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The Religious Dimensions of the Biological Narrative

Ursula W. Goodenough
Washington University in St Louis, goodenough@wustl.edu

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Abstract

A cell/molecular biologist challenges the thesis that science and religion are two ways of experiencing and interpreting the world and explores instead the possible ways that the modern biological worldview might serve as a resource for religious perspectives. Three concepts -- meaning, valuation, and purpose -- are argued to be central to the entire biological enterprise, and the continuation of this enterprise is regarded as a sacred religious trust.

Keywords: nihilism; purpose; selection; symmetry; valuation.continuation; meaning; meme; new naturalism; niche;

Religions have come to serve many roles, but in the context of this symposium we can focus on religion as the source of explanation, addressing what we can call the Big Questions: What is the meaning of life? What is my life for? In Western faith traditions, the explanations offered are framed in the context of a creating, interested God who has both a purpose and a plan.

The disciplines of science also seek to provide explanation, and although they do not directly take on the Big Questions, they offer up a worldview that is not obviously dictated by a personal God concerned with human beings. As the physicist Steven Weinberg (1988, 154) puts it: “The more the universe seems comprehensible, the more it also seems pointless. ”

Various responses to this nihilistic proposition have been offered, including the fundamentalist rejection of the scientific cosmology and the postmodern deconstruction of the scientific cosmology as just another truth claim. The title of this symposium offers a third response, namely, that science and religion are two ways of experiencing and interpreting the world. In other words, we are offered a dualism, one that is commonly expressed in such dyads as reductionism versus holism, physical versus spiritual, analysis versus transcendence, left-brain versus right-brain. The idea is to keep things separate.

My problem with this approach is that it is founded on an anthropocentrism in the sense that human beings, their particular understandings and beliefs and emotions, are set apart, are treated differently, are effectively accorded a separate cosmology. My understanding of biology has led me to a very different conclusion. I see the whole enterprise, from bacteria to starfish to maples to humans, as operating on the same principles, as profoundly homologous. So for

me, a religious perspective is useful only if it deeply acknowledges that I am a collection of cells and experience and interpret the world as an organism, using chemistry and physics to do so.

Ian Barbour (1994, 463-64) has summarized two religious perspectives that include this acknowledgment. In the first, exemplified most recently by the creation spirituality of Thomas Berry, Brian Swimme, and Matthew Fox, we are urged to celebrate the beauty of the universe story and experience fulfillment in the awe, wonder, and gratitude it elicits. In the second, theologies are sought within nature, generating such concepts as God as the author of the improbable universe or God as the author of natural selection.

I have initiated what I believe to be a distinctive approach. I do not attempt to develop a theology because I happen to be a nontheist, albeit I most readily experience transcendence in medieval cathedrals. On the other hand, I am trying to go beyond the spirituality movement, beyond poetry, beyond awe and wonder. Although I experience these emotions deeply, I believe we can go much further. Recent discoveries in biology tell us that concepts central to religious thought, concepts that we have believed to be unique to human perceptions and concerns, are in fact operant throughout the biological world. These new understandings allow us to experience cognitive affinity as well as spiritual affinity with the rest of nature. Moreover, they suggest that we can seek guidance from nature as we articulate religious principles. The resultant system of belief can be called a new naturalism.

I will apply this approach to three concepts: meaning, valuation, and purpose. A concept like meaning, I have come to conclude, has been thought to be restricted to higher human faculties simply because human meaning systems were the only ones we could apprehend. Indeed, the very concept, the word itself, was invented by human brains to describe a facet of human perception. But meaning, I will argue, is in fact fully applicable to the perceptions of a bacterium or a starfish or a maple. I will make the same case for valuation and intentionality. I will then propose that the collective planetary enterprise of meaning, value, and purpose is a sacred enterprise and that its existence can serve as the source of ultimate meaning, value, and purpose. Finally, I will outline how such a faith statement might provide guidance and spiritual resources for human existence and global resolutions.

