Quantum Theology beyond Copenhagen

with Mark Harris, "Quantum Theology beyond Copenhagen: Taking Fundamentalism Literally"; Shaun C. Henson, "What Makes a Quantum Physics Belief Believable? Many-Worlds among Six Impossible Things before Breakfast"; Emily Qureshi-Hurst, "The Many Worries of Many Worlds"; Elise Crull, "Interpretation Neutrality for Quantum Theology"; Wilson C. K. Poon and Tom C. B. McLeish, "Is There a Distinctive Quantum Theology?"; and Ernest L. Simmons, "The Entangled Trinity, Quantum Biology, and Deep Incarnation."

THE ENTANGLED TRINITY, QUANTUM BIOLOGY, AND DEEP INCARNATION

by Ernest L. Simmons

Abstract. By utilizing the concept of quantum decoherence, augmented by the novel theory of quantum Darwinism, to understand the transition from the quantum to the classical worlds, the scaling up of the concept of quantum entanglement2018 to the biological level offers a fascinating metaphor for the presence of the creative spirit in nature and the "flesh" of Incarnation. This in turn provides helpful theological metaphors for articulating divine presence at the level of life in theistic evolution, partially addressing the issue of evolutionary theodicy by supporting the concept of deep Incarnation. The point of understanding the Incarnation as deeply entangled enfleshment is that it brings the suffering of creation into the life of the Redeemer as well as the Creator, facilitating redemption and hope through the divine life.

Keywords: deep Incarnation; evolutionary theodicy; quantum biology; quantum Darwinism; quantum decoherence; quantum entanglement; trinity

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> Long before humans arrived, the way of nature was already a *via dolorosa*. (Holmes Rolston III, 2001, 60)

> Shut up and calculate! (David Mermin 2004)

The task of the comprehension much less the meaning and definition of reality around us is an ongoing challenge in both physics and theology,

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made no less challenging by the quantum revolution of the last century. Is "shut up and calculate" all that we can do in our attempt to understand physical reality? The human mind and heart say no and hence the many attempts over the last decades to find ways beyond the Copenhagen Interpretation, which if true would appear to leave reality permanently beyond human conceptual reach. If indeed "to observe is to change," (much like Wordsworth's "we murder to dissect") is the nature of reality as a whole always to remain behind a diaphanous gown of obscurity, tantalizingly close but bound only by the grasp of probability?

The Copenhagen Interpretation forces one to live in the ambiguity of existence when one craves clarity and permanence. Is there no comprehension of reality beyond the calculation of probabilities within the wave function? How does one move from the quantum to the classical world? As Wojciech Zurek, one of the founders of what is called quantum Darwinism, puts it, the "Quantum measurement problem is a technical euphemism for a much deeper and less well - defined question: How do we, 'the observers', fit within the physical Universe?" (2004, 2). It is little wonder then that almost from the moment of Bohr's first articulation attempts have been made to refute, revise or discard it. Bohr, the first philosopher of quantum mechanics, was much more comfortable with ambiguity than many of his successors. So the question arises, can we go beyond Copenhagen? Which is to ask, are there ways to clarify the transition from the quantum to the classical world and what would be the significance for theology?

Building upon the understanding I developed in my earlier book *The Entangled Trinity: Quantum Physics and Theology* (Simmons 2014), in this essay, I will explore the metaphorical (from *metaphero*, to "carry over") appropriation of quantum concepts, such as entanglement, for the understanding of the presence of the Divine within biological creation and deep Incarnation. The scaling up of the concept of quantum entanglement to the biological level, for example, offers a fascinating metaphor for the presence of the creative spirit in nature and the "flesh" of Incarnation. The thesis of this article is that the empirical extension of quantum phenomena (employing a constructive role for decoherence such as in "quantum Darwinism") into quantum biology at the classical level lends support to the metaphorical appropriation of quantum concepts at classical levels of reality. This in turn may provide helpful theological metaphors, such as entanglement, for articulating divine presence at the level of life in theistic evolution, partially addressing the issue of evolutionary theodicy by supporting the concept of deep Incarnation. With such a broad subject, this essay will undertake a modest task, a "thought experiment" (Einstein's *Gedankenexperiment*) if you will, by exploring such connections as an expression of constructive theology. It does not intend to prove anything in either science or theology but perhaps demonstrate a "hypothetical consonance" (Peters 1998 and 2006; Simmons 2007) between these scientific and theological concepts. We will begin with a short overview of Entangled Trinitarian Panentheism and then turn to a brief and very elementary statement of quantum decoherence and quantum Darwinism, as well as examples of quantum biology, before turning to the difficult topic of evolutionary theodicy and what the concept of deep Incarnation, enhanced by the metaphor of entanglement, might provide as a hopeful response.

