

## Wonder and the necessary alliances of science and religion

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### Abstract

*Both science and religion claim descent from wonder. In the first part of this essay, I analyze these paths of descent and use this common origin from wonder to model how science and religion could creatively act in concert. In the second portion of this essay, I try to show how new concepts of evolution coming from developmental biology and symbiosis research strengthen the links between science and religion. These concepts place the competitive model of evolution within a larger non-competitive, and even cooperative, framework. I use embryological models to discuss how new things are generated by interactions between prior entities that are different from one another yet sharing underlying similarity. In the third portion of the essay, I document the need for concerted action of science with religion in the conflicts and alliances between three great centers of social power: science, religion, and corporate interest. Recent data has shown the immediate need for strong alliances between science and religion in preserving wonder and life as we know it.*

### 1. Wonder, the common progenitor of religion and science

“I am fearfully and wonderfully made,” says the psalmist (Psalm 139:14). But what is it to be fearfully and wonderfully made? How does one respond to this wonder and *yiráh*/fear/awe of one’s body? I want to go back to the source of these questions: wonder. I will be proposing some hypotheses concerning wonder and the relationship of science and religion.

I profess embryology, the science of how one’s bodies are made, a science that seeks answers to ancient questions: How did I come into being? How does sexual union generate a new life? How do I come to look like my parents? How come I have only two eyes, and they are both in my head and nowhere else? How do my muscles become connected to my bones? How come some people have penises and others can have babies? What traits of mine are learned culturally and which ones did I inherit biologically? How am I like and how am I different from other animals? Why can’t I grow back my hand like salamanders do?

Embryology is a profession where wonder remains an operative category. Reviewers of embryology textbooks will write whether or not they think the book under consideration has captured the wonder of development. Wonder is actually expected in the teaching laboratory, and it is used as a motivation to learn the science. French embryologist Jean Rostand [1] said it very well when he wrote, "What a profession this is – this daily inhalation of wonder." As an embryologist, I'm privileged to experience wonder daily and to expect to be amazed when I enter the laboratory. For many of us, though, wonder has become something we experience only on vacations or as a surprise.

I would contend that wonder is a primary experience, the result of the mind encountering the universe. But only mystics, perhaps, can live in a state of perpetual wonder. For most of us, wonder has a short half-life and rapidly decays into two lesser, but still powerful components: awe and curiosity. This is clearly seen in language, where wonder has both these meanings. Curiosity is seen in the English expression, "*I wonder.*" Awe is seen in our declarations of "*the wonder of the world.*" Awe and curiosity both originate from wonder. From curiosity comes the quest for truth about the physical universe and the testing of ideas against other ideas and against experience; that is to say, the foundations of philosophy and science [2]. From awe come the reverence and gratitude that are characteristic of the religious attitude. Science and religion, let me hypothesize, both descend from wonder.

We see this genealogy from wonder in fragments, and I will try to put them together. First, let's look at the path to science. Plato and Aristotle both agreed that wonder is the beginning of knowledge. Echoing Plato's Theaetetus, Aristotle [3, 4] notes, "For it is owing to their wonder that men both now begin and at first began to philosophize". At the beginnings of modern science, Francis Bacon [5], no friend of either Aristotle or Plato, reaffirmed that wonder was "the seed of knowledge." Statements of wonder are not uncommon in the autobiographies of our contemporary embryologists [2].

One of the most important statements of wonder in embryology is from the medieval rabbi and physician Maimonides. He writes [6]:

*A pious man of my time would say that an angel of God had to enter the womb of a pregnant woman to mold the organs of the fetus...This would constitute a miracle. But how much more of a miracle would it be if God had so empowered matter to be able to create the organs of a fetus without having to employ an angel for each pregnancy?*

Indeed, my job, my career, is to discover some of the ways by which ordinary matter (whether divinely created or not) can form itself into an organized embryo. It's amazing. The biologist and poet Miroslav Holub [7] writes:



*Between the fifth and tenth days the lump of stem cells differentiates into the overall building plan of the embryo and its organs. It is like a lump of iron turning into the space shuttle. In fact, it is the profoundest wonder we can imagine and accept, and at the same time so usual that we have to force ourselves to wonder about the wondrousness of this wonder.*

Yet, I write about the molecules and processes by which the embryonic stem cells interact with their neighboring cells to create the precursors of the brain, heart, skin, and gut. The knowledge of how this wonder takes place does not diminish it in any way. Rather, in positive feedback, it makes the process even more wonder-full. “The amazing thing about mammalian development,” writes embryologist Veronica van Heyningen [8], “is not that it sometimes goes wrong, but that it ever succeeds.” So wonder can give rise to curiosity, which promotes the theorizing and testing that is science. Wonder can give rise to knowledge.

But knowledge is not wisdom. Moses, Jesus, Siddhartha, and Muhammad did not know the number of protons in a carbon atom or the four bases of DNA. Knowledge is critically important, but it cannot pass for wisdom.<sup>1</sup> Wisdom is how to use one’s knowledge to lead a righteous life. It is the framework of the mind, not its furniture. “Awareness of the divine,” writes religious philosopher Abraham Joshua Heschel [11], “begins in wonder.” For wonder generates not only knowledge, but also wisdom. He continues, “The beginning of awe is wonder and the beginning of wisdom is awe... Knowledge is fostered by curiosity; wisdom is fostered by awe.”