Complementarity

To talk about biology, we have to begin with chemistry. Organisms survive because they carry out chemistry. Chemistry, like everything in the universe, is ultimately described by physics, but for our purposes we can focus on interactions between molecules, entities that we can think of as shapes. A critical parameter is the way the shapes fit together, hand in glove, lock and key. This property is called complementarity, where to complement means to fill up.

For the large molecules that participate in the chemistry of organisms, complementarity is sovereign. This is particularly true for protein molecules, which we can think of as long chains of amino acids that fold up to generate pockets and protuberances designed to fit with other molecules. A useful analogy is to think of jigsaw puzzle pieces in three dimensions. Many proteins function as enzymes, holding two molecules in adjacent pockets so that they are more likely to interact and form a reaction product, an operation known as catalysis. The resultant reaction product has a new shape which allows it to participate in a new set of shape interactions, and so on. Hence the whole of biochemistry can be described as cascades of shape changes.

A particularly interesting group of proteins are known as receptors. Receptors are located in the membrane that surrounds the cell. One side of the receptor faces out into the environment, the other side faces the cell interior where the biochemistry is going on. Each receptor carries a pocket on its outer face which is complementary to some molecule in the environment. When the molecule fits into the pocket, the receptor changes shape, and this deformation spreads to the interior domain, analogous to squeezing a long balloon at one end and having it bulge out at the other. When the interior domain adopts a new shape, it forms new pockets and protuberances that are complementary to internal molecules, and this sets off a new cascade of shape changes which ultimately results in behavior appropriate to the molecule. The technical word for this process is signal transduction: the receptor is said to transduce an external signal into appropriate biochemistry.

Organisms carry receptors that bind directly to food molecules, eliciting the behavior necessary for food uptake. Other receptors act more indirectly. For example, many bacteria carry receptors complementary to molecules released by decaying organisms. These molecules are not used as food; rather, they indicate the location of the food source. In this case, the molecule-receptor interaction and the resultant cascade of shape changes results in the behavior of moving toward the decaying material, a trait known as chemotaxis. Receptors in the nose perform analogous functions in vertebrates. Another class of receptors carry pigment molecules in their pockets. The pigments change shape when they absorb light; these shape changes induce the pockets and hence the receptors themselves to change shape, initiating such behavior as vision or phototaxis. Many receptors are complementary to molecules produced by other cells, permitting cell-to-cell communication. Thus pancreas cells, sensing that blood-sugar levels are too high, secrete the hormone insulin, and when insulin binds to receptors displayed on fat cells, it elicits rapid sugar uptake. And, finally, nerve and muscle cells carry receptors for neurotransmitters that are released by other nerve cells. When the neurotransmitters bind, they elicit nerve-cell firing or muscle contraction.

Meaning and Evaluation

We are now in the position to explore the thesis, and deconstruct resistance to the thesis, that receptor systems work in the same fashion as mental activity and that receptors serve as transducers of meaning.

Let's begin by describing mental activity. If we use as an example the mental response to a chair, we can identify three operations. When I perceive a chair and respond by sitting on it, I am performing a direct operation on the chair: it is the stimulus, my sitting is the response, and my perception of it elicits the response. When I instead hear or read or somehow perceive the word *chair*, my brain calls up the concept of a piece of furniture and I say that I understand the meaning of the word *chair*. And when I hear the word *chair* when I have been standing up for a long time, the word elicits additional brain states: I find myself longing for a chair, looking around for a chair, and so on. In this case, we say that the word has both symbolic meaning and affective meaning.