Entangled Trinitarian Panentheism

The Doctrine of the Trinity is an exercise in wonder. It is drawn from the wonder of our own existence and the diverse experiences of the divine encountered by the early Christian community. The movement was from three to one, not one to three. God was encountered in multiple ways as creator, redeemer and sanctifier, and these diverse experiences were then connected back to the one God of Israel. This pluriform experience eventually gave rise to the Doctrine of the Trinity, particularly following the Council of Nicaea in 325 CE where Christ as the Logos was affirmed to be divine. Christian thinkers attempted to coherently place the Christian experience of the divine somewhere between the pluralistic polytheism of the Greco-Roman world and the singular monotheism of the Jewish tradition. Christianity became a *pluralistic monotheism* with all the paradoxes, contrasts and creativity that implies (Simmons 2014, 1). I employ the theological model of panentheism, God is in the world but more than the world, to model this pluralistic monotheism.

In my earlier work (2006, 2014), I argued that the classic understanding of *perichoresis* (mutual indwelling of the persons of the Immanent Trinity from *perichoreo*), developed by the Cappadocian Fathers, could be enhanced by metaphorically employing quantum entanglement. Understood as nonlocal relational holism, entanglement could help explicate for today the meaning of divine energy, activity and relatedness within a panentheistic model of God.[1] This would allow us to talk about the Trinity in such a way that the inner life of the Immanent Trinity is entangled with the external expressions of the Economic Trinity in relation to creation. This would also mean that the Spirit is always connected to the activity of the Father and Son in creation and that the Father and Spirit are connected to the Son in the Incarnation, including the Crucifixion and Resurrection. Divine entanglement becomes a way of understanding the *perichoretic* expression of divine love and grace in the creation affirming the so-called Rahner's Rule that, "The Economic Trinity (God disclosed in revelatory acts in the creation) is the Immanent Trinity (God in the Godhead itself)" (Rahner [1970]; Polkinghorne 2007, 103). Just as particles that are once interrelated are bound together by quantum entanglement, so too the mutual indwelling activity of the Trinity can never be dismembered. An entangled understanding of the Trinity does indeed give rise to an understanding of a God that, as St. Paul referred to at the Areopagus, is one in which we "live and move and have our being" (Acts 17:28 NRSV).

What we see here is the interconnection of creational existence between divine initiative and response characterized by self-giving (agape) love. Denis Edwards observes, "The Spirit is the interior divine presence empowering the evolution of the universe from within, enabling a universe of creatures to exist and become" (2004, 200). This is key to the panentheistic model in that God is already present within the universe that divine love is making possible. This means that God is closer to us than we are to ourselves in a radical interiority. Edwards reflects that it is precisely because God is understood as transcendent that God can be thought of as immanent in creatures in a way that is not possible for a created being. It is because God is wholly other that God can be, "*interior intimo meo*-closer to me than I am to myself" (Edwards 2004, 200). The metaphorical appropriation of entanglement gives ontological identity to the manner in which panentheism models God's relationship to the creation.

There is a foundational interconnectivity between God and creation such that not only does one influence the other but they exist in a communitarian relationship. In such a relationship, *"Perichoresis may be conceived as the mutual indwelling energy of the divine Trinity through which the creation is created and which evolves within the life of God as entangled superposition"* [Italics in text] (Simmons 2014, 153). Creational existence is communal just as the Trinitarian divine life is communal because it is part of the divine communitarian life (see Polkinghorne 2001 and Moltmann 1993; Clayton and Peacocke, eds. 2004). This relationality is constitutive of creation itself. Theologically appropriating entanglement as an ontological metaphor for this divine together-in-separation provides the basis for such communion. God can never be separated from the creation, for God is entangled through the fullness of divine love, the *pleroma*, that makes the creation possible in the first place. The creative divine energy of God is lovingly entangled with the creation (Simmons, 2021).

In order to use quantum concepts metaphorically in theology, especially for deep Incarnation, it would be helpful to consider whether these concepts can be scaled up to the biological level. Do quantum processes such as entanglement and superposition play a part in biological processes? It is my contention that they do and as such are able to provide theological metaphors for the connection of creation and redemption through deep Incarnation understood in the context of theistic evolution. To that we now turn by first looking at the challenge of quantum decoherence.

