ENERGY AND THE GENERATION OF THE WORLD

by George L. Murphy

Abstract. Energy concepts in theology and natural science are studied to see how they may aid the science-theology dialogue. Relationships between divine and human energies in classical Christology and energy ideas in process theology are significant. In physics, energy has related roles as something conserved and as the generator of temporal development. We explore ways in which God and the world may interact to produce evolution of the universe. Possible connections between the double role of physical energy and the bipolar character of God in process theology are noted. Energy helps to describe God's relationship with the world in both theological viewpoints and, thus, may bridge them.

Keywords: Creation; energy; generation of the world; process theology; time.

THE ENERGY CONCEPT IN THE SCIENCE-THEOLOGY DIALOGUE

The science-theology dialogue, like all conversations, requires some commonality of language and of concepts between partners in the discussion. Difficulties can arise, however, when superficially common language actually has different meanings for different groups engaged in a dialogue, and careful study may be needed to overcome the problem. This has been the case, for example, with words like "sacrifice" in dialogues between different parts of the Christian tradition. Of course, the more fundamental questions have to do not simply with the meanings of words but with possible correspondences of shared concepts with reality.

One concept which seems to have some promise for the science-theology dialogue is "energy." It has a long history in philosophy,

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theology, and the natural sciences, and as such is deeply embedded in those disciplines. It thus seems to be a natural concept for science-theology discussions. Some modern theologians have tried to use the concept of energy to bridge the gap between theology and science. But the meanings for those disciplines of the word "energy," and its equivalents in other relevant languages, have diverged considerably over the past centuries, and incautious use of the word may make it appear that there is more common ground than actually exists. There is special danger here because the word "*energy*" has, even in unsophisticated use, connotations of power, life, "getting things done," and both creative and destructive effect. (Think, for example, of the affective significance which the phrase "atomic energy" has for people today.)

As we will see, energy concepts do have considerable potential for the dialogue. We must, however, get beyond superficial similarities of language in order for them to be very useful in this regard. There should, of course, be no suggestion that the concepts of energy used in modern physics or biology are "better" or "worse" than older concepts associated with this term in philosophy or theology or that the usage in one discipline has to conform to that in another. All of these energy concepts are ones we construct in order to aid us in our understanding of reality. The purpose here is to explore areas where the various energy concepts overlap and to suggest some ways in which carefully defined and mutually acceptable ideas of energy may function profitably in conversations between science and theology today.

The manifold connotations of "energy" of interest here are related to the Aristotelian *energeia,* "the activity that transforms potentiality into actuality" (*Dictionary of Philosophy* 1989). The *energy* of any nature in this sense is the activity appropriate to that nature. *Energeia* is closely related to the noun *ergon,* "work," "either as the activity of a thing or as the product of that activity" (Peters 1967, 61). (The *erg* is, in fact, the name of a unit of energy in the metric system.) *Energeia* can often be translated, especially in the Christological discussions considered in the next section, as "operation," a word derived from the Latin *operari,* "to work." The next section traces the use of the concept of energy in patristic, Byzantine, and modern Western theology, with particular attention to process thought in the latter epoch. We will then consider the ways in which the concepts of energy and work have been developed in the natural sciences. Finally, some possible ways of linking these developments will be discussed.

ENERGY IN THEOLOGY

Energeia and related Greek words are used extensively in the Septuagint and the New Testament for activities of God (for example, Gen. 2:2–3, John 5:17), of the demonic (1 John 3:8), and of human beings (2 Thess. 3:10) (*Theological Dictionary of the New Testament* 1964). (But *energeia* itself is ascribed only to God and demonic beings in the New Testament.) The reference in Wisdom of Sol. 7:17 to the "operation of the elements" (*New English Bible* translation of *energeia stoicheiōn*), the functioning of the materials of the world, is of interest as well (see also Wisdom of Sol. 13:4).

The ideas of *energeia* used in the patristic tradition are strongly influenced by the Aristotelian use of the word to mean "operation" or "actualization." This term came to special prominence in Christian theology in the ongoing Christological discussions following Chalcedon. That ecumenical council had said that there are two natures in Christ, divine and human, and that the unity of Christ consists in the fact that there is one person of God Incarnate, the divine Second Person of the Trinity. Continuing attempts to clarify the concerns related to this definition led, in the seventh century, to the combined proposals of *monoenergism* and *monothelitism,* that Christ possessed only one operation (*energeia*) and will (*thelēma*), and that these were divine (Pelikan 1974, 62–75). While this proposal is usually referred to as monothelitism, with reference to the suggested singleness of will, the emphasis on a single operation is at least as significant, and it is that concept which is of concern here.

