local interconnections, which may take place over cosmic distances, and it also confirms the fact that a reality which is entirely independent of consciousness does not exist. This conclusion, as Tsakiris suggests and Coyne willfully remains ignorant of, undermines the position of metaphysical materialism that is maintained by Coyne by ignoring the evidence. How ironic it is that Coyne in his WET blog claims that it is Tsakiris who is "deeply and *willfully* ignorant."[7]

The phenomenon of quantum entanglement, which is the fact that quantum 'particles' can be interconnected as potentialities smeared out over large distances until an observation disentangles them, was first highlighted by Schrödinger who wrote that:

> Attention has recently been called to the obvious but very disconcerting fact that even though we restrict the disentangling measurements to *one* system, the representative obtained for the *other* system is by no means independent of the particular choice of observations which we select for that purpose and which by the way are *entirely* arbitrary. It is rather discomforting that the theory should allow a system to be steered or piloted into one or the other type of state at the experimenter's mercy in spite of his having no access to it.[8]

In other words when we have an 'entangled' quantum situation wherein two systems are part of the entanglement, observation of one system, which disentangles the system from its quantum state of potentiality, will instantaneously disentangle the other system, even though it may be vast distances away.

Quantum entanglement, then, occurs when two or more particles interact in a way that causes their fates to become linked. It becomes impossible to consider, or mathematically describe, each particle's condition independently of the others. They constitute a single quantum state of potentiality, which means that there are no fully existent 'particles' but only potential particles. Two entangled particles often must have opposite values for a property - for example, if one is spinning in "up" direction, the other must be spinning in the "down" direction. If someone measures one of the entangled particles and, by doing so, measures it into an 'up' state, this causes the entangled partner to become spin 'down.' Making the measurement 'here' affected the other particle 'over there' instantaneously, even if the other particle was a million miles away. And this observational effect involves a conscious decision to perform the observation.

The questions which immediately become relevant are 1) how does the distant particle 'know' its partner has been measured, and 2) how does it 'know' what attribute its partner has adopted? A crucial debate which was raised in a famous paper written by Einstein, Podolsky and Rosen, called the EPR paper, '*Can Quantum Mechanical Description of Physical Reality Be Considered Complete?*' was as to whether entangled particles could be thought of as having, or indeed *whether they did have*, on board pieces of information which determined their behaviour. This is the way that Einstien thought reality must be, it must consist, at some level, of definite entities, 'elements of reality' he called them, which are both independent of other entities and independent of the minds of the observers. As Schrödinger had pointed out with his famous cat thought experiment which he outlined to Einstein in a letter (ψ denotes the quantum mathematical wavefunction of quantum potentiality):

> Confined in a steel chamber is a Geiger counter prepared with a tiny amount of uranium, so small that in the next hour it is just as probable to expect one atomic decay as none. An amplified relay provides that the first atomic decay shatters a small bottle of prussic acid. This and – cruelly – a cat is also trapped in the steel chamber. According to the ψ-function for the total system, after an hour … the living and dead cat are smeared out in equal measures.[9]

In other words because the quantum world hovers in a state of undetermined potentialilty, when unobserved the macroscopic world should theoretically also hover in indeterminacy. It is only when a measuring 'observation' is made that the quantum 'superposition', which means a potentiality of both possibilities, of the live and dead cat can be disentangled to become one or the other. Einstein was never happy with such a view which is why he considered quantum theory to be 'incomplete.' Quantum theory, however, clearly suggested that Einstein's definite 'elements of reality', a concept sometimes referred to as 'hidden variables,' do not exist and therefore quantum entanglement is a fundamental aspect of reality. And if this turned out to be the way that unobserved reality really was it would mean that 'reality' would not fully exist but would be a kind of quantum soup of potentiality containing all possibilities, until, that is, it is 'observed.'

The influential high energy physicist John S. Bell was dissatisfied with the fact that this situation seemed to be beyond resolution and he spent some time considering a method by which the issue could be resolved one way or another. In 1964 he published a paper entitled '*On the Einstein-Podolsky-Rosen paradox*'[10] which transformed the study of the foundation of quantum mechanics. The paper showed that no "*physical theory which is realistic and also local in a specified sense can agree with all of the statistical implications of Quantum Mechanics.*"[11] This means that the implications of quantum theory contradicts a locally real world, which is a world wherein 'elements of reality' have definite properties independent of observation and there are no faster than the speed of light interconnections. From his assumptions about how a locally real world, which is a world without spooky interconnections, must function Bell proved an inequality, later called "Bell's Inequality", which is violated by the quantum mechanical predictions made from an entangled state of a composite system.

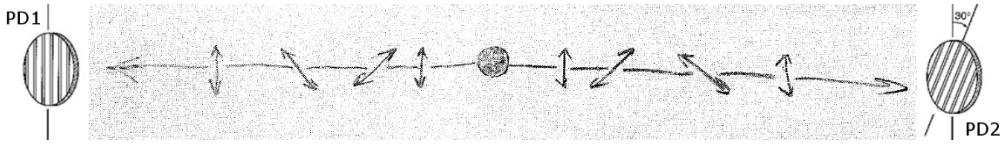


Figure 3

An inequality is a mathematical formulation which indicates that a certain sum on one side of the inequality musts be less than or equal to a certain number. Consider the case of a source emitting entangled polarized photons, one to the right the other to the left (figure 3) towards two polarization filters, PD1 and PD2. In the experiment the filters can either be set to correspond with each other of turned to an offset of 30 degrees or -30 degrees. What Bell showed was that if there were 'hidden' on board information, corresponding to Einstein's 'elements of reality', then the following inequality *must* be satisfied:

$$N(PD1= -30, PD2=30) <= N(PD1= -30, PD2= 0) + N(PD1= 0, PD2= 30)$$

Where N(X) indicates the number of photons which pass with the detectors set in the configuration X. Quantum theory (at the time it was called 'quantum mechanics') predicted that reality would fail this test, indicating that Einstein's belief in a local world of 'real' externally independent bits and pieces of reality, which were independent of the minds of observers, was false.