Quantum Decoherence and Biology

Almost from the beginning of its development, it had been thought that the dynamic but delicate states proposed in the quantum world would not scale up to the level of molecules, much less to living cells. They would simply decohere, lose their structure, and not be influential at all larger scales. Yet, in both physics and biology, there has been the deep-seated desire to understand how the realms of the micro- and macroscopic interrelate. Quantum events must in some manner be connected with classical, everyday life. One path to deeper understanding and further examination of the role of quantum decoherence was begun in 2003 through the work of Wojciech Zurek, who proposed the concepts of pointer states with einselection and envariance (discussed below). In addition, discoveries by others in what has become known as the field of quantum biology seem to offer some tantalizing suggestions. The value of understanding the nature of environmental entanglement to facilitate the state changes from the quantum to the classical level is just coming into view. Whether a new understanding of the role of quantum decoherence involving some type of pointer selection, some natural selection or "Darwinism," will actually solve the measurement problem is highly debated, but it is becoming a more seriously considered theory. An increased role of quantum phenomena in biology is another area for demonstrating the "survival" of certain quantum states into the classical world. Some quantum states may even be influential in such diverse phenomena as DNA bonding, bird migration and, perhaps, photosynthesis (McFadden 2002; Abbott, Davies and Pati 2008; McFadden and Al-Khalili 2014). While all of this is highly speculative, after developing them briefly, it will still be worthwhile to explore what possible significance these concepts, metaphorically appropriated, might have for theology.

Quantum Decoherence/Darwinism

There is always an essential element of pragmatism in physics. Does the experiment or process work? Given the problem of induction, this may be one of the best results one can hope for in science. Quantum physics works! That is one of the great successes of the Standard Model of particle physics. Entanglement is a basic feature of the quantum formalism and is an empirical fact, which has been confirmed by many different labs with many different particles, and was definitively demonstrated by Anton Zeilinger in the Canary Islands in 2018 (Zeilinger 2018). So our discussion here cannot go "beyond entanglement" in so far as it is a proven element in QM.

Various suggestions employing a quantum "bottom up" (moving from the quantum to the classical level, Russell 1999) or a chaos theory "lateral" (moving sideways from classical to classical via quantum

Polkinghorne 2007) approaches among others have been employed, particularly in the Divine Action Project,(Russell, Murphy, Isham, 1999, 2003, 2007, 2018) with significant success. But the problem of the quantum-classical transition still remains a challenge. This is where quantum decoherence involving selection, pointer states, and quantum biology becomes important for scalar appropriation of quantum metaphors. Decoherence, where the delicate superposition encounters the measurement process, was always thought to cause the collapse of the wave function and not permit the influence of quantum states upon classical ones. But this may not always be the case in an extremely high concentration of quantum states and entangled environment. As will be explained shortly, a quantum state, say in an atom, becomes entangled with a quantum state in the environment, say a photon of sunlight, and both are preserved and then have the capacity for replication becoming the "fittest." More speculatively, can entanglement, leading to the "natural selection" of pointer states (quantum states that are especially robust in the face of decoherence) not only allow for the transition of quantum to classical but also classical to biological?

Beginning in 2003, Wojciech Zurek, working at Los Alamos, sought to determine how the classical world could emerge from the quantum world. He came to propose that certain quantum states, by becoming entangled with their environment, could be stabilized, particularly as replicated through the entangled environment. This stabilization process he saw as a "survival of the fittest" process and somewhat whimsically named it quantum Darwinism (hereafter referred to as QD), not to be confused with biological Darwinian evolution. Induced by the environment interacting with the quantum system, the many possible quantum states are selected against in favor of a stable pointer state (so named to be analogous to a pointer on a dial). Zurek puts it this way,

> Effective classicality of a property of a quantum system can be defined by using redundancy of its record in the environment. This allows quantum physics to approximate the situation encountered in the classical world: The information about a classical system can exist independently from its state. In quantum theory this is no longer possible: In an isolated quantum system the state and the information about it are inextricably linked, and any measurement may – and usually will – reset that state. However, when the information about the state of a quantum system is spread throughout the environment, it can be treated (almost) as in classical physics – as (in effect) independent from the state of the open quantum system of interest. This is a central idea that motivates the *quantum Darwinism* approach to the interpretation problem… This view of the emergence of the classical can be regarded as (a Darwinian) natural selection of the preferred states. Thus, (evolutionary) fitness of the state is defined both by its ability to survive intact in spite of the immersion in the environment (i.e., environment-induced superselection is still important) but also by its propensity to create offspring – copies of the information describing the state of the system in

> that environment. I show that this ability to 'survive and procreate' is central to effective classicality of quantum states. (Zurek 2004, 121) [Italics not mine]

Zurek sees survival as assisted primarily by the entangled environment in which the quantum probability states allow einselection (environment-induced superselection) to occur, assisting in the emergence of pointer states. It is these pointer states which regular decoherence brings about leading to a definitive measurement. (For a dissenting opinion, see Kastner 2015.)

These pointer states also allow for massive multiplication so that multiple observers would observe the same thing. Zurek and Jess Reidel, another QD advocate, calculated that a grain of dust one micrometer across, after being illuminated by the sun for just one microsecond, will have its location imprinted about 100 million times in the scattered photons. It is because of this redundancy that objective, classical-like properties exist at all (Zurek 2018, 2019; Ball 2019). Reidel comments, "Quantum Darwinism putatively explains, or helps to explain, all of classicality, including everyday macroscopic objects that aren't in a laboratory, or that existed before there were any humans" (Ball 2019). As Philip Ball comments, "It doesn't matter, of course, whether information about a quantum system that gets imprinted in the environment is actually read out by a human observer; all that matters for classical behavior to emerge is that the information get there so that it could be read out in principle" (2019). Zurek's point is that the classical understanding of decoherence had ignored the environment and it is the environment that is key in making the transition from quantum to classical levels by assisting in the multiplication of the pointer state.