After considerable controversy, monoenergism and monothelitism were rejected by the Sixth Ecumenical Council in 680–681 (Pelikan 1974, 70–72; Bettenson 1963, 92–93). It took the position that each nature has its characteristic operation, so that the Chalcedonian doctrine of two natures in Christ implies two natural operations (and wills)—which, the council was careful to insist, are always in accord with one another. While, therefore, there would in any given situation be only one result brought about by Christ, there would always be two impulses (and not only one, as for monoenergism) concurring to produce that result. (For the uses of *energeia* in this controversy, see *A Patristic Greek Lexicon* 1961.)

Monoenergism would mean that human nature was present but did not in fact do anything distinctively human in Christ. The decision of the Sixth Council insists that both God and humanity are not only *present* in Christ but *act* in him, in different but consistent ways, for the salvation of the world. Each nature in Christ performs what is appropriate to that nature. For example, in the classical view, the operation of the divine nature was understood to have performed the miracles of Jesus, while the operation of the human nature enabled him to eat, sleep, and suffer. These distinctions are set out with care in an influential work by John of Damascus (1970, 304–14). Centuries later, Lutheran and Reformed theologians addressed in their distinctive ways the relationships between divine and human operations in Christ in connection with their debates on Christological issues (Schmid 1961, 315–16 and 334–37; Heppe 1978, 445–46).

A somewhat different development of the energy concept, which is still controversial today, took place in later Byzantine theology in attempts to explain and defend the mystical practices and ideas of the contemplative movement known as Hesychasm (Ware 1972, 70–80). Those who followed this path (closely associated with the use of the "Jesus Prayer") claimed that it was possible for human beings to perceive "the uncreated light of Tabor," the light of Christ on the Mount of Transfiguration (Matt. 17:2). Taking seriously the biblical statements that no creature can "see" God (for example, John 1:18), but also holding to the promise that Christians are to be "participants of the divine nature" (2 Pet. 1:4), Gregory Palamas argued that while the Hesychasts could not perceive the *essence* of God, they were able to behold the uncreated *energies* of God.[1]

The ideas of Palamas have a significance that extends beyond the historical controversy over Hesychasm and deals with a matter of perennial religious concern. They represent an attempt to preserve the divine mystery, the impossibility for any creature completely to comprehend God, while still holding that it is possible for creatures to know God at least indirectly. The distinction between the essence and the energies of God that Palamas used in this attempt goes back to the Cappadocian Fathers of the fourth century (Ware 1972, 77). But the way in which Palamas set out this distinction has been looked upon unfavorably by many Western theologians, for it has seemed to them to introduce a polytheism into the Christian concept of God (Barth 1957, 331–32; Pelikan 1974, 270). Of course, that was not Palamas's intention, but whether or not it is the effect of his teachings is another question.

Classical theology thus made use of the *energeia* concept to try to express fundamental Christological and Trinitarian beliefs. In particular, it provides one way of speaking about how God is involved in what goes on in the world, especially in the salvation history centered on Jesus of Nazareth. One question must be whether attention to such developments can be useful in any way for the dialogue of theology with science, which makes use of rather different developments of the idea of *energeia*.

Energy concepts were reemphasized, due to influences from the developments in the natural sciences discussed in the next section, with the modern movement of process theology. In *Science and the Modern World,* Whitehead (1925) discusses the concept of energy in the scientific sense, and the few mentions of energy in *Process and Reality*, while somewhat more general (for example, in speaking of "throbs of emotional energy") show the same influence (Whitehead 1969, 138). But the energy theme does not play a dominant role in his arguments. The situation is different in the writings of Pierre Teilhard de Chardin and John Cobb, Jr.