So here we have part of the genealogy from wonder. Wonder can generate curiosity and awe. From curiosity, one gets knowledge. From awe, one can get wisdom. Commenting on the numerous times in the Bible (e.g., Proverbs 1:7; Psalm 111:10; Job 28:28) where awe is pronounced to be the beginning of wisdom, Heschel [11] claims that awe is the primary requisite of the religious attitude. “Awe precedes faith; it is at the root of faith.” The Scottish philosopher and essayist Thomas Carlyle [12] similarly viewed wonder, not faith, as the basis for worship.<sup>2</sup> According to this perspective, awe is the principle attitude of the religious

<sup>1</sup>There are, however, important relationships between knowledge and wisdom. One rabbinic commentary (Tanhuma 2,5; see [9]) suggests that Noah was called “righteous” because he went out of his way to painstakingly acquire detailed knowledge of the habits and feeding schedules of the animals so that he could house them properly on the ark. Here we have the beginnings of the notion that one has to know what is true in order to do what is good. The agnostic evolutionist Thomas Huxley [10] made this an explicit principle: “Learn what is true in order to do what is right.” Here we also see one instance how science and religion can form alliances despite their differences. To this biologist (and I’m sure to many more), the Noah story is probably the stupidest narrative of the Bible. However, we can learn from this story that the world can suffer for human moral failings, that humans have a stake in creation, and that wisdom needs knowledge.

<sup>2</sup>“Worship is transcendent wonder,” wrote Carlyle [12], and he agreed with Novalis that the wonder of all wonders, the true object of veneration, must be the human body. There are very few religious prayers or rituals that acknowledge the wonder of our carnal bodies. One of those prayers is the Jewish prayer, “*Asher Yatzar*,” which is said after successful defecation or urination ([www.jewishpathways.com/files/asher-yatzar.pdf](http://www.jewishpathways.com/files/asher-yatzar.pdf)). It acknowledges that God has made us “with wisdom,” and that if any of our body’s valves be open when it should be shut or shut when it should be open, we would not be alive to offer praise to God who heals the flesh and acts wondrously (“*U’mafli la’asos*”). This prayer, coming when it does, also celebrates the wonder of metabolism. We have numerous prayers for the entry of food into our body; this prayer may be unique in celebrating its exit. But both intake and exit are critical events, worthy of blessing, for they mark our

person, since awe generates the reverence and gratitude that are critical for the religious view of the world. Thus, one can affirm the following lineages from wonder: wonder gives rise to curiosity and awe. Curiosity gives rise to science and philosophy; awe gives rise to religion.

Surprisingly, then, science and religion, instead of being antagonistic enemies, find themselves to be close relatives, cousins, grandchildren of wonder. Any fights between them are within the family, not between aliens with separate genealogies. And what we call “science” and “religion” are only two members of the family. In this essay, “religion” will be shorthand for “religious attitude.” This awe-inspired attitude, preceding theology, does not depend on theology; nor is it dependent on belief in a deity. Animistic and pantheistic traditions may, in fact, apprehend the awe in nature more directly than monotheistic religions; and Humanists, although denying a transcendent deity, recognize awe in nature as well as in artistic achievements.<sup>3</sup>

So what do we do with this newfound family? Here, again, Heschel helps us by stating the problem in a stark existential manner: “It is not a sense of awe, wonder, or fear, which is the root of religion; but rather the question of what to do with the feeling for the mystery of living, what to do with awe, wonder, or fear...” Moreover, warns Heschel [11], “As civilization advances, the sense of wonder declines... Humankind will not perish for want of information; but only for want of appreciation.”

The problem, then, is two-fold. First, why doesn't our civilization sufficiently recognize wonder? And second, how do we respond to wonder? To answer the first question, we find that much of this decline in the sense of wonder is due to the structure of our disciplines. There is in Western thought a fear of Wonder and its power. Philosopher Mary-Jane Rubenstein [15] has documented that one of the West's most important philosophical projects has been the internalization of wonder into philosophy, making wonder, itself, an object explainable by rational thought. Wonder may have been the font of knowledge for Aristotle, but he claimed that after it initiated curiosity, wonder would be dangerous, preventing one from rationally realizing “the better state” of knowing the causes. Similarly, René Descartes and Francis Bacon saw wonder as a passion that precedes knowledge and which must be quickly jettisoned. To them, the rational control of the wondrous was a source of power. And in religion, wonder and awe become replaced by theology and piety. Without awe, both theology and piety get stripped of fear and trembling, of power and of the recognition that one is not “in control,”

metabolism. Metabolism is nothing less than the strategy of living matter. It is the separation of form and substance. We live by constantly changing our component molecules. If they do not change, we die [13, 14]. The metaphor is that of a wave or whirlpool that keeps its identity and form by changing the molecules that comprise them.

<sup>3</sup>In America, humanists have shown much more sensitivity to the awe of nature than fundamentalists, who view the Bible as a science text, reducing wisdom to mere “fact.” Later in this essay, we will focus on Western monotheistic religions, because the crisis in the environment is a Western-derived crisis, and it reflects power relationships between science, religion, and economics that are particularly Western. In that power network, humanism becomes less important, as it can appreciate awe and defend it intellectually, but it has so far lacked the emotional force to rally people against corporate interests.

a recognition crucial to wonder in both science and religion. So one important project, one that should be performed in science and religion, is to take wonder seriously and to realize that it is becoming endangered. It cannot be assumed anymore.

The second question concerns what to do with the sense of wonder, awe, and fear; and that is the subject for the remainder of this essay. The main answer is that the two “warring” descendents of wonder—religion and science—will have to form alliances. According to the model I’m presenting, both science and religion depend on wonder and will perish without wonder. So science and religion should be allies in preserving the sources of wonder. At the present, we have three enormous social sources of power: science, religion, and economic profit. As long as science and religion remain enemies, money wins. It will create technologies out of science for the pollution of the planet in the name of progress, and it will create theologies that conflate a person’s worth with his or her financial worth. However, it is not difficult to imagine a series of real alliances between science and religion. Imagine evangelical Protestants with a serious view of stewardship allying themselves with evolutionary biologists for the protection of wetlands. Imagine staunch Roman Catholics making agreements with Planned Parenthood to protect the fetus by eliminating BPA and other fetotoxic chemicals from the environment.

