

Article

Deus ex Machina & the Conscious Cosmos

Chris King^{*}

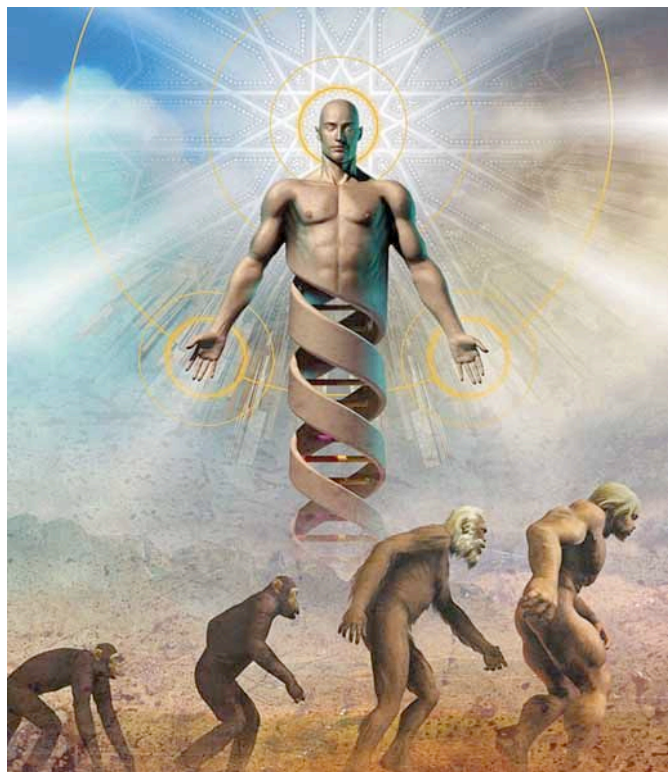
ABSTRACT

It is proposed in this article that the ultimate answer to the “deus ex machina” paradox is neither invoking God in the machine nor humanity as a molecular automaton, but consciousness as a space-time spanning property of the cosmos. This implies that we are playing a pivotal and in its essence a cosmological role through our subjective consciousness in bringing about a cognizant universe aware of its own existence and imbued with a sense of purpose expressed in and through our free-will and sense of compassion for the unfolding nature of conscious existence amid the mortal toil of biological sexuality. In discovering this change of perspective lies our redemption through taking full responsibility for our actions participating in a deepening understanding of this extraordinary universe, in which we as sentient beings are the conscious progenitors of its becoming.

Key Words: conscious cosmos, deus ex machina, God, free will, sentient being.

The concept of “god in the machine” evokes all the paradoxes of nature and existence, from religious creationism to mechanistic atheism. We shall use this evocative notion to escape from the contradictions of current world views and to discover the roots of our transformative consciousness.

Right: Artist’s impression of human transcendence through the evolution of nucleic acids (Cover from Lichtenberger 1912, 4shared.com).



Tragic Roots of a Great Notion

The term “deus ex machina” has an intriguing and paradoxical history, not from God transcending the flawed mechanism ascribed to nature, but the creative process of poetry and theatre. The Latin term goes back to the Greek ἀπὸ μηχανῆς θεός (apò mēkhanēs theós),

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meaning "god from the machine". It harks back to Dionysian theatre, where the deities were literally portrayed in theatre using machines, such as mobile cranes, to enable the supernatural figures to ascend from the depths, or fly into the heavens on stage.

More generally *deus ex machina* is conceived of as a plot device whereby a seemingly unsolvable problem is suddenly and abruptly resolved by the contrived and unexpected intervention of some new event, character, ability or object –a ‘supernatural’ intervention – intended to move the story forward when the writer has "painted themselves into a corner" and sees no other way out.



Euripides' *Medea*, performed in 2009 in Syracuse, Italy (Wikipedia).

Opinions about this device run right across the spectrum. More than half of Euripides' tragedies employ a *deus ex machina* in their resolution. In *Medea*, a dragon-drawn chariot sent by the sun god, is used to convey his granddaughter Medea, who has just committed murder and infanticide, away from her husband Jason to the safety of Athens.

However Aristotle criticized the device in "Poetics", where he argued that the resolution of a plot must arise internally, from previous action of the play: "For we grant that the gods can see everything. There should be nothing improbable in the incidents; otherwise, it should be outside the tragedy". However, he praised Euripides for generally ending his plays with bad fortune, consistent with tragedy, and suggested "astonishment" should be sought: "since it is probable

that improbable things will happen".

The Greeks could think this way because, although they saw their deities as omniscient, they were polytheists who felt free to enact the lives of their gods and goddesses creatively in tragedy and comedy. They could thus appreciate the boundaries of legitimate use of the device, unlike monotheists who adopt more inflexible positions.

Horace in his *Ars Poetica*, vv. 191-92, instructs poets that they should never resort to a "god from the machine" to resolve their plots "unless a difficulty worthy a god's unravelling should happen."

This criticism is particularly cogent in regard to creationism, where to accede to a mythological six day sabbatical account in Genesis, God is forced to come to the rescue of fundamentalist religious belief, when all the scientific evidence, from the geochemical record, through fossils to genetic sequences attests to evolutionary diversification.



Two views of the Sabbatical Creation of Genesis (thepersonalistproject.org and author's photo of a greeting card)