Teilhard makes extensive use of energy terminology in his theological treatments of evolution: Two of his collections of writings are titled, after major essays in them, *Human Energy* and *Activation of Energy* (Teilhard 1969 and 1970). The word "energy" in his writings often seems closely related to usages in the natural sciences. In his essay "Human Energy" (Teilhard 1969, 113-62), he speaks of three forms of energy: "incorporated," "controlled," and "spiritual." The first two, the energies of the human body and those utilized by human technology, are forms of energy considered in biology and physics. Teilhard's understanding of spiritual energy, which "is localized in the immanent zones of our free activity, and forms the stuff of our intellectual processes, affections and volitions" (Teilhard 1969, 115), is not as precise. Are spiritual and physical energies convertible into one another? If so, spiritual energy could be measured in the physicist's laboratory. Initially, Teilhard says that spiritual energy "is probably incapable of measurement, but is very real all the same," but shortly thereafter he says that it is "not improbable that science will one day" be able to measure it (Teilhard 1969, 115–16). The character of spiritual energy is important because it is this energy which, for Teilhard, is especially significant for understanding evolution. It is related to love, the attraction which is bringing humanity together with Omega-Christ. In *The Phenomenon of Man,* Teilhard (1959, 63–64) explicitly argues that physical and spiritual energies cannot be transformed directly into one another and goes on to assume that all energy is physical in nature. But then he distinguishes between "tangential" and "radial" components of this energy (Teilhard 1959, 64–66). Tangential energy is the energy of relationship between entities on the same level of organization and corresponds to the usual scientific sense of energy. Radial energy, on the other hand, is that which draws such entities together to a higher level and plays the role of a spiritual energy. It is also, as he says significantly, that which draws "forwards" (Teilhard 1959, 65). The distinction between tangential and radial energies has some parallels with the classical theological distinction between created and uncreated energies, though all of Teilhard's radial energy is not simply that of God.

How are we to understand these distinctions? Dobzhansky (1968) says that "Teilhard surely does not claim to have discovered two new kinds of energy previously unknown to physicists and physiologists." Barrow and Tipler (1986, 198), on the other hand, argue that thought can in fact be related to physical energy via information theory and that, therefore, as a scientific theory Teilhard's idea "crashes to the ground." Those familiar with Teilhard's writings will not be surprised if there is some lack of clarity in his introduction of provocative concepts. If radial and tangential energy refer to two different aspects of the same entity, then the terminology is somewhat misleading.

We ought to note, in particular, that Teilhard does not actually give a precise definition of the energy concept he is using. At some points he uses the word in the elementary scientific sense of a quantitative measure of the motion of bodies or of what can be converted into such motion. At other points, however, Teilhard's "energy" seems to have more the sense of "operation," as in classical philosophical and theological language. He can speak, for example, of "a single energy operating in the world" (Teilhard 1959, 63). I will argue that the latter usage has a good deal in common with a somewhat more abstract aspect of the scientific concept, the idea of energy as the generator of temporal development, which is discussed in the next section. The mixture of different, though related, concepts of energy is partially responsible for the confusion already noted. The final section argues that if we make appropriate distinctions, we may use ideas similar to Teilhard's to speak of phenomena in the world as at the same time creaturely and divine works.

A rather different development within the process tradition is that of Cobb (1969). He begins by pointing out that modern science has greatly modified classical notions of matter and that the basic particles of modern physics can hardly be considered to be bits of inert substance. They are rather, he argues, "energy-events," and what we regard as a single entity through the course of time is transmission of energy from one event to another. He then suggests that thought can be regarded as a further example of an energy event and, finally, that God may be spoken of in a way continuous with this: "If what is most real are energy-events, and if these are highly diverse in character, then God can be conceived as a very special kind of energy-event" (Cobb 1969, 68–73).

Cobb's concept of energy here leans strongly in the direction of the modern scientific use of the term rather than toward the traditional philosophical usage. This being the case, we have to ask questions at at least two levels. First, is this description of matter in terms of energy events, and especially the distinction between that description and ideas of matter as inert substance, accurate? Second, does Cobb's description of God in terms of energy then encounter some of the same difficulties as do Teilhard's ideas? It will be helpful to consider the scientific concept of energy more fully before addressing those questions further.

ENERGY IN THE NATURAL SCIENCES

"Energy" has been one of the most fruitful concepts in the natural sciences, uniting different areas of study and pointing the way toward new developments. In scientific usage, the word has everyday, almost intuitive connotations as well as quite abstract mathematical ones. Energy is, of course, crucial for the development of science-based technology—Teilhard's "controlled energy"—and a technological culture depends heavily on adequate energy resources. But the concern here is primarily with conceptual developments.