Now what can we do with these terms at the level of receptors? We can in fact recognize the same three types of response. When a food molecule binds to a receptor and the cell responds by taking it up and metabolizing it, this operation is equivalent to perceiving the chair and sitting on it. When instead an insulin molecule binds to an insulin receptor and the cell responds with sugar uptake, the operation is equivalent to hearing the word chair and calling up the chair concept. The insulin molecule is not high blood sugar itself; it *means that* blood-sugar levels are high. Indeed, we can make use of the word metaphor, which is usually associated with poetry but in fact simply means "to carry over," and say that insulin is a metaphor for high blood sugar in the same sense that the .word *chair* is a metaphor for the piece of furniture. The perception of the insulin metaphor entails complementary binding and a shape change on the part of the receptor, an event that may seem quite different from the mental perception of the word *chair* until we recall that mental perception in fact entails the binding of neurotransmitters to their receptors on brain cells.

The goal of the two operations is also concordant. The "purpose" of the word *chair*, we can say, is to elicit the biochemistry necessary to call up the mental concept of the piece of furniture; the purpose of the molecule insulin is to elicit the biochemistry necessary for sugar uptake. Overall, therefore, we can say that the fat cell comprehends the symbolic meaning of the molecule insulin in the same sense that the brain comprehends the symbolic meaning of the word *chair*.

So what about affective meaning, our third level of response? When the brain attributes value to the word *chair*, the operation is a learned response: associative neurons have come to couple the concept of a chair with the positive experience of relieving fatigue. But mental evaluations can also be hard-wired, as when we reflexively assign a negative attribution to the smell of a dead rat. The housefly, of course, has coupled a reflexive positive attribution to the smell of a dead rat. Humans instinctively move away from the rat; flies instinctively move

toward it. The same stimulus, therefore, is evaluated in different ways.

When we take this “down” to the level of a simple bacterium, we find that bacteria use receptors continuously to evaluate their circumstances. Molecules released from decaying organisms, as we have said, elicit the positive response of chemotaxis. Toxic molecules, in contrast, induce the bacterium to swim away from their source. The chemotaxis elicitors bind to one set of receptors; the toxins bind to a second set. And again we employ the concept of coupling: the shape changes in the chemotaxis receptors are coupled to cascades of biochemistry that result in attractive behavior; the toxin receptors are coupled to biochemistry that results in avoidance. Looking at the bacterium as a whole, therefore, we can say that it indeed possesses an affective system, an onloff yeslno response to each meaning.

In summary, then, all organisms, from bacteria to humans, employ three types of perceptual response. The first is direct, as when food is coupled to the response to ingest it. The second is symbolic, as when the smell of food or the word food is coupled to the response to move toward it. And the third is affective, as when a smell or a word is given an attribution, is evaluated.

We can now emphasize an important distinction between the direct and the symbolic: the symbolic involves meaning whereas the direct does not. Food itself is not a symbol for food. It is food. In contrast, the word food is a symbol, as is insulin. Organisms employ both direct and symbolic types of perception, but of particular interest is that all organisms use meaning systems, and they all evaluate these meanings.

This is of interest because, as nearly as I can tell, meaning systems are unique to biology; they are not found in the worlds of physics and chemistry. In physics and chemistry, as well as in biology, we find ubiquitous information, where information can be generally defined as structure. Thus atoms and salt crystals have information, as do insulin and chairs and words. All meaning systems, then, employ information, but information is not the same as meaning. In physics and chemistry, as well as in biology, we also find transformations, where things turn into other things. Thus the light from the Big Bang now takes the form of microwaves, a neutrino plus a neutron can transform into an electron and a proton and vice-versa, and one molecular shape can transform into another shape. But in a meaning system, where one thing stands for another, one thing does not become the other. It is this relationship, I believe, that is found only within cells and between cells.

The uniqueness of humans is that we know the meaning of the word meaning. We not only interpret symbols from without, we also create and interpret symbols from within. This ability, while an astonishing innovation, is only the most recent innovation in the evolution of receptors. Meaning and valuation systems, per se, prevail all the way down.