Elise Crull, in an excellent entry on "Quantum Decoherence" in the *Routledge Companion to the Philosophy of Physics*, argues for an important role for quantum decoherence beyond simple collapse. She observes,

> Nature's apparent "preference" for certain bases of measurement is not due to as-yet undiscovered selection rules, but rather to the relative stability of particular bases over others due to decoherence dynamics. The rate at which a system's phase relations become decohered in a particular environment depends on the strength and character of the system-environment entanglement. System DoFs [Degrees of Freedom] that commute most effectively with environmental DoFs will become most quickly entangled with one another, and therefore most robustly decohered in the associated basis. (Crull 2018, 11)

Crull cautions, however, that "…while decoherence explains the apparent definiteness of pointer positions, it is a separate claim – and one not substantiated by decoherence qua physical process alone – to insist that pointer positions are truly definite" (Crull 2018, 13). While decoherence may allow for environmental saturation, significant presence in an environmental location, there is also the challenge of the definition of classicality to which this transition may be ascribed. None of the traditional definitions of classicality are able to explain the emergence from quantum to classical. Crull concludes, "Since decoherence models are designed to examine precisely these dynamics in wide-ranging situations, many consider this the most promising approach to the question of emergent classicality" (Crull 2018, 15).

While there are questions regarding the function of pointer states and QD in particular (Kastner), there is increasing evidence of QD's empirical viability. Philip Ball indicates that three experiments have vetted QD. In 2019, three teams of researchers in Italy, China, and Germany have independently put the theory to the experimental test by looking for its key feature: how a quantum system imprints replicas of itself on its environment. One of the tests, done by teams in Italy and China, used a single photon interacting with other photons and found the polarization of the single photon was carried over into the "environment" of the bombarding photons. In Germany, an optical test using a nitrogen atom to replace a carbon atom in the crystal lattice of a diamond was used to test QD saturation. The nitrogen atom has one more electron than the carbon atoms in the diamond and this free electron's spin was used in the experiment. It was found that this spin was replicated in the surrounding environment and the information of the spin saturated quickly.

QD has also been found to be helpful in quantum chemistry as well. Brandss and Poznanski argue for the value of employing QD in quantum chemistry. They state, "It [QD]is shown to play a pivotal role, giving support to the signature of life and consciousness at the quantum-classical transition zone where long range correlative information is cultivated by energy-entropy dissipation in organisms at multiple levels of hierarchical and functional organization" (2020,1). They go on to affirm regarding DNA that, "Due to their quantum properties, the electron-proton formation of hydrogen bonding provides both stability, preserving the genetic code, and transiency, giving rise to mutations" (3). What this is attempting to show is that quantum processes play a role not only in the transition from the quantum to the classical but also in certain biological functions, such as DNA bonding as well.

Quantum Biology

The father of quantum biology is considered to be the great physicist Erwin Schrödinger, who wrote a book in 1944 entitled *What is Life?* (1944, 1967). Here, Schrödinger speculated that quantum phenomena may be influential on life but, before the discovery of genetics, it was considered too speculative. For most of its history, therefore, quantum phenomena were believed to only occur at the subatomic level. Starting around 2000, however, it was discovered that quantum phenomena may not only be present at the biological level but essential to some biological functioning, including evolution (McFadden 2002In 2003, NASA convened a conference at its Ames Laboratory in California entitled "Quantum Aspects of Life" with presentations to explore these ideas, later published in a book by the same title (Abbott, Davies and Pati 2008). The ideas of quantum biology are still very controversial but some areas of application have achieved greater certainty than others. The role of quantum states in hydrogen, essential for proton bonding in DNA mentioned above, is one such example. That discovery may, in fact, be a vindication of Schrödinger's initial insight. I will briefly discuss two other examples of such "quantum biology" to illustrate the value of quantum concepts for discussing much larger systems.[2]

Example One: Quantum Photosynthesis-Superposition in Biology. One of the most essential processes for all life on earth is the ability of the chlorophyll molecule to capture the energy of light and transform it into chemical energy, usually in the form of glucose, which can be used by other life to provide the energy for life itself (Castro et al. 2008, 51–70). But one of the questions in the process is how the molecule is able to capture such a high percentage of the energy of the light photons that hit its leaf. It is almost 100% efficient. One theory is that this partially has to do with quantum coherence and superposition. As the photon strikes the chloroplast it knocks an electron out from an atom in the chlorophyll molecule. This excited electron, called an exciton, then has a very small amount of time (in the order of femtoseconds, or 10^{-15} s) to convey the energy to the reaction center of the chloroplast to be converted into chemical energy. There are many possible routes that it can take but only one is the shortest and most efficient. If this route is determined by trial and error most of the energy would be lost through wasted heat, but it does not do that.