A complete history of the energy concept in science, like that of the philosophical and theological concepts, begins with Aristotle. (A useful discussion from the standpoints of both the history and the philosophy of science is in *New Catholic Encyclopedia* 1967.) The modern concept of what is now called kinetic energy first emerges with Leibniz as *vis viva,* "living force," the product of the mass of a body and the square of its velocity. (The term "living force" refers to the significance of this quantity for bodies in motion, in distinction from the "dead forces" involved in static equilibrium. For the controversy between Cartesians and followers of Leibniz in this connection, see *Dictionary of the History of Science* 1981. In modern physics, "force" and "energy" are carefully differentiated.) One-half of this quantity is now defined as kinetic energy, $\frac{1}{2}mv^2$. This has the important property of *conservation* in a collision between elastic bodies such as steel balls: The sum of the kinetic energies of the bodies is the same after the collision as it was before.

This is not true when other forces, such as that of gravity, act on bodies. (The kinetic energy of a body released from rest clearly increases as it falls.) In this case one can show from Newton's laws of motion that the change in the kinetic energy of a body is equal to the *work,* $W \equiv \int_C \boldsymbol{F} \cdot d\boldsymbol{r}$, done by the force $\boldsymbol{F}$ as the body moves along the path C. In elementary mechanics, one often introduces the concept of work first and then defines energy as "the ability to do work."

Work is the scientific energy concept which, at the elementary level, is closest to the philosophical idea of *energeia* as "operation". (I have already noted that the words *energeia* and *ergon* are closely related.)

But the greatest usefulness of the energy concept has come through a different development. Though kinetic energy is not conserved when external forces act, a *potential* energy can be associated with many forces in such a way that the sum of the kinetic and potential energies of all of the bodies in a system will be conserved. (That is, the concept of work is subsumed under potential energy.) The idea of energy conservation can be extended still further. What is often referred to as the discovery of the law of conservation of energy in the nineteenth century was the realization by several scientists that *heat* can be considered a form of energy. Energy became a crucial concept for chemists and is especially important for understanding living systems (Asimov 1965). Maxwell's theory of the electromagnetic field at about the same time also led to the recognition of the energy associated with that field.

This line of development reached its climax in 1905 with the famous relationship $E = mc^2$ of Einstein's relativity theory. This states, on one hand, that what had been seen previously as inert mass can be converted into kinetic or other forms of energy, a discovery which has had a profound effect on the world with the development of nuclear energy technologies. But the equation can also be read in the other direction as a statement that all forms of energy possess inertia. (Einstein's [1905] original paper is titled "Does the Inertia of a Body Depend upon Its Energy Content?") Mass can be converted to energy and energy to mass. This means one must be careful about the way one distinguishes between mass and energy. While one must be cautious in stating their relationship, at bottom there is not a fundamental difference between mass and energy: The mass of a body and its energy when it is at rest are the same, the square of the speed of light c in Einstein's equation being basically a factor for conversion of units.[2]

The other revolution in physics that began at the turn of the century, the development of quantum theory, also centered on the energy concept with the idea that energy is *quantized*. (For the historical development, see Jammer 1973.) Planck argued that the energy of radiation could be emitted or absorbed only in discrete amounts, and Einstein proposed that radiation actually is discrete bundles of light quanta or photons. This wave-particle duality was extended to all forms of mass-energy by de Broglie.

The discoveries of relativity and quantum theory led to the kind of picture of matter as "energy-events" which Cobb has described.

Only, as previously noted, one must not think that something like an electron is energy *instead* of mass. As energy it *has* mass, and its mass can be converted into other forms of energy. This takes place, for example, when an electron and positron annihilate one another and the energy of their rest masses is converted into the electromagnetic energy of gamma rays.

The mathematical development of quantum theory, however, has produced another fundamental aspect of energy which will turn out to have considerable promise in our discussion of the science-theology dialogue. This is the role of energy as the mathematical entity which describes the temporal development of a physical system in time.