Yes, it means “dealing with the devil.” But let’s assume that both creationist Protestants and agnostic biologists both want their children to see the loons landing on the lake and to know the taste of freshly caught trout. Let’s assume that the Catholic Archbishop and the physician who prescribes birth control pills both want healthy babies in healthy families. These are certainly not unreasonable assumptions. And such alliances are forming. Recent examples include efforts by the Ethiopian Orthodox Church [16] and the Greenbelt Movement<sup>4</sup> to save and restore forests in Africa, as well as the stewardship coalitions mobilized to stop mountaintop removal coal mining in the Appalachians [17]. In America, the Creation Care movement has urged its subscribers to support legislation tightening restrictions of environmental mercury. “Being ‘pro-life,’” says one editorial [18], “is more than being ‘anti-abortion.’” Stewardship and protection of biodiversity is an area where science and religion can become allies.

## 2. Darwinism and the schism of science and religion

One of the major reasons why biology and religion have been at odds with each other is a scientific theory of biodiversity called “evolution” or “Darwinism.” Evolution is certainly at odds with the literal words of the Bible; but such “Young Earth Creationists” are only a small minority of the people opposed to evolution. More people are against its materialism (no Divine cause is needed), its contingency (there’s no “plan” in nature and no evidence

<sup>4</sup>The Greenbelt Movement, <http://www.greenbeltmovement.org/>

that God cares particularly for the human species), and most importantly, the competitive behavior that is the center of “survival of the fittest” [19, 20, 21, 22].

The adjective “Darwinian” is often used in popular culture to denote competition to the death. Evolutionary theory is indeed about life and death and has four major components [23]:

- there is variation within a species;
- most animals do not survive to reproduce;
- those animals that do survive to reproduce have certain traits that make them particularly fit for the environment;
- the members of the next generation come from this group of survivors and bear the genes that produced the traits that made their parents fit for particular environments.

Evolutionary theory has been tested for over 150 years and it has survived each challenge. We can even look at the genes between chimps and humans and see where we differ. We can even see evolution occurring. When we treat mosquitoes with DDT, only those insects carrying genes enabling them to degrade DDT will survive. In areas of malaria, those humans carrying genes that prevent the malarial parasite from entering their blood survive preferentially. Notice that “competition” is not due to physical violence, but to genes transmitted by parents. Still, there is competition between members of the same species.

The person who promulgated the view that this competition was warfare was Darwin’s friend and colleague, Thomas Huxley. He called nature a “gladiator spectacle,” and he also popularized the paradigm of warfare between science and religion [24, 25]. Huxley felt that he and other non-clerical scientists should be able to teach biology at a first-rate university. In Victorian England, however, he could not teach biology at the Universities of Cambridge or Oxford without being an Anglican clergyman. For nature was seen as God’s creation, and only men of God could interpret it. Science was in the service of religion. Huxley used evolution as a way of separating Nature from God, and in so doing, helped create and propagate the paradigm of science versus religion [26]. While the warfare paradigm is not used today by most scientists (many of whom feel privileged to experience firsthand the awe in nature and who are members of established religions [27, 28]), this paradigm is still being propagated by Richard Dawkins, Daniel Dennett, Rush Limbaugh, and Stephen Meyer.

### 3. A New biological paradigm

Neither of these paradigms – science in the service of religion or the warfare of science and religion – work well today. We need new paradigms relating the offspring of wonder. One

such paradigm may come from the mixing of evolutionary biology with embryology. This paradigm changes evolutionary biology from being a strictly competitive process to being a process that integrates cooperation with competition, with cooperation actually playing a predominant role. The living world, it seems, is full of strange alliances. Let me quickly describe three biological principles that are being introduced into evolutionary biology [23].

### *3.1 Reciprocal induction*

Bodies are made through reciprocal interactions. The fertilized egg divides several times and produces a few different cell types. These cells then interact with one another to produce new cell types and organs. For instance, when a group of cells extending from the brain touch the cells of the head epidermis, these epidermal skin cells are turned into the lens, and the brain cells are transformed into the retina. Interactions between brain cells and skin cells create the retina and the lens, and establish their positions in the eye. The retina and the lens did not exist before this interaction [29]. This reciprocal interaction created new things—a lens, a retina, an eye. Similarly, the limbs and the heart form by interactions between cells. The cells reciprocally change each other. They cannot become what they need to become to make a healthy organism without each other.

This central paradigm of interactive development (the type of development used to generate most organs) is that, first, the single cell, the fertilized egg, divides to create numerous cells. These cells differ by the cytoplasm they inherit or their position in the embryo. The important thing is that even though they possess the same genes (since they are the mitotic descendants of the fertilized egg), they are expressing different subsets of these genes. Once there are differences, then the cells can interact and further change the genes being expressed in their neighbors [30, 31]. All cells are neighbors to other cells, and so they are both affected and affecting in reciprocal relays. Thus, in kidney development, the dozen cell types of the adult kidney are each formed by the interactions of two sets of founder cells. Each of the founder cell types would die if they did not interact. But by their interaction, they form the kidney cell types in the correct linear arrangement.

### *3.2 Evolution as changes in developmental regulation*

How does novelty enter the world? How is a new type of organism produced? Darwin's theory of natural selection works exceptionally well to explain how species adapt to their environments and to explain descent with modification [23, 32, 33]. However, to form new modes of organization—the shells of turtles, mammalian hair, or the large brains of humans, one needs to understand that these are alterations in embryonic development. As Thomas Huxley [30] said in 1893, "Evolution is not speculation but fact; and it occurs through epigenesis." Epigenesis is the technical term for progressive body construction, a term borrowed



from Aristotle and used extensively in the late 1800s to denote embryonic development. But it was only a century later that we had a theory of body construction, so traditional evolutionary theory did not include this area. Competitive selection of existing variation is one part of evolution; but the origin of the existing variation, as Darwin knew [34], was the remaining part.