The Name of the Game

So why are there all these meaning and valuation systems in biology? To answer this question, we need to consider one more principle, one that we can call the name of the game. In any operation, some outcomes are favored over others; the name of the game describes the bottom line. To analyze the name of the game, we employ two parameters: we speak of the criterion, the standard by which the winner is judged, and we speak of the calculus, the method by which the criterion is calculated.

In most of the universe, and certainly in chemistry and biochemistry, the name of the game is to go downhill, where the bottom of the hill is more stable than the top. Thus, given two possible outcomes for a chemical transformation, the outcome that is favored is the outcome that generates the more stable result. For example, during nucleosynthesis in primary stars, the elements that are the most abundantly produced are those whose nuclei are the most tightly bound, examples being carbon, oxygen, and calcium. A well-known statement of this concept is the Second Law of Thermodynamics, where stability is expressed as a lower energy state: since cold is more stable than hot, hot things spontaneously cool. Therefore, we can say that chemistry is governed by the criterion of stability and employs the calculus of thermodynamics.

Since living cells are driven by biochemistry, they are also governed by the criterion of stability. All those cascades of shape changes just described are, in the end, running downhill, from less stable to more stable shapes, and life quickly grinds to a halt unless new sources of unstable starting materials are continuously pumped into the system. These resources take the form of food or in plants, photosynthetic products, and by definition they come from the outside, from the environment. Therefore, the name of the game in biology is to obtain resources from the environment so that life can continue. We can abbreviate this concept and say that the name of the game in biology is continuation.

When we look to identify the criterion, the test by which this continuation/discontinuation is arbitrated, the answer has, of course, been clear since Darwin: life is governed by the criterion of environmental selection. It cannot be stated too strongly: in biology, it is the environment that calls the shots. The unfolding of life has been and will be contingent on the particular course of this planet's development.

A distinctive feature of this planet is that it offers, and continues to generate, a seemingly endless array of different environmental domains: wet and dry, aerobic and anaerobic, hot and cold, with or without other organisms. We give the name niche to a collection of such environmental domains which collectively generate an opportunity, and each organism that seizes this opportunity and attempts

to populate the niche must be able to operate in the context provided. If it fails, the calculus of thermodynamics takes over and it dies.

So what is the calculus used by organisms to negotiate niches? It is, I propose, the calculus of evaluation. Any organism trying to bring about a result, trying to continue, is engaged in the continuous evaluation of its context, its niche. And since many of the stimuli present in the niche have meaning for the organism, the calculus of evaluation often entails the evaluation of environmental metaphors.

We must pause here to sort out some semantics. The terms evaluate and select are often used interchangeably; moreover, both words can imply an intentionality, and both tend to connote positive attribution. When I say that the niche selects the organism, in no way do I suggest that the niche intends to do so, nor do I suggest that the selection results in increasing fitness in a general sense. What results is an organism that can continue in that niche. It is no more or less fit than an organism that can continue in a second niche. And the niche, of course, is totally indifferent to whether there is any organism there or not. Its valuation is passive.

When I say that the organism evaluates the niche, on the other hand, I am most emphatically describing an intentionality. While the word intent is another one of those words that has come to carry overtones of mental calculation, as in intentional versus nonintentional crime, we often use it without such connotations. Thus we feel comfortable saying that the intent of reflexively moving a hand from a hot stove is to avoid pain, even though this behavior entails no higher mental calculations. Intent simply means purpose, and anyone who believes that humans are the only intentional, purposeful organisms has not recently contemplated an ant struggling with a grain of sand or a bacterium swimming up a chemotactic gradient or a tree twisted around to obtain more sunlight.

To avoid misunderstanding, we can restrict the word selection to a passive process and valuation to an active process. We can then say that selection operates throughout the universe in the sense that a stable chemical outcome is selected over an unstable outcome, and a successful niche-negotiator is selected over an unsuccessful negotiator. The term value can then be reserved for judgments reached by perception systems that engage in intentional evaluation. Such systems, to our knowledge, are unique to biological organisms. We can say, then, that the calculus of evaluation employed by living creatures is both intentional and rich in meaning systems and that this calculus drives their continuation.