It had been recognized in classical physics that the energy concept provides a way of formulating the laws of physics that is different from, but equivalent to, the use of Newton's laws of motion, which involve the force concept. In the latter approach, the rate of change of momentum with time for each body is given by the force acting on that body. In the energy-based approach one defines (with some technical qualifications) the total energy of the system, written in terms of sets of coordinates $\{q_i\}$ and momenta $\{p_i\}$, as the *Hamiltonian, H,* of the system (Goldstein 1980, chap. 8). Hamilton's equations, equivalent to Newton's laws, can then be written as

$$dq_i/dt = \partial H/\partial p_i, \qquad dp_i/dt = -\partial H/\partial q_i,$$

where t is time. If one knows the Hamiltonian function of a system, together with initial values of the coordinates and momenta, one can calculate, in principle, the system's temporal development.

The force concept is of no fundamental value in quantum theory. (It can be useful as a secondary concept defined in terms of energies. See, for example, Deb 1981.) The Hamiltonian formulation of classical theory can, however, be extended to give a mathematical expression of quantum mechanics. Like other dynamical quantities, the Hamiltonian in quantum theory is an operator which acts on the wave function which describes the state of a system. The basic Schrödinger equation says that the operation of H on the state Ψ gives the rate of change of the state with time:

$$i\hbar\partial\Psi/\partial t = H\Psi,$$

where $i = \sqrt{-1}$ and $\hbar$ is the characteristic constant of quantum theory, Planck's constant divided by 2π (Dirac 1970, 108–11). This means that if the state of the system at some initial instant t_0 is Ψ_0, it will be altered during a brief ensuing time interval τ by an amount

$(\tau/i\hbar)H\Psi_0$. The Hamiltonian thus produces the change in the state of a system over the course of time.

This relationship can be stated in an even more fundamental way in terms of group theory. The energy operator is the generator of time translations in the group of transformations of special relativity, the Poincaré group (Ohnuki 1980; Schweber 1962, chap. 2).

With these ideas we have, to some extent, moved closer to the older philosophical tradition in its understanding of energy. The Hamiltonian provides a quantitative expression for the way in which a physical system develops by itself in the course of time, as well as the ways in which it is influenced by other physical systems. When dealing with two different systems, such as an atom and electromagnetic radiation, it is the "interaction Hamiltonian" that describes how they influence one another. (The classic presentation of quantum electrodynamics from the Hamiltonian standpoint is Heitler 1954.)

The energy concept has to undergo generalizations, and be connected with other concepts, to make sense within a relativistic quantum theory. Just as relativity requires that space and time be combined into a four-dimensional space-time, it also requires that momentum and energy be combined into a single four-dimensional entity, an energy-momentum vector. While energy is the mathematical generator of time translations, momentum is the generator of translations in three-dimensional space. That Einstein made time a relative entity, and that there is thus an infinite number of time coordinates, means that the Schrödinger equation has to be written in a more general way. Forms of quantum field theory and elementary particle physics based on the scattering operator ("*S* matrix"), rather than on Hamiltonian concepts, have also been developed. But the basic ideas of energy and momentum as generators of time and space translations are still contained in the theories that have been at all successful in describing the microcosm, and these ideas are likely to remain through any future vicissitudes of particle theory.[3]

The law of conservation of energy is closely related to the role of the Hamiltonian as the generator of time translations. That *H* does not change with time is a consequence of the fact that the laws of physics are invariant under time translations, so that they will be the same tomorrow as today. This property is so fundamental that physicists have been prepared to introduce new theoretical entities, such as the neutrino, in order to preserve the conservation law. (This particle was detected a quarter of a century after it was predicted to save conservation laws in nuclear beta decay.) There have been speculations about "biotic" or "psychic" energies which could be related to Teilhard's "spiritual energy." These might exist, but they have not been detected in the same way that other forms of energy have—that is, by their conversion into recognized forms of physical energy. Today there are no anomalies such as existed with beta decay which suggest that psychic or spiritual energies need to be introduced into science in addition to known forms. Thus, from the physicist's standpoint, such new types of energy are, at present, purely speculative.

DIVINE GENERATION OF THE WORLD

The fundamental theological questions that must be dealt with in this area have to do with possible relationships between our idea of God and the energy concept and the associated issue of possible uses of energy concepts to describe the interactions between God and the physical world. The concern here is with the second type of question, with economy rather than theology proper in classical language. Energy may, of course, provide a metaphor which can, to some extent, appropriately represent God and God's associations with the world. But can we go beyond such a metaphorical use of the energy concept? Even if we do not want to speak directly about God in terms of energy (and thus become involved in the type of controversies associated with Palamas), can we develop some adequate analogies between the scientific concepts of energy and the divine activity in the world?