Intelligent Design: God Forced to Rescue His Tragically Flawed Machine

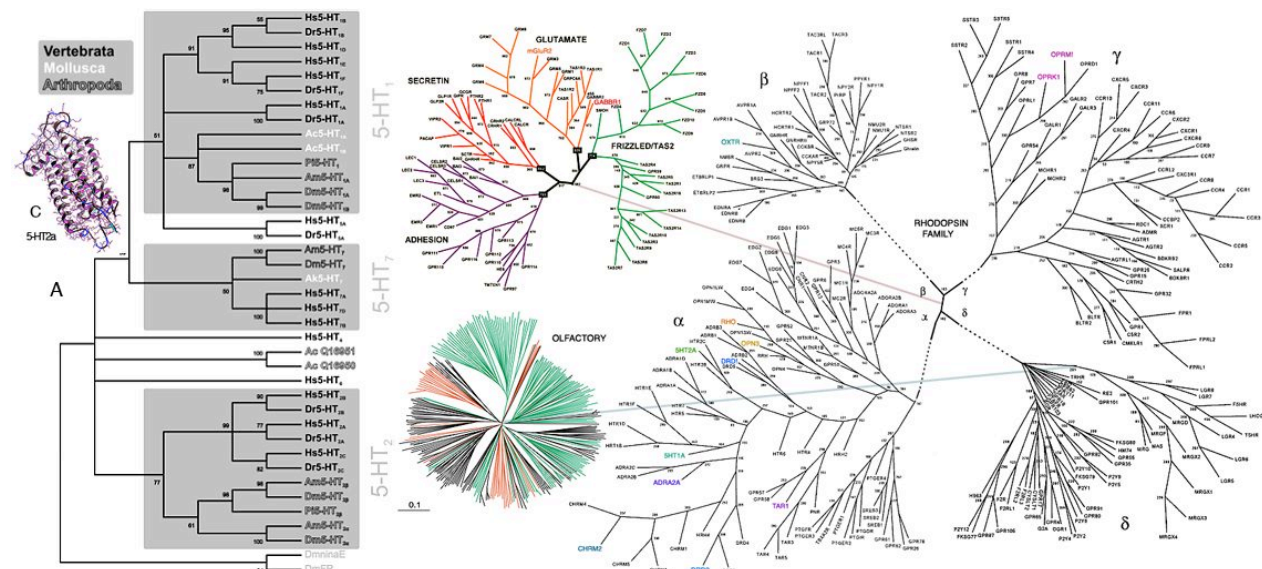
The sabbatical creation is an utterly beautiful mythological creation account. Just like the seven layers of heaven and hell of the ancients from Sumeria to Babylon, the creation takes place in seven days – the week, which quarters the 28 day cycle of human menses, slightly shorter than the 29.53 day lunar cycle, just as our circadian cycle tends to be a little longer than the earth day, but again close enough to form a resonance.

This creation, leading ultimately to woman and man in the likeness of the dyadic 'Elohim, follows an order which makes sense only in a flat Earth cosmos where the Sun, Moon and stars are merely secondary fixtures on a great firmament or 'dome' like the lid on a dinner tray.

Consequently the creation is all out of natural and cosmological order. It begins with Earth *tohu va vohu* – 'without form or void' – until the spirit of 'Elohim moves on the face of the waters. By the end of the first day we have light separated from darkness. On day two 'Elohim put a firmament in place to divide the waters and call it heaven. The third day the land and waters are divided and the earth brought forth grass, and herb yielding seed after his kind, and the tree yielding fruit, whose seed was in itself. At this point we have light and darkness, heaven, and all the plants which are even fruiting, but no Sun, Moon or stars. It doesn't take denial of evolution to see from the most basic energetics that this cosmic machine is never going to fly! Only on the fourth day do the 'Elohim belatedly realize to put the Sun Moon and stars in the heavens. Where the first light came from before is anyone's guess – the big bang possibly?

On the fifth day 'Elohim paradoxically make the fishes, whales and birds of the air who fly up into the firmament above. Then on the sixth day in a last flurry all the creatures of the land appear - the beast of the earth after his kind, and cattle after their kind, and every thing that creepeth upon the earth. In one last afterthought, the 'Elohim make humanity male and female

'in our image after our likeness' to have dominion over the lot. Finally, to consecrate a holiday for spiritual observance, the 'Elohim rested on the Sabbath. One would have thought that, given the invocation in the Ten Commandments against idolatry, that taking sacred texts so literally would also be seen to be a corruption of the essential spiritual meaning, but no such luck.

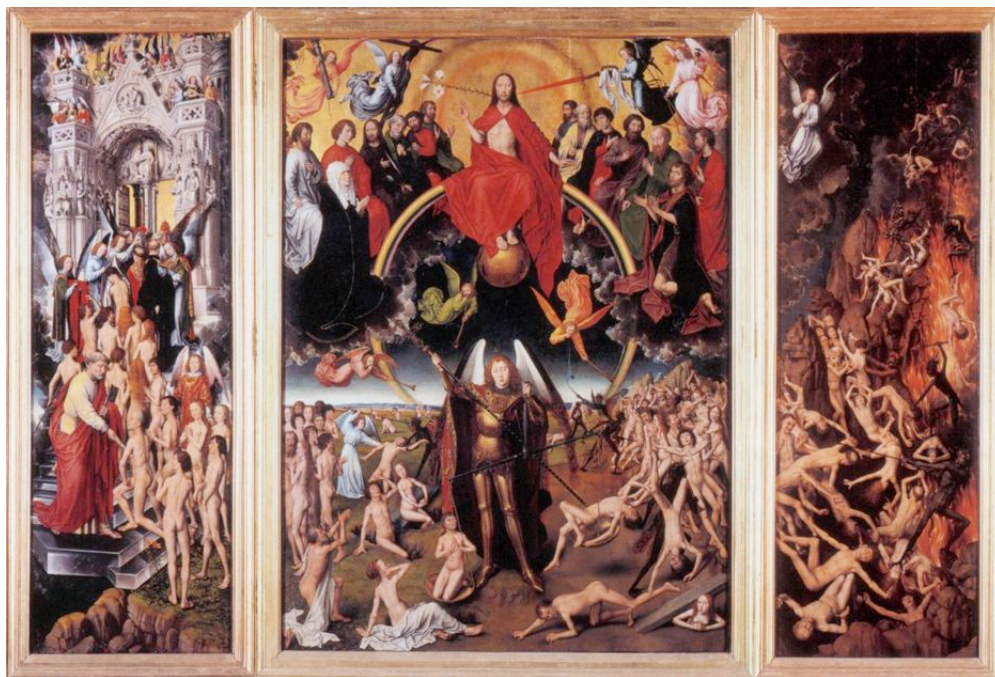


Right: Evolutionary tree of the human G-protein linked receptors (Blenau & Thamm). Every one of us has all these receptors, including everything from neuroreceptors for substances such as serotonin, to sight and smell, but their genetic sequences show a deep evolutionary relationship having evolved long ago before the first multi-celled organisms. Left: The serotonin 1 and 2 families diverged in evolution before the mollusks, arthropods and vertebrates (Fredriksson et al, Zozulya S. et al).

When Copernicus and Galileo discovered that the flat Earth-centric cosmology was a fallacy the church issued ex-communications. Not satisfied with finding the universe has rejected the flat-earth creation, latter day Christians have rallied to paint themselves into a corner over adamantly rejecting both cosmology and biological evolution, despite the evidence from fossils and the geological record, the immense age, size and complexity of the universe, and finally the overwhelming flood of genetic data since the turn of the millennium, confirming in minute detail, the evolutionary process, from the first life forms to migrating human cultures. This is a frank violation of Horace's maxim not to invoke the god in the machine unless unravelling the deity is necessary.