But wait, you ask. What about the DNA part? What about reproductive success? Isn't that the name of the evolutionary game?

To answer this question we need to quickly review what genes do. It turns out that organisms are able to remember the shapes of their receptors and their

enzymes and all of their other proteins. The memory system is a collection of genes, each encoding a particular protein in a DNA sequence. The importance of the genes can be readily grasped by imagining two organisms in the same niche, each possessing the same adaptive collection of enzymes and receptors but only one possessing the instructions to make these proteins and the ability to transmit these instructions to future organisms. Each organism can negotiate the niche equally well, but the version transmitting the instructions will quickly outnumber the version without the instructions and will come to populate the niche. An organism, as the saying goes, is DNA's way of making DNA.

Therefore, there are two ways to articulate the name of the game in biology. The one we have developed states that the name of the game is continuation, the criterion is niche-selection, and the calculus is evaluation. The second states that the name of the game is prevalence, the criterion is. again niche-selection, and the calculus is reproductive success. While the second statement is correct, it should by now be clear that the replication part is almost an add-on. Of proximal selective value is the organism's success in interpreting and responding to the niche so that the instructions can be transmitted.

Whereas the ethos of prevalence has unquestionably been the name of the game in evolution, I have opted to articulate the name of the game in terms of the ethos of continuation. I can give several reasons. First, the ethos of prevalence proves to be a barren resource for generating religious perspectives, its most successful product being the religion of capitalism, with which I have little affinity. But the deeper reason is that the ethos of prevalence seems increasingly irrelevant to our circumstances. Whereas environmental niches have always called the shots, an increasingly selective factor in the global environment is now human culture. Human choice increasingly determines which niches are available and who gets to live in them, a fact that we may applaud when we think of pathogenic bacteria but find more problematic when we think of elephants. Hence the prevalence of a species is governed not only by its reproductive success but also by its value to humans, whether economic or aesthetic. In other words, the global niche now includes both passive selection and active evaluation. With humans increasingly calling the shots, moreover, reproductive success is being increasingly evaluated as maladaptive. We are coming to recognize that the ethos of prevalence, left to run its own course on a finite planet, will generate catastrophe for the human population in particular and for the diversity of species that we depend upon and/or cherish. Therefore, although the ethos of prevalence will unquestionably resume its supremacy should humans become extinct, it is poorly qualified to serve as the name of the game as long as humans are acting as evaluators. By contrast, the ethos of continuation reminds us of what it is that we should value.

Credo of Continuation

We can now return to Weinberg's assertion that the universe itself suggests no

point and to the nihilist thesis that the universe is blind and aimless and devoid of meaning, and we can say, yes, this may well be true of the universe. This may well be true for physics and chemistry where the name of the game is to run downhill and the operant concepts include stability and thermodynamics. This may even be true for evolution, where the operant concepts are random gene mutation and passive selection. But it is not true for life itself, where the name of the game is continuation and the operant and unique concepts include meaning and valuation and intentionality.

Meaning and value and purpose. Have we not arrived at some religious foundations?

“Humbug!” says the dedicated nihilist. “You may have convinced me that there’s lots of meaning and value and purpose going on, but how can you claim that any of this has any ultimate meaning or value or purpose? Here you have all these creatures struggling to interpret their various niches on this particular minuscule planet, while the planet itself is doomed to extinction. What’s the meaning of all the meaning? Isn’t that the Big Question we set out to answer?”

In articulating my response, I recognize fully that I am making a statement of faith. But that’s the reason we are here. For me, the existence of all of this meaning and intent, and my ability to apprehend it, is the ultimate meaning and the ultimate value. The continuation of life reaches around, grabs its own tail, and forms a sacred circle that requires no further justification, no creator, no superordinate meaning of meaning, no purpose other than that the continuation continue until the sun collapses or the final meteor collides.