In his book *The Dance of the Photons* Zeilinger presents an intriguing derivation of *Bell's inequality for polarization of entangled photons* based on the notion of identical twins which are assumed to be carrying fully determinate 'genes'. In this case the 'genes' are representative of Einstein's 'elements of reality.' We consider pairs of identical human twins instead of entangled quantum 'particles.' Identical twins, of course, have 'on board' information; their features do not hover in potentiality prior to observation, so they stand in for quantum 'particles' which are considered to have definite features prior to observation. And we can derive a Bell type inequality which must be obeyed by such an 'inherently real' situation.

The three polarization measurements (0, -30, or 30) are identified with the observation of three features of the twins, their height, hair color, and eye color, and we set this up so that we use two

valued features: tall or short (we can set a height to divide our sample into two groups), blue eyes or brown eyes, blond hair or brunet hair. Because the twins are identical we know that if one of the twins is tall, blue-eyed, and brunet, we also know that the other twin will be tall, blue eyed, and brunet. From the perspective of Einstein, Podolsky, and Rosen, these three properties - height, eye color, and hair color - are 'elements of reality' that we predict with certainty for the second twin upon observation of the first twin. We also assume that the reason for these correlations is that the twins carry the same genes. These hypothetical 'genes' correspond to the 'local hidden variables' we postulate might be operational in the quantum situation.

We can now look at all the possible combinations in a large sample of these twins:

- Tall, blue-eyed, brunet
- Tall, blue-eyed, blond
- Tall, brown-eyed, brunet
- Tall, brown-eyed, blond
- Short, blue-eyed, brunet
- Short, blue-eyed, blond
- Short, brown-eyed, brunet
- Short, brown-eyed, blond

Now we can make some very simple and obvious statements about the numbers involved. For instance:

$$\left(\begin{array}{c}\text{Number of tall}\\ \text{pairs of twins}\\ \text{with blue eyes}\end{array}\right) = \left(\begin{array}{c}\text{Number of tall}\\ \text{pairs of twins}\\ \text{with blue eyes}\\ \text{and brunet hair}\end{array}\right) + \left(\begin{array}{c}\text{Number of tall}\\ \text{pairs of twins}\\ \text{with blue eyes}\\ \text{and blond hair}\end{array}\right)$$

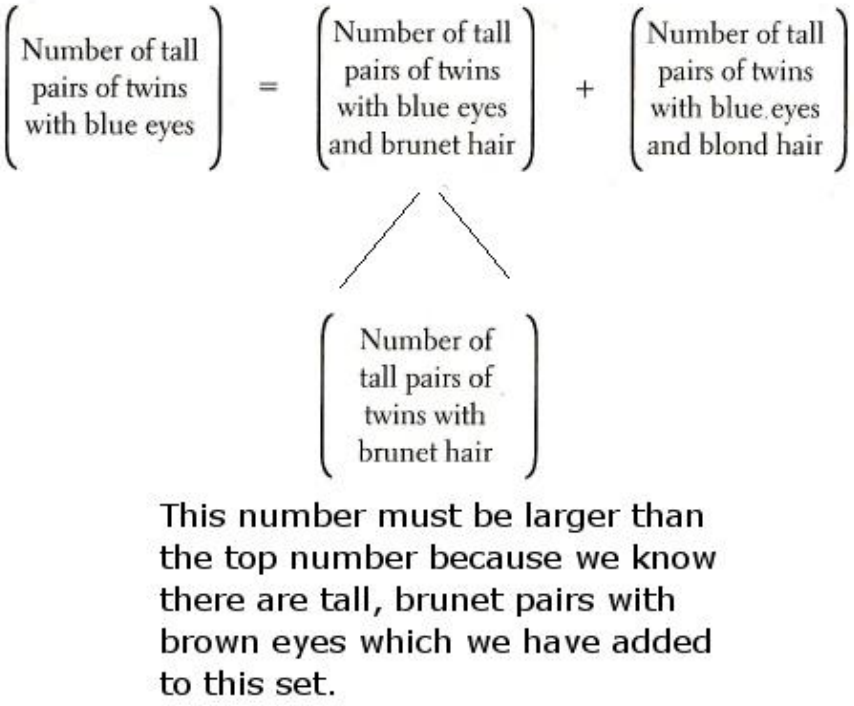
[Exp 1]

The equality (**Exp**ression **1**) should be obvious, as the hair colours blond and brunet cover all the twins there cannot be any tall, blue-eyed twins with another hair colour. From this equation we can derive the following inequality, the symbol '≤' means that the number on the left hand side is less than or equal to the number on the right hand side:

$$\left(\begin{array}{c}\text{Number of tall}\\ \text{pairs of twins}\\ \text{with blue eyes}\end{array}\right) \leq \left(\begin{array}{c}\text{Number of}\\ \text{tall pairs of}\\ \text{twins with}\\ \text{brunet hair}\end{array}\right) + \left(\begin{array}{c}\text{Number of}\\ \text{blond pairs}\\ \text{of twins with}\\ \text{blue eyes}\end{array}\right)$$

[Exp 2]

The reason that this inequality must be true is because both of the bracketed sets on the right hand side of **Exp 2** must be larger than the corresponding bracketed sets in **Exp 1**. This is because extra pairs of twins are added in. In the case of the first bracket on the right hand side pairs of twins who are tall, brunet with brown eyes are added in; and in the case of the second bracketed set on the right hand side we have added in pairs of twins with blue eyes, blond hair and are short. This is indicated in the diagram below:



Now we suppose that we can only observe one property on each twin, we can write down **Exp 2** as follows:

[Exp 3]

Why does this work? Consider the set on the left hand side. The number of pairs of twins where one is tall and the other is blue eyed must be the same as the number of tall twins with blue eyes because they are twins. If the twin of a tall twin has blue eyes then the tall twin must have blue eyes also because they are twins. The same reasoning applies to the sets on the right hand side;

so **Exp 3** is equivalent to **Exp 2** but expressed in a different form. **Exp 3** is *Bell's Inequality for Twins*.