The intelligent-design approach flies directly in the face of all integrity. By comparison with the menial evidence of Copernicus and Galileo we are currently faced with a tsunami of genetic evidence consistent in every detail with the evolution of life. For example all the protein-linked receptors in our body, from those for neurotransmitters, such as serotonin and dopamine, through rhodopsin permitting vision, to the many diverse receptors for smell do not conform to an independent design attuned only to their designated function, but display an evolutionary tree showing they all evolved from a much more ancient precursor. When we take one family of these, the serotonin receptors and compare them with those of other animals we find it originated before the fundamental branchings of molluscs, arthropods and vertebrates, in the first single celled eucaryotes.

Of course the stumbling block in the creationist model of the universe is the very notion of creation itself. As the myth goes, 'Elohim created each of the creatures de novo as is by commanding the earth to bring them forth and set them to carry out their fixed allotted tasks. In the Eden version Yahweh breathes life in Adam and builds Eve from one of his ribs. This picture sets all the life forms up as created - 'made' by manufacture at the beginning of time by a single act of God. They are assembled, but do not themselves have the capacity to transform into new forms, or to adapt to new roles. God made them then and because God made them, like clockwork toys, they have no creative powers of their own, or that would be assuming some of God's powers to themselves. This despite the fact that life is sexually reproductive, even under 'Elohim's command to 'be fruitful and multiply', and thus clearly has the procreative capacity to generate new unique life forms, which every one of us is an example of. Consequently under no circumstances can an evolutionary process be admitted or accepted by religious creationists or intelligent design proponents, even though the evidence is incontrovertible.



The Day of Judgment, Hans Memling (www.lib-art.com)

At every point, attempts are made to select evidence in a non-scientific way to cobble together a resolution to this story to prove God is needed to intelligently design the universe because it can't pull itself up by its bootstraps. The one area where science hasn't quite completed the picture – how life first began – is seized upon as a critical weakness, but even in this area, the evidence, from interstellar gas clouds, through organics on comets, to the decoding of key reaction pathways, and the core biochemical record in living organisms continues to point to natural biogenesis occurring almost as soon as Earth was habitable.

What is so contradictory about the intelligent design fallacy is that it consists of a tragic cycle. Because literalists believe God created the universe and life in six days at the beginning of time, even though it is a charming, but entirely mythological and hence metaphorical account, they are

forced to believe life cannot evolve, so we end up with a machine that is doomed to eventually break down with no hope of improvement or adaption. Because they have invented a broke machine, they then have to complete the tragic cycle by insisting God designed the whole thing to be this way, attempting to incorporate snippets of evidence that appear to suit these arguments, however unscientific these may be. Because we believe God created a flawed universe without the creative potential, we are forced into a deus ex machina fallacy, recreating God as a cosmic designer to solve the tattered mess of life spawned in the sabbatical creation.

But the problems don't just stop there. There are also the diabolical problems of the endless war between good and evil and the schizophrenic divide between a heaven devoid of any creative potential except by grace of God, and eternal damnation in the fires of hell awaiting us as divisive futures when we die and pass into the imagined realm of pure consciousness that we are taught to believe carries on eternally when our mortal bodies pass away. This means that the entire 'machina' of the universe as we know it is just a dress rehearsal for an eternal transfixation – that all of nature, and with it the universe at large, is just a husk to be discarded in a morally retributive cosmos whose only law of nature is obedience to the creator deity.

Mechanistic Atheism: A Mindless Machine with no Redemption in Sight

It is with the scientific revolution that we have come to view the entire universe as a mechanism.

Rene Descartes, the "father of modern philosophy, and also the founder of Cartesian geometry, is renowned for his statement "Cogito ergo sum" – I think, therefore I am (Discourse on the Method part 4). Descartes proposed that the body works like a machine, while the mind (or soul), on the other hand, was described as nonmaterial and as not following the laws of nature. This form of dualism proposed that the mind controls the body, but that the body can also influence the otherwise rational mind, as when people act out of passion. However the critical flaw in Descartes' description has turned out to be the link between mind and body, which he envisaged took place in the pineal gland which we now know functions in circadian rhythms.

Although Isaac Newton was a devout religious believer who attempted to predict the date of the apocalypse, his great achievements are in discovering gravity, defining the laws of motion and co-inventing calculus. In his Principia, Newton came to describe a universe following mechanical laws defining the relationship between causes and their effects. Newton and Laplace after him came to describe the universe as a gigantic mechanism in terms of differential equations and initial conditions.

In 1814, Laplace published what is usually known as the first articulation of causal or scientific determinism: "We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes" (Pierre Simon Laplace, A Philosophical Essay on Probabilities). With the advent of Clerk

Maxwell's equations for electromagnetism and light, this description seemed to be almost complete.

Along with the growth of the scientific model, we came to understand that the phenomena of biology and hence the affairs of human life as defined in terms of our brain and bodily functions are just complex instances of chemical reactions, which ultimately become defined in the physical properties of atoms and molecules and their shared radiation through electromagnetic and other force fields. We enter the era of reductionism, where ultimately everything reduces to the laws of physics.

Humanity trapped in the existential nightmare:
Deus ex Machina by Ekud
(<http://ekud.deviantart.com/art/DEUS-EX-MACHINA-100870568>)

This leads to an existential nightmare, as expressed so succinctly by Bertrand Russel: "That Man is the product of causes which had no prevision of the end they were achieving; that his origin, his growth, his hopes and fears, his loves and his beliefs, are but the outcome of accidental collocations of atoms; that no fire, no heroism, no intensity of thought and feeling, can preserve an individual life beyond the grave; that all the labours of the ages, all the devotion, all the inspiration, all the noonday brightness of human genius, are destined to extinction in the vast death of the solar system, and that the whole temple of Man's achievement must inevitably be buried beneath the débris of a universe in ruins—all these things, if not quite beyond dispute, are yet so nearly certain, that no philosophy which rejects them can hope to stand. Only within the scaffolding of these truths, only on the firm foundation of unyielding despair, can the soul's habitation henceforth be safely built" (Bertrand Russell, *Free Man's Worship*).