Working with the Credo

Very well. Such a statement, which we can call a credo of continuation, may or may not elicit emotional resonance. But this is not the only criterion by which to evaluate a religious perspective. It must also be fruitful. It must also suggest principles and practices for the leading out of our lives. When we consider the two central credos of the Judeo-Christian tradition, the covenant between God and Israel and the redemption offered by Jesus, we see that each has been enormously fruitful, eliciting viable codes of morality and resources for transcendent experience. Can a credo of continuation be similarly germinative?

In asking this question, I came to realize that a new naturalism, a religion embedded in the matrix of life, in fact allows what is rather scornfully called the naturalistic fallacy. That is, it legitimizes the derivation of value from fact, an ought from an is. If life’s collective meaning systems indeed represent ultimate meaning, and life’s continuation indeed represents ultimate purpose and value, then it should be possible to find principles for moral behavior and resources for transcendent experience within this framework. Can this be done?

I will outline two explorations along these lines. The first focuses exclusively on human beings; the second considers the ecology of the planet.

The Seeking and Valuation of Human Meaning. Granted that all organisms are seekers of meaning, humans have gone the full distance. We are meaning freaks. We are at the service of our causal operators, continuously perceiving stimuli and seeking to determine their cause, their source, their interpretation. When the answers aren't apparent, we supply theories, plausible explanations, to close the loop. And then we repeat the operation. And again. And again.

Our receptors are limited in their perceptions --we see and hear only certain frequencies of light and sound, for example -- but we have astonishing abilities to integrate these inputs and store them in our memory systems. We also design machines that detect and analyze things we cannot perceive, and we design computers to manipulate
and store what our brains are poorly designed to manipulate.

Not only do we seek and find meaning in nature; we also create meaning de novo, in our language, our arts, our culture. We are mythmakers and artisans and inventors. We continuously generate new metaphors. Our impetus to be creative is quite as robust as our impetus to understand the universe.

And, finally, we seek and find meaning in one another. We are acutely attuned to each other's moods, gestures, and language and devote considerable time to the development of our relationships.

As we formulate meanings, we also evaluate them. Evaluation, as I have said, was initially a yes/no behavior cascade coupled to a particular receptor shape change. With the development of central nervous systems, it has come to entail an enormously complex system of synaptic connections, both hard-wired and learned.

But there's more going on than this. We are also barraged with meanings that have already been articulated and evaluated by others. Richard Dawkins (1976) has given us the useful term meme to describe such a transmissible unit of cultural meaning, and we find ourselves today inundated with memes. So our task is not only to evaluate the world and come up with relevant meanings and emotional responses; we also must evaluate the prefabricated memes that clamor for our attention.

Memes are unquestionably the basis of what we call human progress: we don't need to roll balls down inclined planes to reformulate laws of motion, and we don't need to repaint the ceiling of the Sistine Chapel. But memes can be problemmatic as well, as epitomized by the caricature of Americans sitting passively while television hits them with one meme after the next. And when memes are adopted by an authoritarian system that seeks to impose them on

others, the result is often unspeakable tragedy.

So how does a new naturalism inform us on all of this? We concluded earlier that the ultimate arbiter of a hard-wired meaning/ value system is the niche. Learned meanings, we can quickly recognize, will also be niche-selected: an inappropriate learned response is quite as maladaptive as an inappropriate reflex. Brains have therefore been selected for accurate perception and appropriate assignments of attribution as they learn.

Having said this, therefore, we realize that the real question is, what is the human niche? What is the selector? We most certainly inhabit physical environments, which I will consider in my final section, but I would argue that the immediate, dominant human niche is our self-conscious self, our personality, our experience of who we are. We form collective selves as well -- with lovers, family, congregations, colleagues -- and thereby expand our niches, placing ourselves in larger contexts. Nonetheless, the human niche is consciousness, individual or collective, onto which we map everything, including our environmental circumstances.