A rather naive approach would be to say simply that God *is* energy, in some way the same type of entity recognized in science. This would go a considerable way toward removing any qualitative distinction between God and the world. Unless some distinction between divine energy and the energy of the world can be made, such an approach could lead to a pantheism in which God is identified with the totality of energy, and from there with the totality of the physical universe. Any origin of the universe would then have to be understood not as creation but as emanation, the conversion of divine energy into the forms of energy recognized by physics (for example, Staub 1986, 256–57). The emphasis would be on the substantive character of energy in modern science rather than on the more subtle role of energy in the temporal development of the world displayed in the equations of Hamilton or Schrödinger.

It is, however, possible to develop more sophisticated connections. In the classical theological tradition, one speaks of energies—that is, operations—associated with the divine nature and of those associated with created natures. In the Incarnation, according to the Sixth Council, these operations remain separate and unconfused but are always in accord with one another. The divine and human energies literally cooperate in Christ.

Now in some traditional understandings of God's ongoing creative work in the world (John 5:17), one also speaks of a concurrence or cooperation between divine action and secondary causes, created physical processes (Schmid 1961; Murphy 1991). The term "cooperation" is especially significant, for it means literally that God "works together" with the materials, structures, and processes of the physical world. The picture this term suggests is sharpened when we see, with quantum dynamics, physical energy as that which generates the temporal development of a system. The doctrine of concurrence would then describe the divine energies as working in concert with created energies which characterize the physical process in question. Divine energy would work *through* the physical to generate the evolution of the world. Since the process can be described exhaustively from the physical side in terms of natural processes, the world is comprehensible "though God were not given"—but the divine operations are involved in everything that happens! The idea can even be extrapolated to the extent of seeing the origin of the universe as taking place through divine cooperation with physical energies in a paradoxical process of "mediated creation *ex nihilo*" (Murphy 1987). This would accommodate the type of theory which Hawking (1988) and other cosmologists have been attempting to develop in recent years in order to describe the very early universe in terms of elementary particle physics and quantum gravity (Drees 1991).

Creation—both "in the beginning" and today—would then take place in a way parallel to the classical understanding of the Incarnation. There would be mutual working together of divine and created energies to generate the universe. The question of whether or not such an approach would require that we attribute to the divine energies the type of separate reality suggested by Palamas would need further exploration.

The theological development would be rather different in the context of process thought. While here God and the world are not taken to be simply identical, as in naive pantheism, neither is there understood to be a sharp separation between God and the world. (Thus the term "pan*en*theism" may be appropriate.) God is not, as in much of classical theology, absolutely independent of the world, "affecting but not affected."

In process thought, God is the one who continually generates the world. In modern physics the Hamiltonian, the energy operator, plays that role. Without requiring an overly simple identification of God with the total Hamiltonian of the world, process thought would seem to call for a close association between the two, as Cobb has argued. It is the energy of the world which is the generator of world process.

One might also attempt to relate energy to the bipolar character of God in process theology. Energy in the scientific sense has two aspects which are apparently very different but which are actually related quite intimately. Energy is that which generates temporal *change,* but energy itself is *conserved.* The relationship between these two aspects can be seen clearly in the formulation of quantum dynamics in the Heisenberg picture (Dirac 1970, 111–16). The rate of change with time of a dynamical variable A, and thus its time development, are obtained from the commutator of that variable and the Hamiltonian: $i\hbar dA/dt = AH - HA$. (This gives the quantum analogue of Hamilton's equations when A represents coordinates and momenta.) But a constant aspect of the world, the conservation of energy, is manifested in the fact that $dH/dt = 0$ because H (like all operators) commutes with itself.