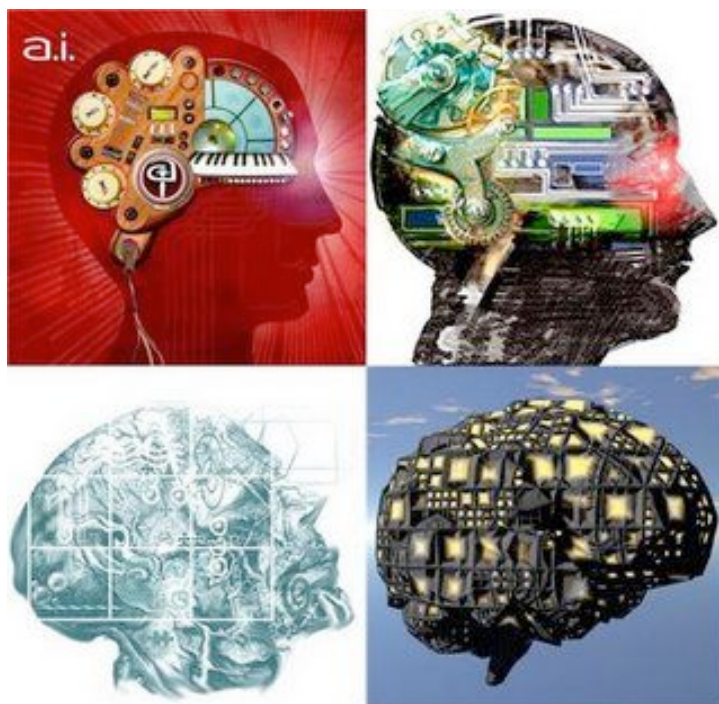


Everything might have remained caught in this nightmare except for two "dark clouds" noted in the 1900 warning by Lord Kelvin - the Michelson-Morley experiment, which led to the discovery of relativity and black body radiation which led to quantum theory. Thus the deterministic Newtonian universe opened up to new forms of uncertainty at the quantum level, although some aspects of the theory, such as quantum electrodynamics remain one of the most

quantitatively accurate theories of physics ever devised. Quantum theory has opened up the philosophical arena surrounding both determinism and the part played by the mind of the conscious observer in reality. Quantum uncertainty involves the causality-violating process of reduction of the wave function, which founding researchers have attributed to the intervention of the conscious mind on the probability superpositions of quantum mechanics.

However running against this quasi-mystical trend in physics have been two great developments in scientific discovery, which have profoundly strengthened the notion of causality and determinism in the everyday universe around us. Both of these stem partly from a reaction to the Second World War, with physicists developing the fields of biology and computer science.

The first gave rise to molecular biology and molecular genetics, which began with the discovery of the structure of DNA and has led all the way to the explosion of genetic science in initiatives such as the human genome project. Over half a century this has laid bare the physical mechanisms underpinning all biological processes and the computational and informational processes enabling biological organisms to reproduce and develop true to their genetic code despite mutational change.

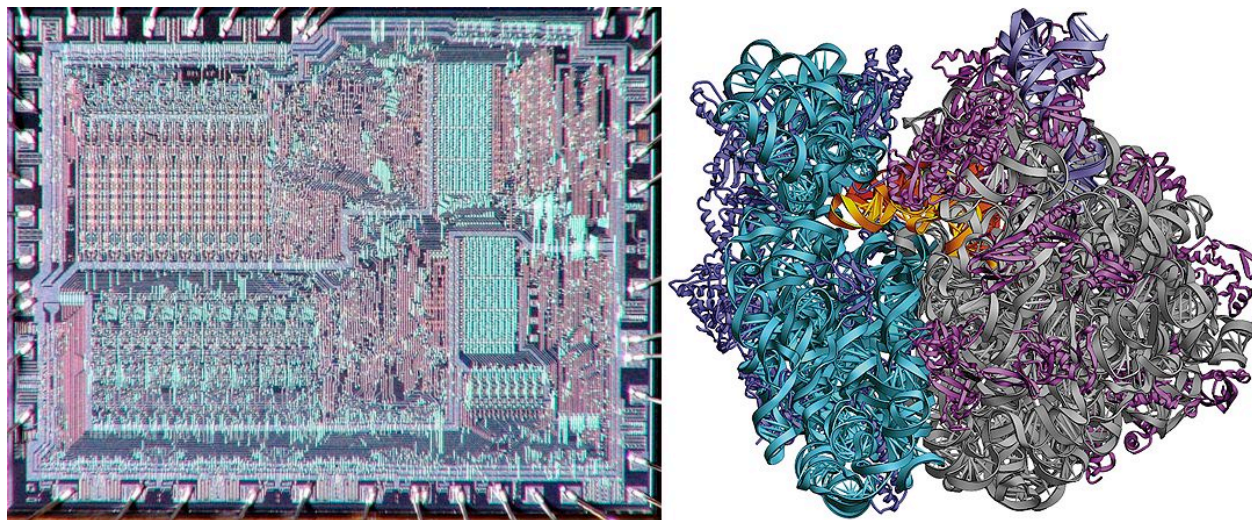


Artificial intelligence closes in on the conscious brain: four internet views (the -messiahs-blog.blogspot.com).

The second is the revolution in digital computing and digital communications that has brought about the explosion of computing power, from super computers to laptops and cell phones and spawned the internet, along with robotics, and artificial intelligence. Not only has this transformed human society into an interconnected global village, but it has brought upon us a cybernetic form of thinking – that causality is simply a matter of instruction sets following strict rules prescribing how 0s and 1s are encoded into new forms of information.

The confluence of these two highly deterministic sciences has led to a new kind of collective 'cyborg' mythology, that conscious experiences are really just brain function, that human beings are really just molecular machines and the brain is just a biological computer, admittedly a very different sort of computer from the serial digital computers having a central architecture basically identical to that originally conceived of by John von Neumann, perhaps working using parallel processing and brain waves rather than purely digital 0s and 1s, but nevertheless just a computer for all that, and that the only difference between a conscious being and a personal computer is one of scale and complexity – although our laptop may not be currently conscious,

given the right artificial intelligence and enough processors and memory space, computers will, like us become conscious beings.



AMD 9080A series CPU (www.cpu-world.com)
and the 70s ribosome involved in protein translation in the cell (rna.ucsc.edu).

Although subjective experiences are all that we have to access the physical world with, the privacy and non-replicability of subjective experience has led to a situation in which objective science has successfully built a description of reality covering diverse aspects of the physical world, from solid-state semi-conductors to biological tissues, and even to brain function based on classical deterministic notions of functional mechanisms. By comparison, the role of mind has slipped by degrees into a neglected orphan status, in which many scientists regard it as merely an epiphenomenon, perhaps the shadow of a kind of internal model of reality generated by the functional brain, but unable to have any affect on physical functions, reducing free will, and our sense of personal conscious autonomy to the status of a necessary delusion we all depend on to keep functioning and live out our reproductive, social and professional lives.