So, given this niche, it follows that the dominant human criterion for evaluating a meaning or a meme must be: Does this meaning work for me? Does it make sense? Does it resonate? How does it make me feel? And, perhaps not surprisingly, the human capacity for emotional response has developed apace. We don't simply say yes/no to a meaning. It delights us, or outrages us, or bores us, or arouses us sexually, or amuses us, or transports us. And here, at last, we have come full circle. Science and religion, analysis and transcendence, physical and spiritual are not dualisms placed in opposition, nor are they two ways of experiencing and interpreting the world. They are as beautifully complementary as a molecule and its receptor. They fill each other, complete one another.

If we initially select for the most appropriate psychological and cultural matrix of meaning, then its negotiation becomes our most imminent source of concern and fulfillment. Each life can be said to be a search for symbolic and emotional meaning. Each search is sanctified. And the astonishing diversity of outcomes is celebrated, just as we celebrate the diversity of those myriads of species doing their thing in the rain forest. To insist that the choice of memes must be a personal choice is to reject any imposition of memes on others, any form of totalitarianism, the exception, of course, being laws that prohibit memes of murder and mayhem. But in no way does it follow that all memes will or must flourish. If human evolution is now operating by meme selection rather than gene selection, then the evaluation of memes becomes a vital activity. Memes can be championed and revered, or they can be challenged, deconstructed, and exposed as flawed or dangerous or foolish. There is nothing that fills me with deeper concern than the present climate of relativism, that weary shrug of the shoulders as we contemplate the sovereignty of memes based on fear and greed. Our meanings will only bring fulfillment if we believe in them passionately, if they

become our religion and we become their evangelists.

The Planet. And now we can turn to the planet. It goes without saying that we are fast approaching a global crisis in the allocation of the world's resources, and the prevalent, seductive memes that encourage consumption and growth are designed to obscure any cooperative traits that we might inherit or learn. The resolution of these enormous problems is ultimately the province of politics and economics, but it is important to deflect a potential misunderstanding. In saying that meaning systems must be personal, in no way does it follow that agreement cannot be reached on a set of central memes that govern global politics and economy. In one model, Loyal Rue (1994) offers the concept of a federal system, a federation of meaning, wherein the diversity of individual and cultural and biological meaning systems is retained while shared tenets are developed to apply to global affairs.

The adoption of a new naturalism can endow such an enterprise with a religious dimension, providing conviction and purpose and fervor, reminding us that we must not only address these problems to avoid political and economic chaos but also because we have a moral obligation to do so. All creatures are interrelated. We share the same proteins, and we share the same systems of meaning and purpose and evaluation. Most multicellular organisms evolved very recently, in a burst of phylogenetic innovation at the dawn of the Cambrian 500 million years ago for animals and 300 million years ago for land plants. We evolved from a lineage of simple protists, cells that eked out their existences during the previous three and one-half billion years by working out the essential parameters of biochemical cascades and signal transduction. The contemplation of all of this continuation, all of this connection, all of this enormous effort to reach our present level of diversity is for me a deep spiritual resource. I care about having it continue. Its continuation is a commandment.

A new naturalism can also be a source of memes for guiding the enterprise. Religions have always been in the business of meme generation, offering narratives that orient and inform the course of existence. Such stories have traditionally described the dilemmas experienced and the moral and spiritual decisions reached by particular persons -- Moses, Job, Peter, Saint Francis -- persons with whom we identify and whose faith decisions we try to emulate. Such stories are, of course, to be cherished -- they link us with our heritage, they speak deep psychological truths, and they are sacred to those who orient their lives within the eminence of God. But, in addition, a new naturalism would strive to articulate metaphors from nature, metaphors that have a universality, a global meaning that transcends particular cultures and faith traditions. Their very universality may make them particularly appropriate to guide the search for a global federalism. Let me end by sketching two such metaphors.