Functioning almost like a quantum computer, the exciton, taking what is called a "quantum walk," in contrast to a classical random (drunken) walk, explores *all the possible routes at once*, determining which is the most efficient and follows that (McFadden and Al-Khalili 2014, 127). It does this because of the coherent superposition of the wave function. Since the particle is also a wave it passes through the cell like a wave covering all routes at once like a quantum computer and then collapses back into a particle, the exciton, upon determining the shortest. How this collapse occurs is a matter of considerable debate but the energy transfer is measurable. Without quantum superposition, photosynthesis would not be possible, and without photosynthesis neither would life. Every living creature depends upon this process to acquire energy for its own cell formation, reproduction and growth. McFadden and Al-Khalili conclude, “Life seems to bridge the quantum and classical worlds, perched on the quantum edge” (2014, 132, Al-Khalili, 2015). This subject is still a matter of much controversy, however. The most recent survey of research concludes,

> The detection of quantum effects in photosystems persisting for long enough to be considered non-trivial has led to substantial progress over the last decades. The subject of coherence in photosynthesis is an ongoing, contentious issue, with comprehensive previous reviews centered on both experimental and theoretical advancements. Although there is no doubt that coherence is present in LHCs [Large Hadron Colliders] over short timescales, proof of a functional role for quantum coherence in photosynthesis still eludes researchers. Recent research has instead highlighted an interplay between both quantum and classical mechanics in photosynthetic systems. (Kim et al. 2021, 3, 1–48)

The development of more sensitive detectors may, hopefully, help clarify the relationship.

Example Two: Quantum Robin-Entanglement in Biology. Since the late 1970’s it has been known that the European robin in its migration from Sweden to Spain every fall somehow detects the electromagnetic field of the earth, known as magnetoreception. This field is very weak, about one hundred times weaker than a refrigerator magnet. How does the robin do it? It has been discovered that a protein in the retina of the bird’s eye, called cryptochrome 4, has within it a pair of entangled electrons. McFadden and Al-Khalili observe,

> To understand how quantum entanglement gets tangled up with biology we have to combine two ideas. The first is this instantaneous connection between two particles across space: entanglement. The second is the ability of a single quantum particle to be in a superposition of two or more different states at once: for example, an electron could be spinning both ways at once, so we would say it was in superposition of “spin up” and “spin down” states. We combine these two ideas by having two entangled electrons in an atom, each in a superposition of its two spin states. (McFadden and AL-Khalili 2014, 186)

It is this state in the chryptochrome 4 (CRY4) protein that allows the robin to detect the electromagnetic field, because, as photons of light hit the retina, chryptochrome 4 forms free radicals which affect the final chemical state in the bird’s eye. McFadden and Al-Khalili again,

> As we described, the energy of this photon is used to eject an electron from one of the atoms within the FAD molecule [the pigment molecule *flavin adenine dinucleotide* that absorbs blue light], leaving behind an electron vacancy. This can be filled by another electron donated from an entangled pair of electrons in an amino acid called tryptophan within the chryptochrome

> protein. Crucially, however, the donated electron can remain entangled with its partner. The pair of entangled electrons can then form a superposition of singlet/triplet states, which is the chemical system that Klaus Schulten found to be exquisitely sensitive to a magnetic field. (2014, 191)

This electron state is so sensitive to the electromagnetic field that it makes a difference in the chemical products produced so that a signal is sent to the bird's brain telling it where the nearest magnetic pole lies (2014, 192). McFadden and Al-Khalili then reflect, "We have no idea what this magnetic 'seeing' looks like to birds, but since chryptochrome 4 is an eye pigment that is potentially doing a similar job to the opsin and rhodopsin pigments that provide color vision, perhaps the bird's view of the sky is imbued with an extra color invisible to the rest of us (just as some insects can see ultraviolet light) that maps onto the earth's magnetic field" (2014, 192). It is really quite amazing, to think that this robin may, in some way, be able to *see* the electromagnetic field and that the color intensity perhaps provides it migrating direction.