It is a world view which is not really justified by the science, but rather by popular impressions of it in the media and in science fiction productions, in which humans and computers become ever more closely equivalent. We and all of human conscious experience becomes just one big data set on the information super-highway. Free-will is dead long live the CPU!

Could any form of (intelligently) designed computational system replicate, or emulate, biological brains and consciousness? One might presume that any interactive system that can develop genetically could also be designed from the top down but this isn't necessarily the case. We don't yet have any idea of what the physical principles are underpinning subjective consciousness. Philosopher Jerry Fodor famously complained that: "Nobody has the slightest idea how anything material could be conscious. Nobody even knows what it would be like to have the slightest idea about how anything material could be conscious." Until we do we can't make significant progress on what sort of synthetic physical system might also support it.

The brain is a fractally generated developmental system where the genetic code results in organization from the molecule up and in turn cell type specific interactions involving cell migration to develop resonant neurocircuits which ramify as the brain develops. It's not a set of modules put together top down according to an overall design. The code is generative but not prescriptive - it doesn't specify the final arrangement but only the recursive process to generate a chaotically resonant complex system through very complex molecular feedbacks in the way genes are orchestrated through non-linear couplings in nucleic acid structure.. There is no viable way to replicate this developmental complexification in the solid state semiconductor physics of the digital computer. If the conscious brain falls into class that requires bottom up developmental ramification for the system to form, we are back to a synthetic brain using genetic technology - utilizing the genetic processes underlying the biological brain structures we already have naturally and gene technology plagiarized from existing biological systems.

The vision of human as a computational automaton becomes another kind of existential nightmare and another breakdown of the deus ex machina, this time by a complete failure to engage the process necessary to redeem the mechanical nightmare from its own pitiless future. By losing the mind to the cyborg mechanical monster, we have created a demiurge universe null and void of both consciousness and any autonomous will, doomed to its own extinction as entropy wipes away all distinction and the 'statues made of matchsticks crumble into one another', as Bob Dylan lamented.

Of course this universe is not quite as defunct as the morally retributive cosmos of the monotheistic tradition's intelligent design. It does leave room for the mechanism to evolve by random mutation and natural selection, even if all the ensuing life forms are really just molecular automata of one sort of another.

But there is no rhyme or reason to any of it. The best we can say of it is that, although we have no conscious will of any kind, evolution has selected us to feel that we do, so that the mechanics of the life process continues unimpeded by existential ennui and a complete loss of faith in our joie de vivre, let alone our discredited élan vitale.

Effectively the machine is a dysfunctional shadow of what it needs to be to support volitional subjective conscious existence, but by refusing to invoke the deus ex machina when it is genuinely required, at least as consciousness ex machina, and claiming that we can act as intelligent designers of a computational machine eclipsing our own awareness, we remain stranded as mechanical canaries in a cage constructed by our own predilection for mechanically verifiable certainties – in denial of the manifold entangled uncertainties of the quantum universe.

In effect this is a second manifestation of the design delusion. Creationists think the conscious universe must be an intelligent design of God. Deterministic materialists think conscious brains could be intelligently designed by humans. Same delusion - same misconception - external design as a generative metaphor based on mechanistic human manufacture. Concrete thinking in the entangled universe.

How do we find our way out of this predicament? It's all a question of revitalizing the ghost in the machine. And it is also centrally a question of getting the physics right. This model of reality

is based almost entirely on a classical notion of physics, one which was superseded with the discoveries of relativity and quantum theory.

The Mind Escapes its Mechanistic Bondage in the Quantum Universe



Brian and mind are complementary but categorically different manifestations of an existential cosmological reality (Chris King).

At the same time as this highly deterministic myth about reality became common currency, the status of the mind and of conscious experience as a foundation of reality had become almost completely eroded.

If we turn back the clock again to the middle of last century, Gilbert Ryle's "The Concept of Mind" argues that "mind" is "a philosophical illusion hailing chiefly from Descartes and sustained by logical errors and 'category mistakes'". According to the

official doctrine ... every human being has both a body and a mind ... each person has direct and unchangeable cognisance. In consciousness, self-consciousness and introspection, he is directly and authentically apprised of the present states of operation of the mind. ... I shall often speak of it ... as 'the dogma of the Ghost in the Machine.' It is one big mistake and a mistake of a special kind. It is, namely, a category mistake". According to Ryle, mental processes are merely intelligent acts and in this sense he is part of the flow of psychological behaviourism, which was dominantly influential at the time, but he criticized both Cartesian dualism and behaviourism alike as too rigid and mechanistic to provide us with an adequate understanding of the concept of mind.

The idea of the category error has veracity because mental experiences are categorically different from physical phenomena. Conscious experiences are entirely subjective while physical processes are objective and verifiable by others. This doesn't necessarily mean that subjective experiences are unreal, but that they cannot be understood or classified using the same analytical techniques as we do with physical phenomena.

Towards the end of the twentieth century a growing need to understand higher brain functions and the role of conscious decision-making has led to the emergence of the so-called science of consciousness research. While at the easy end this simply constitutes modelling higher brain function and the integrated neurophysiological processes supporting conscious attention and cognition, at the opposing 'deep' end we come to the "hard problem in consciousness research" enunciated by David Chalmers – the fact that no purely objective functional description invoking integrated brain states can be equivalent to, or explain of its own accord, the nature of conscious experience, because subjective consciousness and objective brain function are so utterly different

qualitatively, turning Ryle's category error into a categorical complementarity of attributes, as different as the wave and particle aspects of quantum reality.