Now the point of this inequality is that it must be satisfied by a 'Reality' which conforms to our everyday notions concerning reality, which is that 'Reality' is made up of individual, separately existing things which have their features inherently attached to them independently of observations. In fact this inequality must be passed by reality if 'genes' can be considered to be independent and self-enclosed 'elements of reality.'

Zeilinger comments upon Bell's achievement in devising this possibility for performing 'experimental metaphysics':

> How is it possible that a statement as simple as Bell's inequality might not hold in nature? The problem we have is that the considerations that led us to Bell's inequality were extremely simple. I would argue that they are so simple that the Greek philosopher Aristotle could already have derived Bell's inequality had he known that this was an interesting and nontrivial problem. We did not have to use quantum mechanics for its derivation. But Aristotle would never have expected that this could be an interesting problem. In contrast, he probably would have said that this is quite uninteresting, because nature obviously has to behave in a way so as not to violate the inequality.

As Daniel Greenberger commented, to think that nature could possibly function in a manner to violate Bell's inequality is surely "crazy".[12] This is because we are all conditioned by our dealings with our everyday world to simply believe that the apparently 'external' world and the objects within it must be independent of our minds, having absolutely no dependence on mind or minds in any way. Also the notion that every piece of the apparent 'matter' within the universe might be quantumly connected through quantum entanglement is also hard to conceive of. We tend to believe the 'classical' view of reality is the way reality really is.

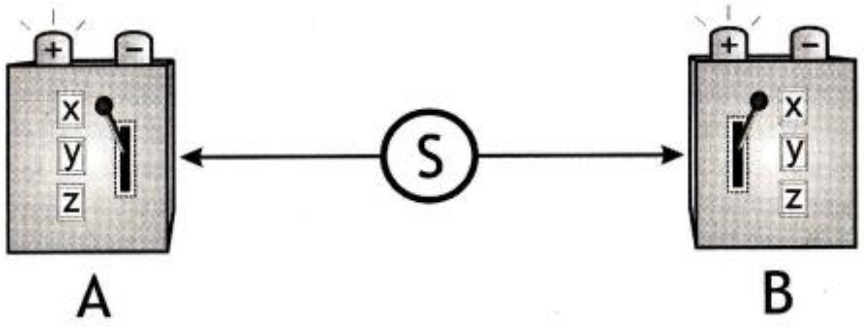
Zeilnger transform this 'twins and genes' analysis into the quantum situation and derives *Bell' inequality for pairs of entangled quantum particles*:

$$\begin{pmatrix}\text{Number of}\\ ++\text{ results with}\\ \text{apparatus A on } x\\ \text{and apparatus}\\ \text{B on } y\end{pmatrix} \leq \begin{pmatrix}\text{Number of}\\ ++\text{ results with}\\ \text{apparatus A on } x\\ \text{and apparatus}\\ \text{B on } z\end{pmatrix} + \begin{pmatrix}\text{Number of}\\ +-\text{ results with}\\ \text{apparatus A on } y\\ \text{and apparatus}\\ \text{B on } z\end{pmatrix}$$

In this version we can take: x = -30, y = 0, z = 30, '+' indicates the photon passes through the filter, '-' indicates it does not.

Bell's inequality must be satisfied for a 'locally real' 'Reality' to be functioning, which is a 'Reality' with 'real' individuated and separate 'things', or 'elements of reality,' to ultimately exist independently of observations, and independently of all other apparent 'things.' This point is crucial and needs emphasizing. In a 'classical' type world, which is the type of world Darwin

assumed he inhabited and Coyne still thinks is essentially operative, a world wherein 'matter' is the straightforward 'matter' conceived of by Newton and Descartes, a 'matter' which is entirely independent of the minds of observers, *Bell's inequality cannot be violated. Quantum theory predicts that Bell's inequality must be violated; and it turns out that in all experiments (except an early one which certainly was defective) quantum physics has been validated and Bell's theorem violated.*



Arrangement for the experimental observation of entanglement. A source S emits pairs of particles. One particle is registered by measurement station A, the other particle by measurement station B. Using a switch at each measurement station, the experimentalist can decide which kind of measurement, *x*, *y*, or *z*, is performed on the respective particles. The measurement result for each of the positions of the switches has only two possibilities, + or −.

Figure 5[13]

In his excellent book *Sneaking a Look at God's Cards*, physicist GianCarlo Ghirardi, in the final paragraph of his 'Telepathy or Cheap Trick' section, which discusses quantum entanglement and Bell's theorem, writes:

> I would like to conclude this section with a quotation from Einstein that is particularly apt for the example just discussed, and shows how lucidly he intuited (even while refusing to accept) the deepest implications of the theory, long before Bell's own analysis: "It seems hard to sneak a look at God's cards. But that He plays dice and uses 'telepathic' methods (as present quantum theory requires of Him) is something that I cannot believe for a single moment."[14]

Indeed, it seems remarkable that Einstein, who was the first to take the notion that 'Reality' at its deepest physical level was quantum in nature, when he used the idea to solve the puzzle of the photoelectric effect, and was the person, of course, who overturned notions of absolute space and time with his relativity theories, simply could not, and would not accept that independent and completely separate 'elements of reality' ultimately do not exist.

Ghirardi, however, tells us that the evidence tells us that "the photons themselves must be telepathic."[15] Experiments of extraordinary delicacy and precision have been carried out, many of them by Zeilinger and his team, to probe the phenomenon of the telepathic nature of quantum entanglement. Ghirardi describes one carried out by Alain Aspect and collaborators, who carried

out one of the first precise demonstrations of the violation of Bell's inequality, that involved a system which precluded any form of hidden message being transmitted at the speed of light and he concludes:

> Personally, I take the experiment of Aspect and his collaborators as conclusive: photons really are telepathic, or to use more scientific terminology they cannot be considered as possessing any local characteristics that determine whether or not they will pass the test before the test is carried out. Nevertheless, they still react the same way for the same test.[16]

In other words they are instantaneously interconnected at the deep quantum level of reality. And this kind of deep interconnection applies to all kind of 'particles'. Zeilinger concludes that:

> Quantum particles do not behave like identical twins. Even though they always show the same results when they are measured for the same property, we are not allowed to explain this by saying that they carried that property before and independently of observations.[17]

Note the clear indication that the properties which are finally manifested are *not independent of observation*. The properties that the apparent particles adopt are in some way measured into existence by observation. This situation clearly indicates the fact that consciousness is in some way interconnected with the quantum realm.