This understanding of magnetoreception has recently gained more experimental evidence and demonstrates the value of quantum phenomena for classical functions. Emily Conover,(2021) writing in *Science News*, drawing on an experiment review article from *Nature*, summarizes that, "Scientists think that the magnetic sensing abilities of CRY4 are initiated when blue light hits the protein. That light sets off a series of reactions that shuttle around an electron, resulting in two unpaired electrons in different parts of the protein. Those lone electrons behave like tiny magnets, thanks to a quantum property of electrons called spin."spPeter J. Hore and Henrik Mouritsen, writing in *Scientific American* in April 2022 (3), also affirm the role of blue photons setting off electrons in the tryptophan of the retina behaving like a "molecular wire." These results are significant on several fronts. If the radio-frequency fields affect the magnetic sensor and not, say, some component of the signaling pathway that carries nerve impulses to the brain, then they provide compelling evidence that a radical-pair mechanism underpins the bird's magnetic compass. Such quantum-based direction finding may also eventually be found in other migrating creatures. So superposition and entanglement are increasingly thought to occur in the biological world.

This discussion of quantum decoherence and quantum biology has attempted to show that it is not inappropriate to metaphorically employ quantum concepts beyond the quantum level. They do appear to be present and influential at these more complex levels. When we move to the biological level, however, another great challenge to theological appropriation appears, namely, the massive suffering, death and extinction that is found in evolutionary history. How can God be understood to be present in the midst of such loss? Is God the cause of such suffering and loss? This raises the difficult question of evolutionary theodicy.

Evolutionary Theodicy and Deep Incarnation[3]

The issue of evolutionary theodicy is concisely focused by Niels Henrik Gregersen. The deep question is, "Indeed, if God's way of maintaining and developing the world of creation happens through the means of natural selection, *how can the Christian belief in the mercy of God be consonant with the ruthlessness of evolutionary processes?"* [Italics not mine] (2001, 192). Christopher Southgate's work on evolutionary theodicy proves very helpful here.

Evolutionary Theodicy

One of the most helpful ways to address theodicy (the reconciliation of the existence of God with the existence of evil and suffering) is to do a good/harm analysis (GHA) of the various aspects and recipients of actions. Christopher Southgate and Andrew Robinson have developed a threefold typology for GHA, which provides a background for analyzing various types of theodicies.

(1) Property-Consequences GHA (Eteological): A consequence of the existence of a good as a property of a particular being or system. For example, "Free Will."

(2) Developmental GHA (Teleological): The good is a goal which can only develop through a process which includes the possibility of harm. For example, Irenaean/Hick "Soul Development."

(3) Constitutive GHA (Axiological): The existence of a good is inherently, constitutive, inseparable from the experience of harm or suffering. For example, Beauty/Ugliness (Southgate and Robinson 2007, 70).

This then produces nine types of possible theodicies, with three types of theodicy for each category of GHA depending on whether the focus is on a "Human," "Anthropocentric," or "Biocentric" Reference (Southgate and Robinson 2007, 72). It is not necessary to go into these various types here but only to see that in many cases more than one type of theodicy might be necessary, especially if one is addressing both the human and wider biotic (creation) suffering simultaneously.

Drawing on this GHA, Southgate works with the insight that questions of theodicy are of different types so that only one explanation is insufficient. He proposes what he calls a "compound theodicy" involving several different approaches. In his very fine book *The Groaning of Creation: God,* *Evolution, and the Problem of Evil*, he offers six affirmations for a compound theodicy;

> 1) the affirmation that creation is good, 2) an only way argument, "An evolving creation was the only way in which God could give rise to the sort of beauty, diversity, sentience and sophistication of creatures that the biosphere now contains." 3) that God co-suffers with "every sentient being in creation," 4) the Cross of Christ is the epitome of this divine compassion, 5) a pelican heaven (McDaniel) where creatures "that have known no fulfillment in this life" will find it so that, "No creature should be regarded as an evolutionary expedient." 6) a high doctrine of humanity as co-Redeemer so that humans, "have a crucial and positive role, cooperating with God in the healing of the evolutionary process." (2008, 15–16, see also 2002)

Southgate observes, "All evolutionary theodicy, then, should start from a version of the 'only way' argument, based on a developmental good-harm analysis. This was the only, or at least the best, process by which creaturely values of beauty, diversity, and sophistication could arise" (2008, 48). (For a fine collection of critiques, see *Zygon* September , regarding animal suffering, Sollereder, 2019.)

Southgate then seeks to argue for a "deep intratrinitarian kenosis" which links, "the creation of biological selves to the theology of Trinitarian creation" so that, "It is from the love of the Father for the world, and for the glory of the Son, that other selves gain their existence, beauty, and meaning, that which prevents them from reverting to nothingness….It is from the power of the Spirit, predictable only in its continual creativity and love, which is the same self-transcending and self-renewing love as is between the Father and the Son, that each creature receives its particularity" (63). Connecting this with the GHA would necessarily include the loss of species as well as generalized suffering for all biological creatures, but this is the price that is paid to achieve such emergent complexity, not the result of a human "fall" which would have had to come much later in evolutionary history (2020, 61–75).