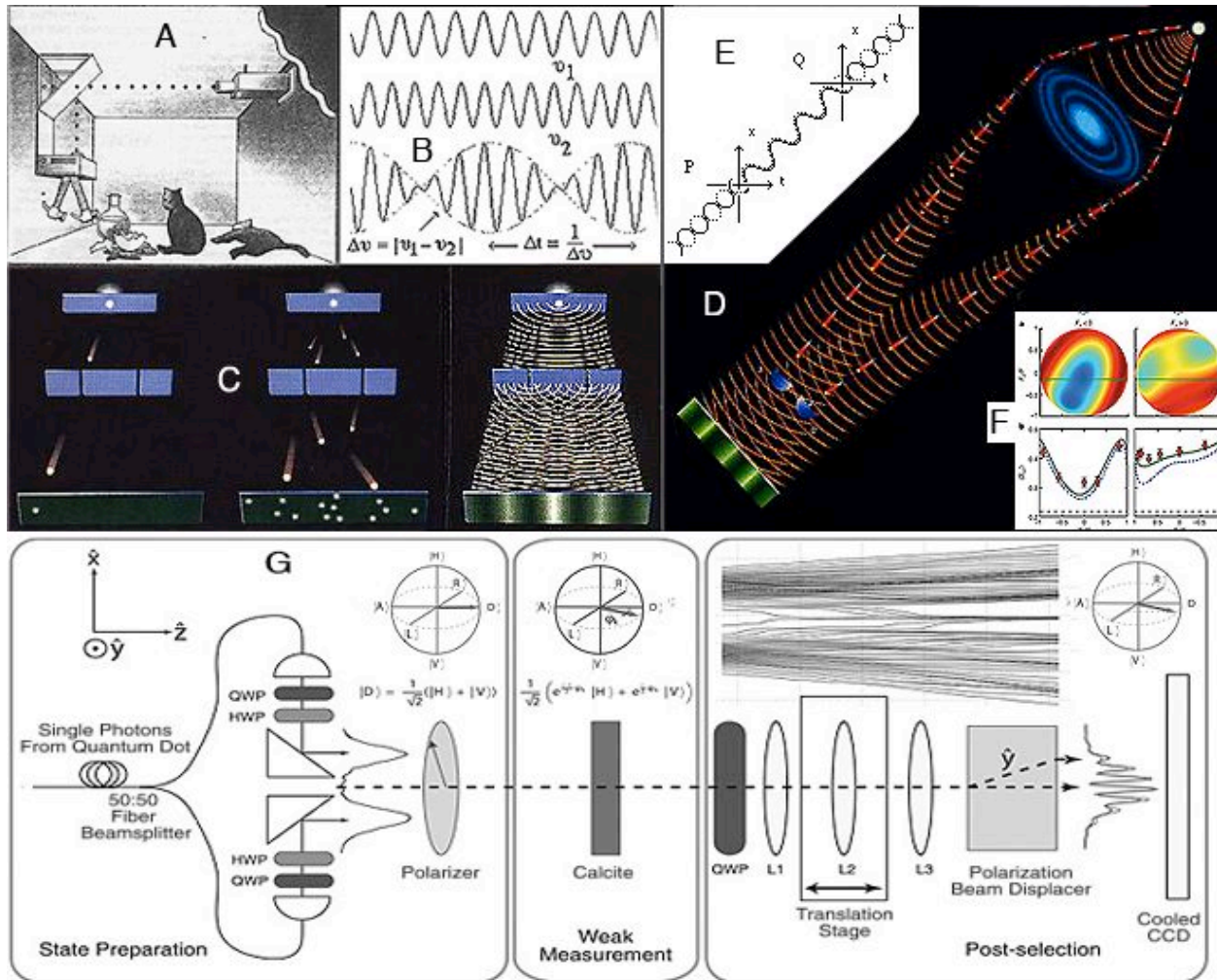
Subjective consciousness poses the ultimate dilemma for the scientific description of reality. We still have no idea of how the brain generates it, or even how, or why, such an objectively elusive phenomenon can come about from the physiology of brain dynamics. The problem is fundamental because, from birth to death, the sum total of all our observations of the physical world, and all our notions about it, come exclusively through our subjective conscious experience. Although neuroscience has produced new techniques for visualizing brain function, from EEG and MEG to PET and fMRI scans, which show a parallel relationship between mental states and brain processing, these go no way in themselves to resolving how these objective physiological processes give rise to the subjective effects of conscious experience.

The advent of quantum theory has fundamentally altered our idea of a deterministic universe where defining the conditions at an earlier point in time determines the conditions at successively later points in time, as a dynamical system progresses. In this sense the notion of temporal causality – that causes at an earlier time define subsequent effects at later times also becomes fundamentally changed.

Quanta have both a wave and a particle nature. They are emitted and absorbed discretely as particles but travel through space and time as a wave. For example in a two-slit interference experiment photons are each released as a particle from an excited atom, and then travel as waves through the apparatus, which we can see because each one travels through both slits and they then strike the photographic plate in a pattern which reflects the superimposed wave amplitudes. However each single photon arrives in a different place, which cannot be predicted, in what is called reduction of the wave function. It is only when many have passed that we can see the wave pattern from the probability distribution of the particles. Causal determinism is thus violated for each quantum.

Quantum uncertainty is a fundamental feature of the dynamical process, preventing us knowing both the energy and the time of an event simultaneously. The more precisely we need to define the energy results in the time being spread over an increasingly large interval and vice versa according to the relation $\Delta E \Delta t \approx h$. This arises because energy is equivalent to frequency $E = h\nu$ and to determine the frequency within a given accuracy requires counting how many wave fronts have passed over a period of time using beats as shown in B in the image above.

But quantum reality has many more tricks up its sleeve. If two particles of complementary spins, or polarizations, occur in a single wave function, they become entangled in such a way that finding out the identity of one cause the other to immediately have the complementary identity, no matter how far away it is, and to do so in a way which cannot occur by information travelling between the two particles at below light speed.



A: Schrödinger cat paradox experiment. B: Uncertainty is determined by wave beats. C: In an interference experiment the photon is first released as a particle but travels as a wave through both slits only to be absorbed again as a particle on the photographic plate. The particle distribution follows the superimposed wave amplitudes to form bands. D: Wheeler delayed choice experiment shows that changing the detection method after the photon has traversed its path can retrospectively change which way it went. E: Transactions explain exchanged quanta in terms of waves travelling both forwards and backwards in time. F: Quantum chaos can introduce new forms of entanglement (in this case with nuclear spin (Chaudhury et al. 2009). G: Weak quantum measurement is made in a way, which is confirmed only in the future of the ensemble when the absorption takes place (Kocsis et al. 2011)

Moreover the boundary conditions defining an exchanged quantum appear to involve both the past emitters and the future absorbers, in a transactional handshaking in which the future also has an effect on the past. This handshaking relationship can be seen in the transactional interpretation E above, in which the exchanged particle is an overlap of an offer wave from the emitter and a confirmation wave from the absorber travelling backwards in time. This effect can also be seen in the Wheeler delayed choice experiment D above, where switching between individual detectors and an interference film after the photons have passed the gravitationally lensing galaxy, determines whether they went around one or both sides.