In their excellent book *Quantum Enigma: Physics Encounters Consciousness* Bruce Rosenblum and Fred Kuttner give a summary of the implications of the Bell violation:

> Bell's theorem in a nutshell: Suppose our world to have physical real properties that are *not* created by their observation. Further, suppose that objects can be separated from each other so that what happens to one cannot affect the other. (For short, we call these two suppositions "reality" and "separability") From *only* these two premises – both assumed in classical physics but denied by quantum theory – Bell deduced that certain observable quantities could not be larger than certain other observable quantities. This *experimentally testable* conclusion of Bell's theorem, which *must* be true in any world with reality and separability, is Bell's inequality. If Bell's theorem is shown to be false in *any* situation, one or both of the premises leading to it (reality and separability) *must* be false. … In what we will call a "reasonable" world, objects have physically real properties (not merely properties created by their observation). Moreover, in such a reasonable world, objects are separable. That is they affect each other only by physical forces, which cannot travel faster than the speed of light (not by "spooky actions" traveling infinitely fast). The Newtonian world described by classical physics is, in a sense, a reasonable one. The world described by quantum physics is *not*. Bell's theorem allows us to test to see whether perhaps it's just quantum theory's *description* of our world that's unreasonable, and that our actual world is in fact a reasonable one. … When the experiments were done, Bell's inequality was violated. … Our world therefore does *not* have both reality and separability. It's, in this sense, an "unreasonable" world.[18]

This means that the ultimate quantum nature of the 'stuff' of reality, what Zurek calls "dream-stuff", is not Newtonian 'classical' type stuff. The term "unreasonable," however, is slightly misleading, the quantum world is only "unreasonable" for someone, like Coyne, who expects the

world to be comprised of tiny billiard balls. Coyne wants to brush all this "unreasonableness" aside and pretend that he can carry on as if living in Darwin's 'classical' times. He says:

> It's as if you're saying we can't play billiards and we can't shoot rockets to the moon because of this stuff that happens on a micro level. The fact is that assuming that these phenomena apply on most of the levels of reality that we deal with renders everything wrong is simply incorrect. For most macro phenomenon, Newtonian or classical mechanics works fine. For most micro-phenomenon you're turning to quantum mechanics. It works fine. And in terms of evolution I don't see how this quantum mechanics affects evolution at all.[19]

And this is an extraordinary and ignorant statement because we are discussing biology at the micro level of genes and DNA, not moon-shots. Photosynthesis, a central mechanism for the maintenance of life, is now known to operate by a quantum 'look-ahead' mechanism. And this mechanism, described by Feynman's sum over histories approach to quantum phenomena, is fundamental to the quantum world. As physicist Neil Turok, Director of the Perimeter Institute for Theoretical Physics, has pointed out:

> According to quantum theory, the world is constantly exploring all of its possible classical states all of the time, and is only appearing to us as any one of them with some probability.[20]

It would be remarkable if this fundamental quantum mechanism was not an aspect of the process of evolution.

It is at this point that it is important to be clear that the nature of this interconnection is an issue of controversy. This is why Coyne is able to claim that the notion that consciousness is in some way involved at the quantum level is 'controversial'. But this just indicates his ignorance. The fact that the disentanglement of properties depends *in some way* upon observation is not controversial, which is why Zeilinger writes that the breakdown of local realism means:

> …the property of a particle observed in a specific experiment is not an element of physical reality before the measurement is performed. In the end this means that the reality depends upon the decision of the observer… [21]

And yet at the same time a few pages earlier Zeilinger also says that:

> It is dangerous – and not supported by the physics of the quantum measurement process – to claim, as is sometimes claimed, that it is the mind of the observer that influences the quantum state.[22]

One can only conclude that even Zeilinger is confused as to the *actual nature of the dependence* of the manifestation of quantum properties on the decisions of observers. As has been pointed out earlier Zeilinger elsewhere has clearly indicated that the 'classical' notion that the material world is independent of observers is "obviously wrong." The above quote, however, would suggest that Zeilinger does not want to suggest that the mind of an individual observer can directly affect quantum reality, and therefore reality in general. Or, perhaps Zeilinger is worried about sticking his neck out too far on the issue of the interconnectedness of consciousness and the quantum realm. The problem is indicated by Wojciech Zurek, instigator of the 'quantum Darwinism' paradigm, as follows:

> …while the ultimate evidence for the choice of one alternative resides in our illusive "consciousness," there is every indication that the choice occurs much before consciousness gets involved and that, once made, the choice is irrevocable.[23]

In other words the ultimate evidence of quantum experimentation and theory indicates that consciousness is clearly implicated in the choices of which potentialities emerge from the quantum realm. And yet the mechanism through which this occurs is such that as time goes by these choices become solidified in a manner such that the functioning of the apparently external material world *appears to be independent*.

Zurek's 'quantum Darwinism' paradigm provides an insight into how this happens. According to Zurek the ultimate 'stuff' of reality is 'quantum dream-stuff' which 'epiontically' created the appearance of the external world and its inhabitants. The term 'epiontic' indicates that perception creates ontology. This reiterates the quantum fact stated by Zeilinger that the external world is not independent of observations. Wheeler stated also stated this quantum fact:

> Directly opposite to the concept of universe as machine built on law is the vision of *a world self-synthesized.* On this view, the notes struck out on a piano by the observer participants of all times and all places, bits though they are in and by themselves, constitute the great wide world of space and time and things.[24]

In other words it is the internal 'epiontic' observing processes of the collective consciousness of the sentient beings within the universe that 'chooses', to use a word used by Hawking and Mlodinow, which potentialities to unfold.