As the genetic mechanisms of epigenesis were becoming discovered in the 1970s, Alan Wilson and Mary-Clair King [35] and François Jacob [36] argued that variation had to be generated during the embryonic and larval periods. The critical differences between chimpanzees and humans or between shrimps and insects lay not in the portion of the genes encoding the proteins used in competition between adults, but in the regulatory regions of genes that are involved in constructing the embryo. The important genes were those generating anatomy, and the key to evolution was to be found in how those genes were controlled during development. Hughes and Kaufmann [37] framed the question very succinctly when they wrote,

*To answer this question [of arthropod adaptations] by invoking natural selection is correct – but insufficient. The fangs of a centipede ... and the claws of a lobster accord these organisms a fitness advantage... However, the crux of the mystery is this: From what developmental genetic changes did these novelties arise in the first place?*

By altering the reciprocal interactions creating organs, one can change the way the animal develops, and hence, its final anatomy.

In general, development can be altered by changing gene expression in any of four ways [38, 39]. Changing the *place* of gene expression enables the formation of such new structures as the turtle shell, the duck's webbed foot, and the bat's wing [40, 41, 42, 43]. By changing the *duration* of developmental processes, one gets such novelties as the dolphin's flipper [44], the snake's ribs [45], and the enormous growth of the human brain. Indeed, current developmental genetic research has shown that there are some genes that promote brain cell division and others that inhibit it. Human brain growth appears to be a combination of the activation of those genes promoting development combined with the repression of those genes retarding development [46, 47]. By altering the *amount* of gene expression, one can explain the different beak shapes of Darwin's finches, as well as the ability of certain people to resist worm parasites better [48, 49]. Last, by actually altering the *composition* of the gene being expressed during development, one can explain how insects come to have only six legs and how the corn kernel grows on the outside of the plant – a mutation that facilitated its use as food [50, 51, 52]. Notice that these changes occur within the embryo. They do not involve adults competing for reproductive success. They concern the arrival of the fittest, rather than the survival of the fittest. This area of evolution concerns the origin of new anatomical structures. It is not about the selection that fine-tunes the members of a species to particular environmental conditions; it is about the origin of the variation that natural selection selects.



### 3.3 Mutualistic symbiosis

Interactions between different species of organisms create new and stable types of organisms. Each organism has its symbionts, persistent microbes that can be acquired from the environment or transmitted from the mother. With the advent of polymerase chain reaction, high throughput RNA analysis, and next-generation DNA sequencing, it was discovered that we are not “individuals” by any of the major biological categories [53]. Anatomically, we are certainly not individuals. We become colonized by microbes at birth, and eventually 90% of our cells are bacterial. We are a complex series of ecosystems, and each of us house about 160 major species [54]. Physiologically, we coordinate metabolic pathways with symbionts. In some insects, essential amino acids are made by enzymes provided by both the symbiont and the host. Genetically, animals have “outsourced” to the microbes the genes that encode these enzymes as well as encoding certain developmental signals. The genomes of animals complement those of their symbionts [55, 56]. The maintenance of our health is critically dependent on these microbes [57, 58, 59]. Developmentally, symbionts have several critical functions. Throughout the animal kingdom, guts cannot be properly formed without the help of microbes [60, 61, 62]. This is the case in vertebrates, where the microbes activate gene expression in the cells destined to become the gut. They induce the formation of several enzymes, as well as producing the signals that induce the gut capillaries and the gut-associated lymph nodes [63, 64]. By anatomic, physiological, genetic, and developmental criteria, we are not “individuals.”

Two of the most critical types of biological individuality are immune individuality and evolutionary individuality. But even these are illusory. The “immune self” model of individuality, was first proposed by Sir McFarlane Burnet [65], and it depicts the immune system as a defensive network against a hostile exterior world. The immune individual rejects anything that is not “self.” But recent studies (see [53]) have shown that this is only a portion of its role. The immune system appears to have evolved not as a defensive army, but as “passport control” or an experienced “bouncer.” It recognizes and facilitates the entry of those microbes that we have allowed to reside within us, and it recognizes and prevents the entry of those we’ve learned are not good citizens. Indeed, elements of the host immune system have been co-opted to support the colonization, limitation, and persistence of symbiotic bacteria within the host [66, 67]. The microbes reciprocate by helping the further development of the immune system, primarily but not only in the gut [54, 67, 68].

The evolutionary selection of the “individual” is now being seen as a more complex situation; because the “individual” has numerous genomes, not just one. In the pea aphid, for instance, the symbiotic microbes provide selectable variation to the entire organism. The genes of some symbiotic bacteria determine whether the aphid is red or green [69]; the genes of other bacterial symbionts determine the aphid’s rate of reproduction and whether the entire organism can survive at high temperatures [70]. Still yet another symbiotic bacteria species provides protection against parasitoid wasps [71]. In humans, there is also evidence that variations

of symbiotic microbes may provide selectable variation [72]. Moreover, since these microbes are often inherited from the mother, they form a second level of genetic inheritance [73, 74]. Thus, nature may select “teams” or “relationships.” The name given to this new “individual” made of multiple genomes is the “holobiont” [53, 75, 76].

#### 4. Philosophical importance of the new biological paradigm

The theory of evolution evolves, and it is now incorporating these aspects from other areas of biology. One of the most important findings has been that each “individual” organism develops symbiotically. Neither animals nor plants develop from a single set of genes. Some of the reciprocal embryonic inductions are coming from cells of other species! The trees that you see are not individuals. Each tree is a community ecosystem. Not only is it not an individual. It never was. Its development is determined by several sets of organisms. Their very cells are populated by other cells [77, 78]. The parable is not only of the mustard seed, but also of the orchid seed. Consider the beauty of the orchid. Note its symmetry, its color. But consider also that the orchid seed cannot germinate when planted. It is too small and does not have the nutrients that will enable it to germinate. Moreover, its seed coat is too thick to allow nutrients to enter from the soil. In order to germinate, in order to make the beauty of the orchid, the orchid seed must fuse with a fungus spore. The fungus will provide the nutrients to allow the orchid to grow, and in so doing, makes its home and shelter. The orchid will enable the fungus to propagate, while the fungus allows the orchid to flourish [79]. This is the way life works. One makes alliances that aid both partners. The medical biologist Lewis Thomas [80] wrote about this:

*There is a tendency for living things to join up, establish linkages, live inside each other, return to earlier arrangements, get along whenever possible. This is the way of the world.*

Biologists Lynn Margulis and Dorion Sagan [78] put it this way, when they say that the organism is:

*The co-opting of strangers, the involvement and infolding of others into even more complex and miscegenous genomes...The acquisition of the reproducing other, of the microbe and the genome, is no mere sideshow. Attraction, merger, fusion, incorporation, cohabitation, recombination—both permanent and cyclical—and other forms of forbidden couplings, are the main sources of Darwin’s missing variation.*

And it’s not only for plants and insects. Human beings are made by interactions and alliances. We are made by reciprocal interactions between the cells produced by the fertilized egg. And we are also made by interactions between ourselves and our symbiotic microbes. We are indeed wonderfully made. As mentioned above, ninety percent of all our cells are bacterial, and they are intimately involved in making us who we are. We mammals do not

form our intestines or immune systems without bacterial help. We have outsourced developmental signals to our bacteria. There are salamanders that store algae in their reproductive glands so that the eggs become covered with photosynthetic plants that supply oxygen to the egg mass [81]. There are bacteria that determine the sex of some insects [82], and some molluscs actually transfer the chloroplasts from their algal food into their skin and become solar powered sea slugs [83]. After that single algal meal, they never have to eat again! There is probably no such thing as a biological individual. So evolution is as much (or more) about cooperation than it is competition. Organisms that cooperate best survive best. I am Team Scott Gilbert. We are all lichens.

This paradigm of entities forming themselves by their mutual and reciprocal interactions is beginning to take shape. In the writings of philosopher Donna Haraway [84], we see an ethic of “becoming with” where Deleuze and Guattari [85] meet Darwin and Margulis. Instead of the existential philosophy characteristic of the competitive evolutionary paradigm “I against all others,” she has a paradigm of “I become with and through the other.” And biological science says that this is not metaphor. Haraway grew up as a devout Catholic, was trained as an embryologist, and she writes [86] that the experience of wonder in both science and religion was crucial to the reciprocal inductions that shaped her philosophy. She relates the “becoming with” philosophy directly to both reciprocal induction and symbiosis.

This new biological view of evolution is important because we humans tend to become what we believe we “are.” Again, Heschel [87] crystalizes this view:

*A theory about the stars never becomes a part of the being of the stars. A theory about man enters his consciousness, determines his self-understanding, and modifies his very existence. The image of man affects the nature of man.*

If we believe that science says we are merely aggressive killer-apes directed by selfish genes, then we will consider certain behaviors “normal” or “natural,” whereas the same behaviors might be considered “aberrant” and “unnatural” if we thought that science had determined that we were the current apex of a trend toward altruism and symbiosis. Science is saying that both competition and cooperation are critical. Indeed, if we think of ourselves as communities of several organisms, survival is a matter of cooperation. And that is where we have to begin. The notion that “Darwinian” and “evolutionary” can serve as synonyms for “selfish” and “ruthlessly competitive” has to be called into question, and largely set aside.

We see this biological paradigm being expressed in certain religious views as well. The notion of an uncentered self becoming with others has, of course, been a major part of Buddhist thought. The sage Nagarjuna finds that the world is composed of interactions and that nothing is. He emphasized [88] that “Things derive their being and nature by mutual dependence and are nothing in themselves.” This doctrine, *Pratityasamutpāda*, is variously translated as “dependent origination”, “conditioned genesis”, “dependent co-arising”, and “interdependent

arising.” Thus, any phenomenon comes into being (be-comes) only because of the coming into existence of other phenomena in a network of mutual cause and effect. Indeed, according to Nagarjuna, what the Buddha awakened to (*bodhi* means “to awaken”) was the truth of interdependent co-origination.

But we now are starting to see this concept in Western religions. These strands were always there, but they are now becoming emphasized. The current Pope, writing as Cardinal Ratzinger [89], noted that in Augustine’s parity of substance and relation, “the undivided sway of thinking in terms of substance is ended; relation is discovered as an equally valid primordial mode of reality.” Can it be that Pope Benedict XVI is in agreement with secular Catholic Donna Haraway [84, 90], who claims that “the smallest unit of analysis is the relationship”? In the Quran (Sura 49:13), the creation of differences allow the interactions such that God understands God’s self. God could have created us all the same (and perhaps even all perfect), but instead chose to create us with difference and variety so that we may be in relationship. The writings of one of the leading rabbis of the Nineteenth Century, Rabbi Samson Rafael Hirsch<sup>5</sup>, claimed that, “One glorious chain [...] of giving and receiving, unites all creatures. None has power or means for itself; it receives in order to give; gives in order to receive, and finds therein the accomplishment of the purpose of its existence.” The Jewish toast *L’chaim* (“to life”) is actually in plural form: “To Lives.” This makes biological sense. Our biology has caught up with the Reverend Martin Luther King, Junior’s theological and ecological vision [91], “We are caught in an inescapable network of mutuality, tied in a single garment of destiny. Whatever affects one directly, affects all indirectly.” This widespread theological worldview and the new biological worldview are converging. “The good” writes Heschel [92]

*[...] does not begin in the consciousness of man. It is being realized in the natural cooperation of all beings, in what they are for each other. Neither stars nor stones, neither atoms nor waves, but their belongings to each other, their interactions, the relation of all things to one another constitutes the universe. No cell could exist alone, all bodies are interdependent, affect and serve one another.*

Did someone say that religion and evolutionary biology and contemporary theology could not find common ground and common cause? Here is a new paradigm where Western religions, Eastern religions, philosophy, and science can find common ground and become allies.<sup>6</sup> Interdependency is the way of all flesh. Reciprocal induction and mutual symbioses are excellent