It is also possible to extract information from a quantum by making a small deformation in its wave function during its path flight without absorbing and thus destroying it, which will nevertheless change the way it is eventually absorbed later, in a way we can learn about its original state from. This doesn't give us enough information to know what happened to each quantum at the time but can be used to build up a statistical profile when all the information is put together after the quanta are eventually absorbed. Critically the pattern of eventual absorptions leaves a strong mark on the earlier weak measurement statistics. This shows up another feature of uncertainty. What God gains by 'playing dice with the universe', in Einstein's words, in the quantum fuzziness of uncertainty, is just what is needed, so that the future can exert an effect on the present, without ever being caught in the act of doing it in any particular instance: "The future can only affect the present if there is room to write its influence off as a mistake", Yakir Aharonov the discoverer of weak quantum measurement declares.

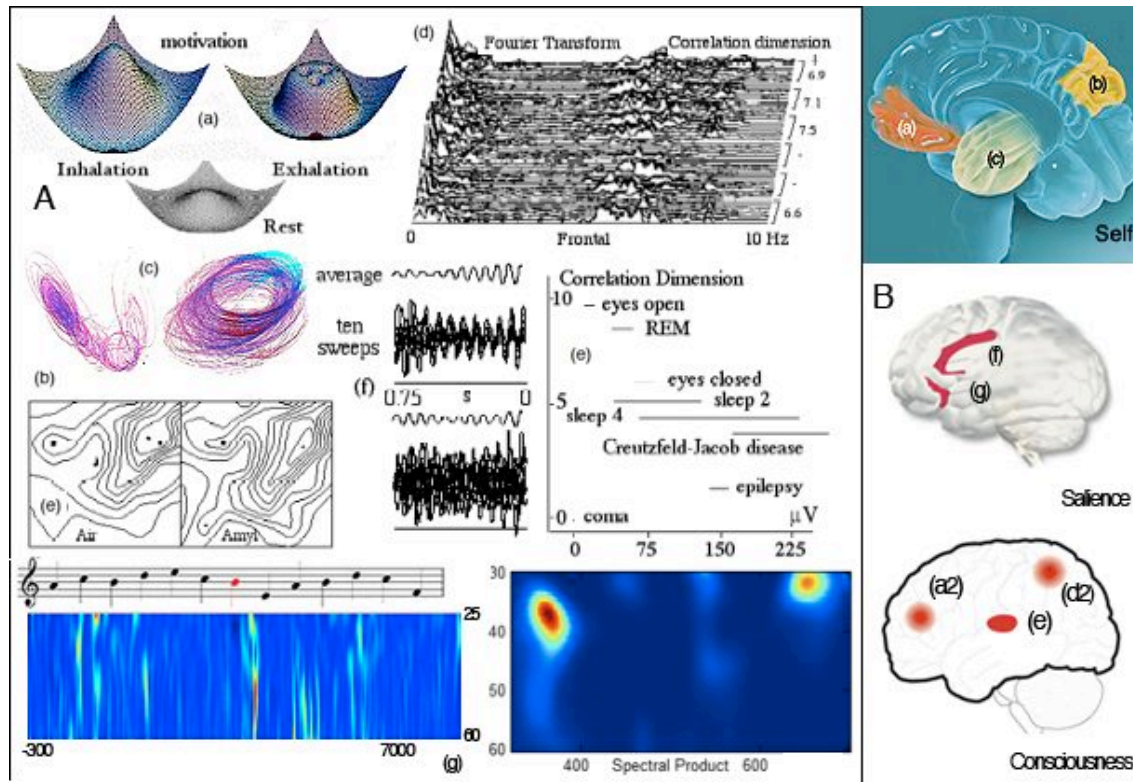
An indication of how quantum chaos might lead to complex forms of quantum entanglement can be gleaned from an ingenious experiment forming a quantum analogue of a kicked top illustrated above in F. In the chaotic dynamic (right) the orbital and nuclear spins have become entangled as a result of the chaotic perturbations of the quantum top's motion. This shows that, rather than the suppression of classical chaos seen in closed quantum systems, reverberating chaotic quantum systems can introduce new entanglements.

Now let's turn back to the brain and conscious mental states. We now know that the aspects of conscious experience are represented over the entire cortex in a many-to-many 'holographic' representation, in which each aspect of an experience such as a given person's face, or a facial expression is stored in a given area. This means that conscious mental states correspond to integrated excitations of brain areas working in a coherent manner together, while local processing that is 'out of synch' with the global brain state remain subconscious processing, which may later become conscious.

This means that there is no single area of the brain responsible for consciousness although a variety of brain studies point to certain areas being pivotal for central aspects of conscious processing, as illustrated in B below, such as the 'self' network, also called the default network because it is activated when we are in idle moments anticipating situations we may shortly be having to deal with. The default network connects frontal and other regions also involved in working memory and cognition. Areas that appear to be pivotal for integrative consciousness, which cause significant problems if damaged, also show a similar arrangement. Other frontal and related areas are involved in a salience network that uses very fast neurons apparently to keep up an ongoing representation of the dynamic present. These ideas are reinforced by brain scans on anaesthetics, which show that loss of consciousness is accompanied by brain areas going out of synch with one another. They also explain why consciousness tends to unitary and attention to centre broadly on one train of ideas at a time (King 2014).

Brain excitations also show the characteristics of dynamical chaos, see A above. They have broad spectrum frequencies rather than resonances, their orbits behave like strange attractors and many states have been found to have a fractal dimension indicative of dynamical chaos. Chaos might seem to be a noisy interference in what might be thought of as an ordered deductive process, but it provides two essential dynamical properties. Firstly it makes a system arbitrarily

sensitive to its bounding conditions in the butterfly effect – a disturbance as small as the eddy from a butterfly's wing can become the source of a tropical cyclone. Secondly it prevents the dynamic getting stuck in the rut of an ordered attractor by shaking the system up a little like a fly buzzing around the room exploring the space fully. Transitions at the edge of chaos thus form an ideal meeting point where new structures can form out of the instabilities and then be incorporated if they have adaptive value.



A: Evidence for dynamical chaos and phase wave-front 'holographic' processing. (a) Freeman's model of olfactory recognition involves a transition from high-energy chaos to enter a new or existing strange attractor basin as the energy is lowered, represented (Skarda & Freeman 1987) (b) in distinct global patterns of olfactory bulb activation. Extended spatial distribution of cortical activation accompanying recognition of an odour. (c) Strange attractors in the EEG. (d) Fourier transforms of an EEG, showing broad-spectrum excitation and correlation dimensions, both consistent with chaotic dynamics. (e) Correlation dimensions of brain states. (f) Increased phase coherence when a musical note becomes anticipated (Basar et al. 1989) (g) Wavelet transform, showing time evolution of amplitudes with a peak accompanying recognition of an anomalous note is consistent with phase-front processing. Spectral product (right) illustrates coherence across several EEG channels. B: Regions identified in the notions of self (Zimmer 2005), saliency (Williams 2012) and consciousness (Bor 2013).