Prior to the evolution of such observers the universe itself is clearly epiontically creating the conditions and paving the way for the emergence of such high level observers. The mechanism which underlies this process is the quantum amplificatory Zeno effect, which is the implied quantum fact that the more often a particular quantum state is observed, or 'registered' to be a particular way the more likely it is to be observed in the same way in the future. Zurek describes his view as follows:

> The main idea of quantum Darwinism is that we almost never do any direct measurement on anything … the environment acts as a witness, or as a communication channel. … It is like a big advertising billboard, which floats multiple copies of the information about our universe all over the place.[25]

But what he does not seem to home in on is the amplificatory aspect. The quantum advertising campaign for the classical world get more solidified the more it is 'bought into.'

The 'Quantum Amplificatory Zeno Effect' is an extension of the accepted quantum Zeno effect. An amplificatory mechanism of this sort must be operational at the dream quantum level in order to account for the emergence of Zurek's 'preferred states' from the potentiality of the quantum field. In his discussion of the "axioms that provide a textbook summary of quantum foundations" Zurek lists them as follows:

1) The state of a quantum system is represented by a vector in its Hilbert space.
2) The evolution of the vector is unitary as generated by the Schrödinger equation.
3) Immediate repetition of a measurement yields the same result.

4) The measurement outcome is one of the orthonormal states – eigenstates of the measured observable.

As Zurek points out, it is the incompatibility of the first two with the second two which constitutes the "measurement problem" - how is it that the many quantum alternatives 'collapse', apparently in interaction with consciousness, into one actuality. Zurek considers that he has at least partially solved this problem with the notion of einselection (environment induced superselection):

> …einselection is caused by the transfer of information about selected observables. Hence, the ontological features of the state vectors - objective existence of the einselected states - is acquired through the epistemological "information transfer".[26]

It is this 'objective' information transfer' which Zurek suggests takes place independently of observing consciousnesses. This seems to be the case.

However, this does not rid the universe of some deeper level of consciousness which epiontically produces the preferred states which are imprinted into the quantum "advertising billboard" which is responsible for doing the 'einselecting.' It is this deeper level of non-individualized consciousness which eventually becomes embodied to various degrees in sentient beings. It is no surprise therefore that the manner in which the consciousnesses of human beings appear to interact with the quantum level of potentiality within quantum experiments at the micro level gives a clue to the way in which the "advertising billboard" of the quantum matrix of the 'classical' world came into being. The clue to this mechanism lies in the third quantum axiom, which is the quantum fact that immediate repetition of a measurement yields the same result. This is called the quantum Zeno effect. Given a superposition expressed in some basis:

$$|\Psi> = P_1|b_1> \text{ x } P_2|b_2> \text{ x } P_3|b_3> \ldots \text{ x } P_n|b_n> \ldots$$

When a measurement is performed this will 'collapse' into one of the eigenstates and all the other possibilities disappear. At the exact moment of collapse the state will be:

$$|\Psi> = P_x|b_x> \quad \text{where } P_x = 1 \text{ and } |b_x> \text{ is the resulting eigenstate.}$$

As time progresses this state will smear out into a spread of possibilities but if measured again immediately the same result will be obtained precisely because the probability is one. Thus quickly repeated measurements can pin a quantum state into ontological stability. If, additionally, there is an amplificatory aspect then ontology would be solidified as time progressed.

There is also an inverse Zeno effect which was originally proposed by Aharonov and Vardi who showed that, by performing a dense sequence of measurements along a presumed path, a quantum system can be forced to follow an arbitrarily chosen path. Johnjoe Mcfadden has proposed that the inverse quantum effect may be a crucial factor in the evolutionary process:

> Both the quantum Zeno effect and the inverse Zeno effect are really aspects of the same phenomenon: the ability of quantum measurement to interact with, and *shape* the dynamics of a system. The special relationship between quantum objects and quantum measuring devices draws out classical reality from the quantum world. … measurement of a quantum system *draws out* from the quantum superposition of all possible states, a

> single reality for the physical world. As Niels Bohr said, '*one must never forget that in the drama of existence we are ourselves both actors and spectators*'. [27]

This is consistent with Hawking and Mlodinow's participatory account of the way the universe evolves:

> In this view, the universe appeared spontaneously, starting off in every possible way. Most of these correspond to other universes …. Some people make a great mystery of this idea, sometimes called the multiverse concept, but these are just different expressions of the Feynman sum over histories. … The histories that contribute to the Feynman sum don't have an independent existence, but depend on what is being measured. We create history by our observations, rather than history creating us.[28]

The actual spread of probabilities must change over time in an excruciatingly slow evolution of potentialities over vast time periods. There is no other way to account for the evolution of the universe. Repeated 'registrations', 'interactions', correlations' 'observations' within quantum dream stuff must make the potentiality for the same quantum possibility increase to an unimaginably tiny extent, and over vast time periods this mechanism builds up the quantum "advertising billboard" of classical reality. In this way the apparent solidity and immutability of the 'external' and 'material' world, as well as the beings inhabiting this world, is built up over time.

In his final section 'What Could That Mean?" of his book *Dance of the Photons* Zeilinger further investigates what he considers to be the implications of the quantum violation of Bell's inequality. He begins by asserting that at least one of the assumptions about "Reality" which were used to derive Bell's inequality must be wrong. These assumptions he lists as follows:

1) **Realism**: This is the idea that an experimental result reflects in some way the 'inherent' features of the particles that we measure.
2) **Locality hypothesis**: the assumption that the real physical situation of the measurement at apparatus B including particle b must be independent of the kind of measurement done at the same time to the distant particle a using measurement apparatus A.
3) **Counterfactual nature of reality**: Zeilinger writes: "There is a third assumption, which we used implicitly but did not express in detail. It is the assumption that it makes sense to consider what kind of experimental result would have been obtained if one had measured a different property than the one that was actually measured. For the case of twins the assumption means that it makes sense to assume that, for example, blue-eyed blond twins must be either tall or short, even if we do not check their height."