<sup>5</sup>See Hirsch, S.R., “Letter Three”, Nineteen Letters About Judaism, page 29 – available online at [http://www.archive.org/stream/nineteenletterso00hirs/nineteenletterso00hirs\\_djvu.txt](http://www.archive.org/stream/nineteenletterso00hirs/nineteenletterso00hirs_djvu.txt)

<sup>6</sup>Some biology books explicitly use concepts of wonder. Biologist Rachel Carson, whose “Silent Spring” initiated the modern environmentalism movement fifty years ago, also wrote “The Sense of Wonder” [93]. This sense, she said, was critical for scientists in an age where scientifically based technology is becoming so important. “It is a wholesome and necessary thing for us to turn again to the earth and in the contemplation of her beauties to know of wonder and humility.” The humility associated with a scientifically informed sense of wonder is also emphasized in Ursula Goodenough’s “The Sacred Depths of Nature,” which seeks to unite science and religion in the preservation of life and wonder [94]. Goodenough also uses sexual reproduction and ecology to demonstrate the “need for other.” This common ground, of course, will not be

models—literally, win-win situations. We can see this historically. “Symbiosis” is a Greek word. The Latin translation of symbiosis, “*convivencia*” has a very technical meaning. It refers to the coexistence and mutual interactions between the Muslim, Jewish, and Christian communities during Umayyad rule in medieval Spain. All three prospered together. Moreover, it was through these interactions that the Greek classics were returned to Europe through the translations of Greek-to-Arabic, Arabic-to-Hebrew, and Hebrew-to-Latin.

Indeed, today, science and religion will have to become partners in some sort of symbiosis, too, if they are going to preserve wonder and thereby preserve themselves, humanity and a diverse living earth. Such interactions are occurring, but very subtly. While most of the attention gets focused on the evolution/creation debates, the real action is occurring in conservation biology. I will make a hypothesis that the major arguments for species preservation come not from science, but from religion, or morality, in general. When one observes the websites for conservation organizations and looks to see why species should be preserved, the scientific answers are phrased primarily in economic terms of what may possibly be beneficial for humans. Species, we are told, should be preserved because (a) they might be making an anticancer drug such as taxol, (b) they may serve as unique food resources, (c) they can serve as biological checks on other species; (d) they are necessary for scientific inquiry; (d) they may be critical for soil aeration and other ecological services; and (e) their genes might be important for making products in the future. This really doesn’t get to the heart of the matter. Why preserve the mountain gorilla, the monarch butterfly, the leatherback turtle, the horseshoe crab, the Bengal tiger, or the California condor? What can we get from the Muhlenberg bog turtle that we can’t find in red-eared sliders or painted turtles? The answer won’t be found in the above list. I hypothesize that the answer actually is a religious, moral, or aesthetic perception that humans should not totally wipe out another species to extinction. The wonder of fullness is the core affirmation at stake.

I’m glad to say that in many of these conservation websites, especially the general ones, one also finds non-scientific reasons to preserve biodiversity – curiosity, beauty, and wonder. Some sites are explicit about this. After mentioning wonder and curiosity, one organization<sup>7</sup> asks, “Does every species have a right to exist? If so, then our call to preserve creation is clear. But even if not, humility in the face of our capacity to despoil the land is called for... Many of Judeo-Christian heritage believe their faith enjoins them to be responsible stewards of creation, and similar themes run deep in other religious traditions as well.” Two things can be seen here. First, this very idea highlights the inversion of nature and humanity during the past fifty years. We are being called upon to preserve Nature. Nature needs us.

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acceptable to Fundamentalists who believe that the Bible can exist without interpretation. Nor will it be acceptable to those who interpret the Bible as predicting a Rapture that will lead to the end of the physical world and the ushering of a new age. Some of these people actually look forward to an environmental apocalypse (see Moyers, W. 2005 at <http://www.beliefnet.com/News/2005/03/Welcome-To-Doomsday.aspx?p=1>), awaiting the coming Kingdom. I believe that in the 21<sup>st</sup> Century, acting upon such views should be considered a criminal offense.

<sup>7</sup>For example, Natureserve, <http://www.natureserve.org>

Nature never needed us before. Nature was a source of wonder and terror. It is now weak and needs our help. This is what Bill McKibben [95] has called “the end of nature.” Not the end of organisms, but the end of this idea of a powerful, sublime, wonder-inspiring, and independent other. Second, this site identifies species conservation as a religious, not merely a scientific, idea. So, while I’m constantly angry at religions for their insipid attacks against evolution, I’m not all that dispirited when I hear that America is a spiritual country. The question is how to engage that spiritual impulse. I think that the disagreements over the origins of biodiversity pale in significance when compared to the benefits of alliance for the preservation of biodiversity.

Indeed, under the symbiosis model that I am proposing, one of the roles played by religion and ethics will be in deciding what is wonder and what is atrocity. Science may tell us that mountaintop mining destroys the habitats for fish and invertebrates, damages human health, and pollutes streams. But it is not science that makes the judgment that this is bad, wrong, or that it is not worth the economic advantages gained by mining the coal. This is the judgment that religion must make, in fear and trembling, in awe of the fullness of life on a mortal and vulnerable earth.