But this may introduce another feature. If a brain state is critically poised because there is no obvious best outcome to a computational assessment, it may in turn become sensitive to the instabilities of a single neuron, a single ion channel and ultimately quantum uncertainty itself. Neurons are often tuned to their sigmoidal thresholds putting the system into a state of critical instability. Certain neural processes, and other dynamical features such as 'stochastic resonance' can amplify such small oscillations from single ion channels to cells and in turn into global brain states.

The critical role of consciousness is to enable an organism to be able to evade imminent threats to its survival. However problems of survival in the open environment are notoriously intractable by classical computation because of super-exponential runaway in the number of computations required. Given serial computation alone, a digital gazelle would become stranded at the crossroads, gobbled by a real predator while it was protractedly ticking over trying to solve the problem of what to do. Hence the massively parallel processing in our brains and the brains of our sibling species, which enables living organisms to make a decision in real time through a transition from the edge of chaos if there is no predisposing factor driving the decision.

Given the fact that the central role of the brain is to anticipate imminent futures and this intractability problem, we are led to a situation in which the brain may use an extra-computational avenue of anticipation to complement computational assessments with the sort of integrated intuition, hunch, paranoia and split-second reactions we know active consciousness is capable of.

But there is another feature of brain processing which we have already touched on – coherent wave excitations – that are essential to distinguish attended signals from the groundswell of incoherent noise and peripheral processing, which is both central to the conscious state and necessary to identify salient features from the flood of sensory and higher-level processing information passing through the doors of perception..

Karl Pribram in the notion of the holographic brain, has drawn attention to the similarity between phase coherence processing of brain waves in the gamma frequency range believed to be responsible for cognitive processes and the wave amplitude basis of quantum uncertainty in reduction of the wave packet and quantum measurements based on the uncertainty relation $\Delta E \Delta t \approx h$, where the relation is determined by the number of phase fronts to be counted.

In effect brain wave states may act like quantum excitations and the brain as a special type of ‘holographic’ quantum computer whose role is to anticipate reality. It is likely that this form of consciousness first arose in chaotically excitable single cells sensing and anticipating the environment around them through sensitive dependence, because all the components we associate with the conscious brain, from ion channels to neurotransmitters and their receptors evolved long before multi-celled animals.

Biology is full of phenomena at the quantum level, which are essential to biological function. Enzymes invoke quantum tunneling to enable transitions through their substrates’ activation energy. Protein folding is a manifestation of quantum computation intractable by classical computing. When a photosynthetic active centre absorbs a photon, the wave function of the excitation is able to perform a quantum computation, which enables the excitation to travel down the most efficient route to reach the chemical reaction site. Quantum entanglement is believed to be behind the way some birds navigate in the magnetic field. Light excites two electrons on one molecule and shunts one of them onto a second molecule. Their spins are linked through quantum entanglement. Before they relax into a decoherent state, the Earth's magnetic field can alter the relative alignment of the electrons' spins, which in turn alters the chemical properties of the molecules involved. Quantum coherence is an established technique in tissue imaging, demonstrating quantum entanglement in biological tissues at the molecular level.

Weak quantum measurement provides a way that the brain might use its brain waves and phase coherence to evoke entangled states that carry quantum encrypted information about immediate future states of experience as well as immediately past states, in an expanded envelope - the 'quantum present' - which we witness as subjective experience.

Effectively the brain is a massively parallel ensemble of wave excitations reverberating with one another, through couplings of varying strength in which excitations are emitted, modulated and absorbed. The entire system could be a reverberating system of massively parallel weak quantum measurement of its ongoing state (King 2014), giving the conscious brain state a capacity to anticipate immediate future threats through prescience, paranoia and foreboding. Notice that the nature of uncertainty noted by Aharonov above might prevent us ever proving that such anticipation occurs in any given instance.

This form of weak quantum measurement would require significant differences from traditional weak quantum measurement experiments, which are designed to produce a classically confirmed result from an eventual statistical distribution in the future, whereas in the brain coherent states would correspond to ongoing entangled excitations themselves extended between past and future through quantum hand-shaking. This would open the quantum loophole in the deterministic nightmare which would admit both subjective consciousness as a sensitive anticipator of immediate futures and free-will as the converse action of conscious volition on brain states through the uncertainty of the physical brain dynamic. Discovering a molecular-biological basis for such an effect would pose an ultimate challenge to experimental neuroscience.

By liberating the conscious mind and volitional will from the shackles of the mechanistic nightmare we are at the same time evoking a deus ex machina in the form of the way our own subjective consciousness is capable of transforming the world and unfolding history to bring about social and psychic change.

The central enigma of quantum reality is the causality-violating reduction of the wave packet. We see this in Schrödinger's cat paradox (A in the second to last image) a cat set to be killed by a radioactive scintillation breaking a cyanide flask. In quantum reality the cat is both alive and dead with differing probabilities, but in our subjective experience, when we open the box the cat is either alive, or dead, with certainty. However, not only is Schrödinger's cat both alive and dead, but in quantum reality Napoleon has both won and lost the battle of Waterloo. Many of these strategic outcomes, indeed all accidents of history, depend on uncertainties that go, in principle, right down to the quantum level.

The whole notion of a single line of history unfolding seems to be something only our conscious awareness is able to determine. Several of the founding quantum physicists, from John von Neumann to Werner Heisenberg adhered to this view. In physicist Henry Stapp's words: "Before human consciousness appeared, there existed a multiverse of potential universes. The emergence of a conscious mind in one of these potential universes, ours, gives it a special status: reality".

This implies that we are playing a pivotal and in its essence a cosmological role through our subjective consciousness in bringing about a cognizant universe aware of its own existence and

imbued with a sense of purpose expressed in and through our free-will and sense of compassion for the unfolding nature of conscious existence amid the mortal toil of biological sexuality.

This appears to be the ultimate answer to the “deus ex machina” paradox – invoking not God in the machine, but consciousness in the cosmos. In discovering this change of perspective lies our redemption through taking full responsibility for our actions participating in a deepening understanding of this extraordinary universe, in which we as sentient beings are the conscious progenitors of its becoming.

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