Zeilinger then writes that:

> We now discuss some of the possible conceptual consequences of the breakdown of local realism. One possibility is that the reality assumption is not correct. This would mean in principle that the property of a particle observed in a specific experiment is not an element of physical reality before the measurement is performed. In the end, this means that reality depends on the decision of the observer - of the experimentalist - about which measurement to perform. The breakdown of realism would mean that the measured result does not reflect any kind of property that existed before and independently of observation.

> Another possibility would be that the locality hypothesis is not correct. Such a breakdown of locality could, for example, mean that something is wrong with our picture of space and time. A quantum system that consists of two or more entangled particles remains an unseparated entity regardless of how far the individual components of the system are separated from each other.
>
> A breakdown of the third assumption would mean that one is only allowed to talk about the properties of systems when these properties are indeed measured. Expressed very simply, the question "What if?" would be illegal. This would certainly contradict our everyday experience. We always consider different possible alternatives, and we base decisions on the possible consequences of these alternatives. For example, to know what will happen if we cross a superhighway during rush hour with our eyes closed, it is not really necessary for us to perform that experiment.
>
> At present, there is no agreement in the scientific community as to what the philosophical consequences of the violation of Bell's inequality really are. And there is even less agreement about what position one has to assume now. Nearly all physicists agree that the experiments have shown that local realism is an untenable position. The viewpoint of most physicists is that the violation of Bell's inequality shows us that quantum mechanics is nonlocal. This nonlocality is exactly what Albert Einstein called "spooky"; it seems eerie that the act of measuring one particle could instantly influence the other one.
>
> The other possibility would be for us to give up the picture of a world that exists in all its properties independent of us. That would mean that we have a very essential influence on reality just by deciding which measurement to perform. There are indeed hints that this might be the message we have to accept.[29]

In the above quote Zeilinger says that there "is no agreement in the scientific community as to what the philosophical consequences of the violation of Bell's inequality really are." The reason for this seems to be that there is a general desire to minimize as much as possible any 'mystical' implications. When one investigates the evidence of quantum theory and the metaphysical debates surrounding it, it is impossible not to notice that there is a tendency to try and produce what Henry Stapp calls 'conservative' accounts as a matter of principle. Coherent 'conservative' accounts, however, are difficult to come by, which is why Zeilinger indicates that we may need to accept the message that "we have a very essential influence on reality just by deciding which measurement to perform."

The violation of Bell's theorem, which has been experimentally verified over and over again with astonishing degrees of precision, indicates that the realm of what was once thought be independent 'matter' and the realm of mind are not separate but interpenetrate in a nonlocal quantum field of potentiality.

One implication of Bell's theorem is the correctness of quantum field theory as the most fundamental *physical and metaphysical* account of 'Reality'. As the physicist and philosopher Bernard d'Espagnat, who has pondered, investigated and written about these issues over a long period, writes:

> …what, from a philosophical standpoint, is by far the most remarkable feature of quantum field theory is that it reduces the (scientifically unmanageable) notion

> "creation" [of particles] to the (scientifically tractable) notion "state change." And the point that is relevant to the here considered issue is that it succeeds in doing so by making primary some concepts of a general nature - such as fields associated with types of particles - and secondary the concept of individualized particles. Consequently, if we are on the lookout for some concept, or "mathematical algorithm," that this theory could be identified as referring to the "basic stuff," we can find none except, conceivably, the element the state of which changes when a particle gets "created" or "annihilated". … Now, in the theory, there are not myriads and myriads of such elements. Indeed there is just one! Which means that, conceptually speaking, the theory is as far from atomism as it is conceivably possible for a theory to be.[30]

It would seem that the most obvious conclusion is precisely that which is indicated by quantum field theory conjoined with the obvious conclusion that the ultimate quantum field must have mind-like qualitative features; otherwise none of us would have minds. In other words the fundamental 'stuff' of reality is a vast non-local quantum field of potentiality which has an internal qualitative aspect of non-individuated consciousness, awareness or cognizance. Not only is this conclusion "as far from atomism as it is conceivably possible for a theory to be" it is also completely inconsistent with any kind of crude metaphysical materialism adopted by Coyne with his "Yeah - those are solid things" approach.

The above outline is an unbiased and correct account of the current evidence according to quantum theory, which is the most fundamental and precise account of the ultimate nature of the 'physical' world currently available to us. However, the comments made by Coyne supporters on Tsakiris' website[31] would seem to indicate that they, like Coyne himself, do not bother to familiarize themselves with the evidence before dashing to defend crude materialist views. The following are a selection of comments (which I comment on):

> One of the worst interviews I ever wasted my time listening to. It's clear the host has an agenda and is only interested in forcing everything to fit it. You had as your guest one of the most renowned evolutionary biologists in the world, and all you can do is push your own wacky pet theories about consciousness?

The ideas that Tsakiris is trying to make Coyne consider as significant for his own field of investigation are not Tsakiris' "wacky pet theories about consciousness", they are notions suggested by the quantum evidence and considered as very real implications by many physicists. In fact some of the early founding fathers of quantum mechanics came to such conclusions. According to Schrödinger, for instance:

> Mind has erected the objective outside world … out of its own stuff.[32]

And Max Planck came to a similar conclusion:

> All matter originates and exists only by virtue of a force... We must assume behind this force the existence of a conscious and intelligent Mind. This Mind is the matrix of all matter.[33]

More recently quantum cosmologist Andre Linde has suggested:

> Is it possible that consciousness, like spacetime, has its own intrinsic degrees of freedom, and that neglecting these will lead to a description of the universe that is

> fundamentally incomplete? What if our perception is as real as (or maybe in a certain sense, are even more real than) material objects?[34]

But committed MUDs simply dismiss such views by calling it "wacky" or full of "woo":

> The idea that quantum effects change any previous observation of non quantum processes is just nonsense. It is the stuff of woo and charlatanism, not science.