## 5. The necessary alliance of science and religion

“When we consider what religion is for mankind, and what science is, it is no exaggeration to say that the future course of history depends upon the decision of this generation as to the relations between them” [96]. But what is the appropriate “relation?” I think the proper relationship is neither fusion nor conquest, but “alliance,” including honoring and practicing the art of partial alliance that is modeled richly in both scientific and religious worlds. Like symbiosis/convivencia, alliances allow partners to keep their identities while interacting. Alliances need not even be permanent. Science is not going to be subsumed by religion; nor is religion going to be subjugated by science. World War II’s “Grand Alliance” of Britain, the Soviet Union, and The United States was also called “The Strange Alliance,” as it brought together the worlds foremost capitalist power, its most Communist power, and its greatest colonial power in common cause against Hitler’s Germany [97]. But alliances of science and religion are critically needed if corporate interest is not to reign supreme among the forces that decide the future. Chief among the reasons for science and religion to forge alliances<sup>8</sup> is

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<sup>8</sup>Another reason to forge such alliances is that neither unalloyed curiosity nor unalloyed awe is necessarily “innocent.” Einstein famously wrote [98], “The situation may be expressed by an image: science without religion is lame, religion without science is blind.” I think it is far worse than that. Awe without respect for scientifically determined knowledge leads to pestilence and disease, for nature can be cruel. Prayer has not prevented AIDS nor stopped the drought in Texas [99, 100] – see also, “Texas Governor asks residents to pray for rain amid extreme drought”, 2011, available at <http://www.foxnews.com/politics/2011/04/23/texas-governor-asks-residents-pray-amid-extreme-drought/>. Curiosity without morality leads to oppression. Classic literature (e.g., *The Bacchae*, *Oedipus Rex*) contains warnings against unrestricted curiosity; and Shelley’s *Frankenstein* [101] explicitly warns of the destruction of awe by malignant curiosity. Science and religion also both claim to want to better the human condition. Neither can accomplish this



what biologists call “the preservation of biodiversity” and what theologically oriented people call “the stewardship of Creation.”

Our stewardship of this planet has not been adequate. Within the next century, we can expect the extinction of half the animal species on this planet [102, 103, 104]. The human population exploded 2.5 times from 1950 to 2008, reaching a total of more than seven billion persons, with many living in desperately unsustainable extremes of excess and of deprivation. Feeding and housing this expansive population is causing a cataclysmic extinction, perhaps similar in scope to the event that destroyed the dinosaurs [105, 106]. During two decades, 40% of the turtle species became in danger of extinction, largely from habitat destruction. Our over-fishing of the oceans to feed ourselves is wiping out many large fish species. Swarms of enormous jellyfish have taken over the oceans from the large fish that used to eat them, and Atlantic Bluefin tuna will most likely be functionally extinct (rarely seen except in zoos) in less than four more years [104, 105, 106, 107]. Levels of carbon dioxide correlate excellently with the temperature of the planet over the past 800,000 years, and in the past 50 years, the rate of carbon dioxide increase has raised levels of that gas higher than ever in human history [108, 109], with each decade hotter than the next.<sup>9</sup> The warming of the arctic has become so extreme that sea ice is vanishing at a rate of a million square kilometers per year, and methane is being released from the Arctic permafrost. Methane is a worse greenhouse gas than carbon dioxide and is expected to heat up the world at an even faster pace [104, 110, 111].

We are witnessing nothing less than the initiation of Tohu V’boku, the Undoing of Creation. The conversion of oceanic regions from fish-dominated to jellyfish-dominated is returning us to an ecosystem that hasn’t been seen on this planet for 500 million years [104, 108]. The large regions of the oceans, now called “dead zones” due to the lack of oxygen and dominated by anaerobic microbes, returns us to the Archaean Era 2.5 billion years ago<sup>10</sup>.

Scientific evidence shows that humans are in large part responsible for this [105, 109]. Not only are we over-fishing the ocean; these oceanic dead zones are concentrated around places where fertilizers are released into the sea. The increase in temperature is coming primarily from human technology, as the amount of resources consumed increased 800% during the twentieth century [104]. Over-fishing and fertilizer use is done by humans in the name of economic profit and the increasingly unequally distributed welfare of the explosively increasing human population. We pollute the atmosphere with CO<sub>2</sub> due to the ease at which new fossil fuels can be drilled, the subsidies given the oil and gas companies to drill, and the political need to keep fuel prices cheap. The fossil fuels also enable the chemical furnaces

alone.

<sup>9</sup>Very briefly, such a “greenhouse gas” allows nearly all wavelengths of sunlight through to the earth. When the earth absorbs light, it then reflects it back. The greenhouse gases such as CO<sub>2</sub> and methane will not allow infrared light to be reflected back, trapping this heating radiation here.

<sup>10</sup>See, for example [http://disc.sci.gsfc.nasa.gov/education-and-outreach/additional/science-focus/ocean-color/science\\_focus.shtml/dead\\_zones.shtml](http://disc.sci.gsfc.nasa.gov/education-and-outreach/additional/science-focus/ocean-color/science_focus.shtml/dead_zones.shtml) and <http://abcnews.go.com/US/north-carolina-bans-latest-science-rising-sea-level/story?id=16913782&page=2>.

to keep producing the nitrogen-rich fertilizers. The wetlands and forests that provide and protect a huge share of our biodiversity are being destroyed for new homes.<sup>11</sup> Creation is being unraveled before our eyes; it is not being done by God, but by human will. As William Souder [112] has documented, environmentalism in America has been a battle of nature and science pitted against industry and its representatives in government.

But it really doesn't matter if the environmental crisis was made by humans. The critical thing is that the crisis can be tamed and brought under control by human intervention. But to do so, there has to be enormous public support for measures that will alter the ways we behave and spend. Scientific data cannot mobilize such support. Religion will have to do it. Only an alliance of science and religion will suffice.

But religious organizations are hedging their bets, issuing pronouncements, but not producing change. In 2011, Pope Benedict asked world leaders to reach a credible agreement on climate change, since "it is by now evident that there is no good future for humanity or for the earth unless we educate everyone toward a style of life that is more responsible toward the created world."<sup>12</sup> This was not a statement made to mobilize grass-roots support, and the representatives at the Durbin Conference made sure that their countries' industry and economies were not threatened. Besides, other influential Catholic leaders have been against the environmental movement. At New York City's huge 1990 Earth Day celebration, Cardinal Joseph O'Connor delivered his warning to those who worry about saving whales and snail darters: "The earth was made for man, not man for the earth." Pope John Paul II reaffirmed this in 1995 [113].