The first begins with the concept of symmetry. Symmetry proves to be the

operant calculus in mathematics and in physics, where one speaks of space-time symmetries and the internal symmetries that generate electromagnetic and gravitational fields. Chemistry and biochemistry, in contrast, are quite indifferent to symmetry: anything that goes goes. But when we consider the products of cells, the designs that cells devise in structuring their form, we once again find symmetry. Everywhere. When cells divide, most cleavage planes pass right down the middle. When cells form internal structures, the subunits associate with one another to form tubes, or helices, or mirror-symmetric fibers, or lattices of hexagons. Mollusc shells are spiral. Flowers and jellyfish and diatoms are radial. And bilaterality abounds, from dimeric proteins to soil algae to faces to brains to centipedes. When proteins set out to specify cells, and cells to specify organisms, symmetry is their most distinctive concept.

Fairness is our social metaphor for symmetry. It's the tit-for-tat strategy that always wins in games of reciprocity. It's the first social concept that children understand -- is it fair that my brother got that toy? Yes, because I got this toy. It's the concept that underlies our games, our judicial systems, our most lofty ideals of how we should behave toward others. Indeed, fairness can be said to be a central metaphor of Christ's ministry. As we go about selecting the collective memes that ensure continuation, the memes of symmetry and fairness emerge from deep within our nature.

Biology also makes judicious, germinative use of asymmetry. When a fertilized frog egg undergoes mitotic cell divisions to form an embryo, the first cleavage is always symmetric and the egg divides in two. The second cleavage is symmetric as well. But the next cleavage is asymmetric. As a result, the four large daughters go on to become the cells that form internal organs, while the four small daughters are fated to become skin and brain. Things then return to symmetry, but a few cleavages later there again occurs a critical asymmetry, which again generates separate cell lineages. What emerges, therefore, is not a round blob of cells but a tadpole, with numerous symmetries and asymmetries generating its form and underlying its physiology.

Therefore, as we contemplate the global future and seek guidance from biology, it is important to take in not only the importance and beauty of symmetry but also the role of asymmetry in bringing about results. Ecosystems may be balanced, may reach equilibria, but these equilibria are rarely symmetrical. They contain hierarchies and discontinuities all over the place. If we approach the global enterprise with the romantic notion that everything must be fair, we operate in a deep delusion. If we approach it with the extreme asymmetry that human concerns must in all cases prevail, the enterprise is doomed, both ecologically and aesthetically. Like the frog egg, we must be ready to alternate back and forth, from symmetry to asymmetry, from fairness to judicious choice, if we are to restore the planet to a niche where intentionality can flourish.

I close with the metaphor of the circle. The circle has been used so often, so

universally, to symbolize life and its continuation that it borders on the cliche. But as we burrow deep into the operation of life, we find resources for its rejuvenation, where the dynamic concept is not the circle but the cycle. Just as there are lunar cycles and seasonal cycles, so are there numerous cycles in the cell. Many metabolic pathways function as cycles: a molecule enters as one shape and undergoes successive transformations, each catalyzed by a separate enzyme, until it is returned to its original shape and cycles round again. And we find that when a cell grows, replicates its DNA, and divides to generate two daughter cells, these then grow, replicate their DNA, and divide in the same fashion. Each cell, that is, traverses what is called a cell cycle, employing highly conserved cascades of biochemistry to do so, and the cycle then repeats in the daughters, and their daughters, and their daughters. Life on the planet can therefore be described as a continuum of continuous cell cycles, extending out from the very first cell. Billions of cell cycles are being traversed in this room right now, both by our own cells and by the bacteria that live within our bodies. Hence cycles are not only powerful metaphors for life's continuation. They actually describe how life continues.

A human life is commonly perceived as a path from birth to death, and most religious systems have sought to ameliorate this perception by offering such concepts as salvation or reincarnation. In its deepest sense, a credo of continuation perceives death as ultimately irrelevant and each life as immediately sacred. What's important is the circle.

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