Such assertions, however, are just not true. It is becoming clear now that quantum processes are found in situations where previously it was, dogmatically, asserted they were impossible. Research on the internet will uncover articles in scientific journals announcing such discoveries as the possibility that "quantum entanglement that holds our DNA together"[35] and "Nobel Prize for medicine in 2008, Luc Montagnier, is claiming that DNA can send 'electromagnetic imprints' of itself into distant cells and fluids which can then be used by enzymes to create copies of the original DNA"[36], and "DNA Can Discern Between Two Quantum States, Research Shows"[37], and:

> Who said only plants are capable of photosynthesis? A study shows that an insect is also able to convert energy from sunlight, carbon dioxide and water into food. The study, entitled "Light-induced electron transfer and ATP synthesis in a carotene synthesizing insect", published on August 16, shows that the pea aphid (Acyrthosiphon pisum) can absorb energy from the sun and transfer it to a type of "cellular machinery" involved in energy production.[38]

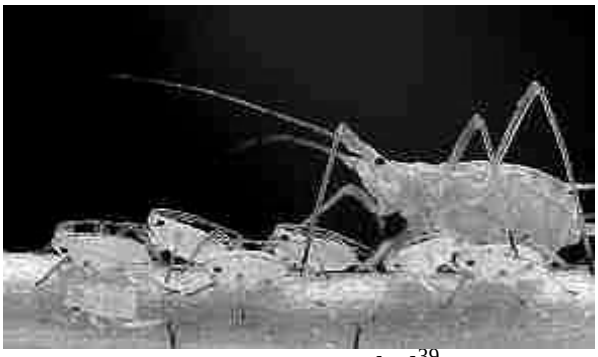


Figure 5 - Pea aphid[39]

The extent to which quantum effects operate in biological mechanisms is a matter (or non-matter) for scientific investigation, not dogmatic abuse. In MUD forums, however, dogmatic abuse to a large extent rules the day:

> This was very frustrating. The host has a profound misunderstanding of evolution, neurobiology and physics. Then he tries to mush them all together to create an alternative reality with absolutely no evidence to back it up (and no, quoting papers you don't understand doesn't count as evidence). I don't know his background, but he surely appears completely deluded by his desire and perception that the "materialistic worldview is about to be overturned", whatever that means. He should never interview a scientist again. Just bring people like Deepak Chopra and have some fun in woo woo land.

Although, as we have seen, there is serious and compelling scientific evidence that crude materialism cannot be true, those stuck in the MUD worldview, without looking into the details of the evidence, assert that the notion that materialism has been undermined is nothing more than a 'belief system':

> After listening to a number of episodes of Skeptico it is obvious to me that far from being an objective and dispassionate examination of the subjects examined, it is in fact a vehicle for propaganda in the service of your belief system. But you have stooped to new depths in claiming that quantum non-locality defeats materialism

How does this claim match up with the facts described above, and the further fact that the most fundamental level of reality, the quantum field, is "insubstantial?"[40]

Here is another attempted MUD defense:

> The quoted extract from the abstract appears to me to give the wrong impression out of its context. But don't take my word for it read the complete abstract is here… Scopus lists 90 articles citing this article and there are probably many others. No doubt Alex, using his extensive knowledge of the literature of quantum theory, will be able to inform us precisely which ones cite it as "the final nail in the coffin of Materialism."

Again we find what seems to be either an inability to appreciate, or a wilful avoidance of, the obvious implications of assertions clearly made in the cited paper. Here is a relevant passage from the abstract of the cited paper:

> Most working scientists hold fast to the concept of 'realism' - according to which an external reality exists independent of observation. But quantum physics has shattered some of our cornerstone beliefs. According to Bell's theorem, any theory that is based on the joint assumption of realism and locality (meaning that local events cannot be affected by actions in space-like separated regions) is at variance with certain quantum predictions.[41]

To make the point more pointedly one might rewrite this for Coyne and his infatuated MUD fans:

> Working scientists such as evolutionary biologists, Jerry Coyne being a case in point, hold fast to the concept of 'realism' - according to which an external reality exists independent of observation …

And, it should be apparent to anyone with moderate intelligence that the kind of materialism embraced by Coyne does not include a type of 'matter' which is *dependent upon observation*!

The fact is that the demonstration of the violation of Bell's inequality does undermine crude materialism. But the contributors to MUD blogs never look into the evidence and arguments in the detail required to appreciate the facts. One might make a case that perhaps Tsakiris was not as acute and incisive in his approach as he might have been, but this is a different issue. However, Tsakiris' suggestion that quantum discoveries must have implications for our understanding of the process of evolution is entirely reasonable.

In his introductory essay, *A Quantum Origin of Life?*, for the collection of exploratory essays, *Quantum Aspects of Life*, physicist Paul Davies suggests there are three possible configurations of the relationship between the classical level and the quantum level in the evolutionary process:

1) Quantum mechanics played a key role in the emergence of life but then became subsidiary to classical processes.

2) Life began classically and then somehow evolved a few quantum mechanisms to enhance efficiency.

3) Life started out as a classically complex system, but later evolved towards "the quantum edge."[42]

But the notion that life started out classically and then discovered some quantum tricks is absurd. According to Hawking and Mlodinow "we are the result of quantum fluctuations in the early universe" so the entire process of the evolution of the universe and life had its origin in the quantum realm. In the light of this, and the fact that one of the most significant processes for life – photosynthesis – uses a fundamental quantum process, the notion that life had to hang around for the classical world to solidify and then later rediscovered the greater efficiency of quantum processes is ridiculous.