Whitehead spoke of God as having both a primordial and a consequent nature:

> There is not the mere problem of fluency *and* permanence. There is the double problem: actuality with permanence, requiring fluency as its completion; and actuality with fluency, requiring permanence as its completion. . . .
>
> This double problem cannot be separated into two distinct problems. Either side can only be explained in terms of the other. The consequent nature of God is the fluent world become "everlasting" by its objective immortality in God. Also the objective immortality of actual occasions requires the primordial permanence of God, whereby the creative advance ever re-establishes itself endowed with initial subjective aim derived from the relevance of God to the evolving world. (1969, 405–13)

It will be seen from this quotation that, if we are to respect Whitehead's nuances, we cannot make a simple equation of "change" with one of the natures of God and "permanence" with the other. But it is from the primordial *permanence* of God that the world's creative advance is ever reestablished, and the world is saved in God's consequent nature. (God in the consequent nature "saves the world as it passes into the immediacy of his own life" [Whitehead 1969, 408].) The "two natures" of energy noted would seem to have some parallels with the two natures of God in Whitehead's theology, though precisely how one would want to set up a correspondence is not obvious.

Teilhard's concept of "radial energy," the energy associated with forces which draw the world together, may be helpful here as well. As already noted, he also speaks of this energy as that which draws the world *forward*. It thus generates a converging temporal development of the universe (Teilhard 1959, 65 and 257–63). Only it has to be made clear that this is not a new type of energy in *addition* to the physical ("tangential") energies already recognized by natural scientists. On the contrary, what Teilhard called tangential and radial energies must be seen as the same entity under two different aspects. It is the same Hamiltonian that is a constant of the motion and that generates the temporal evolution of the universe, an evolution Teilhard described as "cosmogenesis."

This makes it clear that it certainly may be appropriate to speak of God in terms of "energy-events," as Cobb suggests. This is a usage which can be in accord both with the thought of the early Church and with the understanding of physical processes which modern science gives us, as well as with the themes of process thought.[4] We may wish to make a distinction between the divine essence and the divine operations similar to that which has been insisted upon by Palamas and the teaching of the Orthodox Church, but we have to recognize that it is only through the divine operations or energies that creatures have any interaction with God. The emphasis on God's involvement with the world that is such a strong aspect of process theology shows itself in an emphasis on energy concepts. It seems, then, that these concepts can serve both to facilitate the science-theology dialogue and to provide a link between process thought and that of the patristic tradition.

As a final suggestion for further investigation, take note of part of Teilhard's (1959, 264–67) argument entitled "Love as Energy," in which he speaks of the basic role of love, "the affinity of being with being," in evolution. Teilhard is, of course, not the first to speak of this. The popular saying has it that love makes the world go 'round, and in the closing line of the *Paradiso,* Dante speaks of the love which moves the sun and all of the stars. Love is a difficult concept to deal with in a precise scientific way, yet it is profoundly meaningful. From considerations of the importance of altruism in human evolution, Hefner (1993, chap. 12) has argued that it must be seen as a basic aspect of reality. It might be that if we were to follow Teilhard's hint and search for relationships between love and energy, in the senses discussed here, we would gain further insights into the role of love's motive power.

NOTES

1. The critical edition of Palamas's relevant writings and a selection in English are Palamas (1973a; 1973b), both edited by John Meyendorff, whose introduction (pp. 1–22) to the latter edition provides helpful background material and discussion.

2. For discussion of the care needed with Einstein's equation, see Okun (1989). The old way of presenting relativistic dynamics in terms of a mass which increases with velocity, so that simple mass-energy equivalence holds for moving bodies as well as for those at rest, though not "wrong," is no longer in favor. One difficulty with it is that there are particles like photons which have no rest mass. But that all forms of energy have inertia is shown by the fact that all of them (including light) are affected to the same extent by a gravitational field. For the role of *c* as a conversion factor, see Taylor and Wheeler (1966, 1-5).

3. For modern quantum field theory, see Schweber (1962) or Bogoliubov and Shirkov (1983). A covariant generalization of the Schrödinger equation was given by Tomonaga (1946). The bootstrap model for particle physics, in which the *S*-matrix is fundamental, was popularized in Capra (1975), with claims for its similarity with the worldview of Eastern religions. General relativity, in which space-time does not, in general, have any translational symmetries, also requires new considerations of the energy concept. See, for example, Misner et al. (1973, chaps. 19–21).

4. Care also is needed with the term "event." For the physicist, this suggests a definite place and time, a point of the four-dimensional world. Cobb uses the word in a wider sense: " 'Event' is a general term for a happening of any degree of complexity or extension through space and time" (1965, 99).

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