The Evangelical churches are similarly split. The Evangelical Environmental Network organized a Day of Prayer for the Environment, again, not a very strong move compared to its statements on politics or abortion or homosexuality. Moreover, other Evangelicals see "environmentalism as a new religion that perverts the Gospels." As one recent newsletter for the Cornwall Alliance<sup>13</sup> says of those championing stewardship against global warming, "Their ideas are the ideas of ideologues, not of scientists or climatologists. [...] We have to accept that they have succeeded in establishing the religion of environmentalism as the official religion of Western society, as the religion which asks for a radical transformation of the whole Western civilization." This newsletter is endorsed by The Heartland Institute, a foundation that sponsors an annual "International Conference on Climate Change" to debunk notions

<sup>11</sup>One particularly egregious example of economic interests having power over nature and science comes from the state of North Carolina. Here, the legislature banned any government agency to use the newest scientific predictions of global warming. The current predictions of sea level rise would jeopardize the permits of many planned housing developments. The law was sponsored by an organization representing housing developers who wished to build housing developments on coastal land. The governor's two major financial contributors have been the North Carolina Association of Realtors and the North Carolina Home Builders' Association. The governor refused to veto the bill.

<sup>12</sup>Pope Benedict XVI. Quoted in <http://www.catholicnews.com/data/stories/cns/1104646.htm>

<sup>13</sup>The Cornwall Alliance, <http://www.cornwallalliance.org/blog/item/environmentalism-the-established-religion-of-western-society>

that climate change is occurring.<sup>14</sup>

At least in America, certain Christian religious action groups are denying human responsibility for these conditions and claiming that God would never allow humans to destroy themselves. American Congressman John Shimkus<sup>15</sup> voted against bills to limit carbon emissions because God would not let there be such a catastrophe. Industry does not want taxes against its carbon emissions or limits to its fossil fuel use. Moreover, according to one religious high school textbook [114], “There is no shortage of resources in God’s earth. The resources are waiting to be tapped.” In short, religion has not come out strongly for the environment as when it has mobilized masses for anti-abortion and anti-gay rights. Tea Party activist Rush Limbaugh<sup>16</sup> tells his millions of listeners that climate change is a hoax to defraud Americans of their liberty and freedom.

I cannot read such pronouncements about resources and climate change from these sources without thinking of Isaiah and Jeremiah (Isaiah 30:10; Jeremiah 28). Isaiah warns the Israelites of impending disaster unless they change their ways, but the Israelites don’t want to hear it: “Give us no more visions of what is right! Tell us pleasant things, prophesy illusions.” And that is what the climate change-deniers are doing. Jeremiah says that for the Israelite’s disobedience, the easily broken wooden yoke will be exchanged for a yoke of iron. Change is going to happen, but the longer we wait to change our ways, the worse the consequences and the greater the cost [105]. If we were to restore energy balance to the earth (and thereby stabilize climate) by the end of the century, we would have to restore much forest land and reduce carbon emissions by 6%. If we had started to do so in 2005, carbon emissions would only have to be reduced by 3%. If we delay curbing emissions until 2020, the required reductions will be 15% per year.

And like Ezekiel and Jeremiah, James Hansen and colleagues [105] see this as a moral issue because the consequences of the stupidity of the elders will be visited upon the land and their children.

*This situation raises profound moral issues in that young people, future generations, and nature, with no possibility of protecting their future well-being, will bear the principal consequences of actions and inactions of today’s adults [...] It is a matter of morality – a matter of intergenerational justice [...] The injustice of one generation to all those to come must stir the public’s conscience to the point of action.*

Science is warning that “we are at risk of being our own assassins.” [104]. There is no safeguard for us if we cannot use our brains well. Science cannot fight toxic industry alone, it needs the moral, grass-roots, soul-mobilizing ability that can only be found in the religious

<sup>14</sup>The Heartland Institute, <http://heartland.org/events/seventh-international-conference-climate-change>

<sup>15</sup>[http://voices.washingtonpost.com/postpartisan/2010/11/in\\_the\\_gops\\_house\\_god\\_wont\\_all.html](http://voices.washingtonpost.com/postpartisan/2010/11/in_the_gops_house_god_wont_all.html)

<sup>16</sup>[http://www.rushlimbaugh.com/daily/2009/11/24/climategate\\_hoax\\_the\\_universe\\_of\\_lies\\_versus\\_the\\_universe\\_of\\_reality](http://www.rushlimbaugh.com/daily/2009/11/24/climategate_hoax_the_universe_of_lies_versus_the_universe_of_reality)

impulse.<sup>17</sup> Science and religion are the estranged children of wonder. But like Jacob and Esau, they need not love each other to form alliances. Science and religion need to form alliances to preserve the wonder of this world; they need to form alliances to preserve the creatures of this world; and they need to form alliances to keep alive the curiosity and the awe that allows their own renewal. And they need to do this now.

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<sup>17</sup>To say that something is an "abomination" is a very powerful threat. In today's world, described above, calling homosexual behavior or contraceptive use "abominations" sounds silly to me (and belittles the concept of God). So I suggest a thought experiment: Imagine if churches spoke of God's damning to Hell for all eternity anyone who polluted a lake, anyone who built a home upon such a lake, and anyone who bought such a home. That might stop habitat destruction. When each child in American or Canada uses nearly ten times the carbon resources as an average world citizen, who would be the sinner: the parents of a dozen American children or the family that used contraception? Interpretations and priorities do change; and in that remarkably irenic essay of 1925 [96], Whitehead cites Father Petavius and Cardinal Newman as his predecessors in recognizing the importance of this change within theology. "Theology," wrote Whitehead, "itself exhibits exactly the same character of gradual development [as science], arising from an aspect of conflict between its own proper ideas." Furthermore, he concludes, "Religion will not regain its old power until it can face change in the same spirit as does science."

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