Furthermore, given the fact that quantum theory *does* undermine crude materialism, as the violation of Bell's theorem indicates, there is every reason to suppose that quantum effects might be important in life processes, including evolution. According to the geneticist Steve Jones:

> DNA speaks a digital rather than analogue language and inheritance is based … on particles – genes – that can be recovered unchanged at any time.[43]

However, as Tsakiris pointed out to Coyne, particles can also be quantum waves and quantum effects have now been found to be significant in 'particles' at the molecular level of genes. Overall, then, there is good reason to suppose that quantum effects *may* be significant in the process of evolution. But such issues are brushed aside as a matter of dogmatic belief by Coyne and his supporters as irrelevant. Here is another defender of Coyne's materialist MUD worldview:

> Alex Tsakiris: It's the observer effect, Jerry. It's the double-slit experiment. It's our…
> Dr. Jerry Coyne: Yeah, okay, what does that have to do with…
> Alex Tsakiris: Are photons waves or particles, right? So it's like…
> Dr. Jerry Coyne: What does that have to do with evolution?
> Alex Tsakiris: It has to do with evolution because what we find is that it's consciousness.
> If we put our consciousness one way or another it measures this way or that way.
> What a lousy interviewer. … making up references about quantum effects on evolution …

Here our doughty MUD, starting out with an advance barrage of attempted satire and then taking his or her (almost certainly a 'he') lead from Coyne's performance, deploys a ridiculous avoidance tactic. Because the paper cited by Tsakiris does not *explicitly* state that quantum discoveries have implications for evolution theory, Coyne and his followers claim that Tsakiris is "making it up." But this claim is absurd. The discovery that reality is not as 'real' as classical physics treated it as being, clearly has undermining implications for the materialist worldview.

And classical physics was the kind of physics extant in Darwin's time, Darwin lived in a mistaken 'classical' scientific worldview and Darwinism is a 'classical' theory. As we have seen, there is good reason to think that the violation of Bell's theorem means that entirely isolated self–enclosed information cannot be carried by independent gene units. It also implies, because of being dependent upon observation, that all matter is entangled with consciousness. This is why quantum decoherence theorist Wojciech Zurek has clearly said with regard to the 'choice' of quantum alternatives that:

> …the ultimate evidence for the choice of one alternative resides in our illusive "consciousness"[44]

And Roger Penrose tells us that with regard to the quantum 'collapse of the wavefunction':

> …at the large end of things, the place where 'the buck stops' is provided by our *conscious perceptions*. …[45]

None of this subtlety, however, has any interest for the defenders and proponents of MUD:

> If anybody wonders who has the agenda here, this should make it obvious. Care to show us that quote in the Nature paper, Alex? Nonlocality is deep and profound, but it has nothing to do with evolution. And almost surely has nothing to do with consciousness either.

Such assertions would seem to indicate a deep and impressive commitment to the cause of ignorance.

Here is another misguided MUD comment:

> So how have you managed to persuade yourself that consciousness might quite feasibly pre date life? Surely consciousness is not a 'thing' that can (say) move around, but a property of (conscious) things such as brains. So just as a lamp (when switched off) does not become a lamp plus `brightness` which then floats away, so too does a brain, when unconscious, become an (unconscious) brain, not a brain and some free floating consciousness! If you do not believe that consciousness is a property of the brain but is somehow separate from it and irreducible (a la Descartes), then how do you account for periods of unconsciousness, such as when in non-dream sleep or under anaesthesia? Why on your woo model are you not still fully conscious, though temporarily unable to control your brain? If you think that consciousness might pre date life, then what exactly was conscious back then?

But it is not the case that the new perspective required by the quantum evidence requires that we think, "a la Descartes" that consciousness and matter are separate aspects of the process of reality, with consciousness being some kind of immaterial "free floating" field of awareness. It is vital to be aware that Descartes and the other pre-quantum Western philosophers did not have access to full knowledge of the nature of the 'physical' world. For them the quantum level was entirely hidden and therefore they essentially considered that the apparently 'material' world actually is as it appears - solidly extended immutable 'stuff' with no subtle internal structure. Even Max Planck, the instigator of quantum theory, at the beginning of his career thought that matter was internally continuous with no atomic structure[46]. From this perspective the apparent ontological aspects of 'matter' and 'mind' seem absolutely irreconcilable. The quantum revolution changes this situation dramatically for, as Stapp points out, we now know that:

> We live in an *idealike* world, not a matterlike world.' The material aspects are exhausted in certain mathematical properties, and these mathematical features can be understood just as well (and in fact better) as characteristics of an evolving idealike structure. There is, in fact, in the quantum universe no natural place for matter. This conclusion, curiously, is the exact reverse of the circumstances that in the classical physical universe there was no natural place for mind.[47]

In the new paradigm of the 'quantum universe' the apparent independent solidity of matter, which is an illusion (matter is 99.9999999999999% empty space!), is a solidification of quantum 'dream-stuff' which is a kind of infinite energetic potentiality. Furthermore Stapp indicates that this energy field is "idealike" and immaterial, a view which is shared by many significant physicists.

Certainly we know that the quantum fields which underlie the manifestation of the material world are insubstantial and immaterial. The evidence also suggests that they must also have a potentiality to produce consciousness and cognition within organic organisms. This further means that at the quantum field level there has to be vast potentiality and potential awareness. This is why Planck, at the end of his career, said:

> I regard consciousness as fundamental. I regard matter as derivative from consciousness.[48]

This does not mean, however, that Planck thought that the quantum field is conscious in the same qualitative way that human beings are conscious, plotting and designing sentient beings in order to get a foothold in the material world so to speak. The immaterial ground quantum field of the process of reality is most appropriately conceived of as a vast 'ocean' of energetic potentiality that has an internal quality of the potential awareness of consciousness. The physicist David Bohm described this as the holomovement within an 'implicate order':

> I propose something like this: Imagine an infinite sea of energy filling empty space, with waves moving around in there, occasionally coming together and producing an intense pulse. Let's say one particular pulse comes together and expands, creating our universe of space-time and matter. But there could well be other such pulses. To us, that pulse looks like a big bang; in a greater context, it's a little ripple. Everything emerges by unfoldment from the holomovement, then enfolds back into the implicate order. I call the enfolding process "implicating," and the unfolding "explicating." The implicate and explicate together are a flowing, undivided wholeness. Every part of the universe is related to every other part but in different degrees.[49]

And for Bohm, as for Planck, Schrödinger, Heisenberg and other physicists, consciousness, or potential consciousness, is an innate and inseparable aspect of this immaterial realm which underlies the apparently material realm. Furthermore, as Bohm states, "every part of the universe is related to every other part but in different degrees;" this interconnection accounts for a deep level of the evolutionary interrelationships between creatures and environments. Because of the deeply connected nature of the quantum field there must be a quantum informational interconnection between environments and the creatures within them.

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