Southgate goes on to affirm that God is a co-sufferer and that no creature is simply an "expedient" a "means" to a more complex level to ease the impact of such evolutionary loss (2008, 16) (For more on animal suffering, see Sollereder.) This is where the "pelican heaven" (McDaniel 1989) affirmation comes in so that all creatures will experience ultimate fulfillment not just the human. Southgate concludes, "In a sense all theodicies that engage with real situations rather than philosophical abstractions, and endeavour to give an account of the God of the Christian scriptures, arise out of protest and end in mystery" (2008, 16). The concept of panentheism may assist in explaining how this could all be taking place within God in the God-World relationship, while God is also able to transcend it and preserve the meaning and beauty that has been created. (See Whitehead 1929 and 1979, 349—350, Dodds, 2012.) Gregersen's concept of deep

Incarnation develops the identification of God in Christ with the whole of creation and with the suffering of all creatures and may offer a way to contextualize this loss in wider evolutionary development, providing meaning and hope in the face of evolutionary theodicy (Greshko, 2019).

Deep Incarnation

Historically, in trying to understand the "Word became flesh," (*logos sarx egeneto*) (John 1:14), the emphasis has been upon human flesh with an anthropocentric bias. Redemption for the rest of creation was deemphasized. Today, with environmental crises, there is a need to expand "flesh" to a more ecocentric and inclusive focus, to support redemption for all living creatures and the natural environment. Regarding this anthropocentrism of Christian theology, H. Paul Santmire observes, "This was a fateful mistake. If theology is fundamentally *theoanthropocentric*, then the natural world will have its ultimate meaning, it's *raison d'être*, only in terms of God and humanity, as a kind of appendix. Nature will be allotted no integrity of its own in the greater scheme of things. Nature, at best, will have instrumental meanings" [Italics not mine] (2020, xiv). We are paying the price for this position today in the ecological crises we are facing. Santmire argues for a more faithful attitude toward nature based on a *theocosmocentric* paradigm observing, "This way of thinking takes God's purposes with the whole natural world just as seriously as God's purposes with humanity in particular" (xv). To do this requires us to understand God identifying with creation in all its diversity and conditions, including death and suffering. This is where entangled panentheism meets deep Incarnation in the ecology of creation.

Gregersen's concept of deep Incarnation proposes that the "flesh" (*sarx*) of Christ, as with all human flesh, involves the most fundamental processes of biological life and as such connects to all living creatures. That is why it is referred to as "deep," going below the human macro level alone. Denis Edwards contends that, "The cross of Christ reveals God's identification with creation in all its complexity, struggle and pain. Gregersen finds in the cross a microcosm of God's redemptive presence to all creatures that face suffering and death" (2006, 59, 2007.). For Christians this flesh is the basis for God's identification with the suffering of humanity and the wider creation so that it holds redemptive power for all of life. Gregersen clarifies,

> In this context the incarnation of God in Christ can be understood as a radical or "deep" incarnation, that is, an incarnation into the very tissue of biological existence, and systems of nature. Understood this way, the death of Christ becomes an icon of God's redemptive co-suffering with all sentient life as well as with the victims of social competition. God bears the cost of evolution, the price involved in the hardship of natural selection. (Gregersen 2001, 205)

In effect, deep Incarnation affirms a *creatio crucis*, a form of creation through the cross, and addresses the problem of evolutionary theodicy grounded in the brutality of natural selection. In a more recent work speaking of the Trinitarian nature of deep Incarnation, Denis Edwards elaborates, "He [Gregersen] speaks of the 'stretch' of the Trinity, of the relation between the Father and the Word which is bridged by the Spirit. It is this 'divine stretch' between the father and the eternal word, mediated by the Spirit, which is the presupposition of the divine stretch, or reach, into the depths of creation and deep incarnation. Deep incarnation is mediated by the Holy Spirit of God at every point" (2019, 22). While creation is cruciform in nature, a *via dolorosa* as Rolston describes it, with Divine "kenosis" that need not be all that it is, (Wegter-McNelly, 2007).s

This kenotic "emptying" of God into creation does not necessarily mean a withdrawal or absence of God from the world. *Kenosis* has often been used to discuss the Incarnation in relation to humanity but not to describe God's relation to the creation. However, there are multiple meanings for *kenosis* which would also allow for the God-Creation relationship. Gregersen points out that historically there are four different models for kenosis;

(1) God as *voluntarily abdicating*,
(2) God undergoes a *radical metamorphosis or historization*,
(3) God kenotically *refrains from the exercise of detailed predetermination*, and
(4) "By creating the world out of love, God neither withdraws from the world nor gives up divine power, but actualizes divine love in the history with God's beloved creatures. Kenosis is here the self-realization of who God eternally is….The self-emptying of kenosis comes out of the divine plerosis, [fullness] and flows into the fullness of life in, with, and under the world of creation" [Italics not mine] (2013, 256–257). This is the model Gregersen prefers, and is assumed in this article as well.

Only models 1 and 2 would require God's absence from the creation. In deep Incarnation, kenosis means, rather, that it is not a full disclosure of who God is. (For a variety of perspectives on deep Incarnation, see Gregersen, ed. 2015.)

The heart of the Christian faith is the affirmation that God has become "Emmanuel" and, through St. Paul, this "with-us-ness" is understood as the kenotic self-emptying of God in Christ (Phil. 2:7). Kenosis becomes a theological window through which to peer into the heart of divine love and as such reveals not only the manner of the Incarnation but also the very nature of the Triune God. Kenosis understood through the metaphor of entanglement can be used to characterize the spiritual presence of God in the world through nonlocal relational holism and superposition. (See Simmons 2014, Chapter 9.) God is always "with us" as the divine superposition within the midst of the creation. But in the Incarnation, this superposition takes on a unique character as it "collapses" into the particularity of the Incarnation, which is the presence of sanctifying agapeic love in a particular time and place. With the Incarnation, the logos that has been implicit within creation becomes explicit, becoming transparent to the God with whom it exists. The entanglement becomes explicit. One could say that the Son kenotically gave up the Trinitarian *perichoresis* precisely in order to enter into the creation. Christ kenotically emptied himself of the immanent perichoresis of the Trinity in order to enter the economic perichoresis of the creation. The Communion of God clearly becomes communion which includes the world (Simmons 2014, 177). Gregersen further clarifies, "Neither divine omnipresence nor incarnation presuppose that God is 'omni-manifest,' that is, revealed in all the vicissitudes of natural evolution and human history, including natural and human horrors. Rather, the point is that the embodied Word of God shares *from within* the sufferings of all who suffer from the powers of tsunamis, earthquakes and hunger and *takes the side* of the victims of the horrors that human beings inflict upon one another" [Italics not mine] (2015, 235).

Entanglement is one way of conceptualizing this interrelationality, affirming that God is continually present with all creaturely suffering. To be enfleshed means to be entangled biologically. Since God is so related, however, suffering and death need not be the end. The point of understanding the Incarnation as deeply entangled enfleshment is that it brings the suffering of creation into the life of the Redeemer as well as the Creator facilitating redemption and hope through the divine life. The entangled Trinity affirms the interrelationality of the whole of the Economic Trinity so that all creational suffering is brought into the divine *perichoresis* of the Immanent Trinity where it is overcome by divine love which then overflows back into the creation providing hope and grace even in the face of loss. In that transformation lies hope and the divine promise that death shall not be the end. Through the Creative Spirit, there is also a new creation from the old, *creatio nova ex vetere* (Gregersen 2001, 193). Theologian Elizabeth Johnson refers to this as "deep resurrection" (2014, 192–210) and affirms such deep redemption in her book *Creation and the Cross: The Mercy of God for a Planet in Peril*, which seeks to save not only the human species but all species and "will redeem the whole cosmos" (2018 190). With the presence of the Creative Spirit there is the possibility of community, change, redemption and hope which can allow for the preservation of the value of all creatures in God. The creation too becomes *larva Dei*, the "masks of God" as Martin Luther referred to it (Westhelle 2016). This means that while in faith one may appeal to God as Creator one cannot prove such a creation by empirical observation of the natural world.

The Christian affirmation is that Divine love is at the heart of both creation and redemption. Understanding that love as thoroughly enfleshed and entangled with creation connects it to all sentient creatures and perhaps to the cosmos itself.[4] It has been the purpose of this article to show that the scientific understandings of quantum decoherence, quantum Darwinism and quantum biology, demonstrating the plausibility of quantum phenomena scaling up to the classical and biological levels, gives credence to the theological utilization of such concepts for metaphorically expressing the relationship of God and the world and the possibility of hope and redemption for all of creation in the face of suffering, death and even extinction. The metaphorical appropriation of these quantum concepts assists in making a coherent presentation of the Christian understanding of God to a contemporary scientific and technological society. Indeed, quantum entanglement may provide metaphorical assistance in articulating deep incarnation in ways that can bring hope to life caught in the inexorable vice of natural selection.

Notes

1. See Kirk Wegter-McNelly (2011). In Chapter 6, he does briefly, referencing my earlier work (1999, 2006), support the understanding of entanglement as mutual indwelling leading to an enriched understanding of the Trinity but his overall focus is upon the relation of God and creation. He does not further develop the Trinity nor place it in a wider panentheistic model which I am doing here.
2. For an excellent, extended, summary of the current state of quantum biology, please refer to Kim et al. (2021). For a critique of Neo-Darwinism and descriptions of the new understandings of evolutionary development "evo-devo" and the extended evolutionary synthesis, see Moritz (2018) .
3. Some of the material in the following sections draws upon Simmons (2021).
4. For an interesting exploration of this topic, see Ted Peters (2020).

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