John R. Wood

Article

An Ecological Perspective on the Role of Death in Creation

John R. Wood

"The large fish eat the small fish; the small fish eat the water insects; the water insects eat plants and mud." –Chinese Proverb[1]

"The young lions roar for their prey, seeking their food from God." –Psalm104:21 (ESV)[2]

"Life matters. Death matters. Both rely on one another." –Scott Peck[3]

"… the final word of evolutionary biology always seems to come to this: death is the engine of nature." –Paul Santmire[4]

"Truly, truly, I say to you, unless a grain of wheat falls into the earth and dies, it remains alone; but if it dies, it bears much fruit." –John 12:24 (EVS)[5]

Death is pervasive in ecological relationships. Living systems are animated at every level by mortality, cessation, and endings. Nothing in ecology makes sense apart from death. Through long and often personal association, it is difficult for us to see death as anything but evil. If death is present, then something must be wrong. Yet this primarily moral and emotional judgment does not adequately represent our understanding of the ecological role of death in biotic systems. Death animates living systems at every level so that without death there is no community, no ecosystem, no biosphere as we know them. Recent theoretical and empirical work, particularly in aquatic ecology, has focused on the role of programmed cell death (PCD) in regulating population and community structure. Ecologists are now linking the smallest cellular events, genetic and physiological, with planetary biogeochemical processes. Researchers tracking the origin of predation have taken a turn into deep time and the symbiotic origin of cell organelles, asking if they are seeing the roots of multicellularity in death. This understanding of life will continue challenging conventional views of Genesis linking sin and the Fall to bodily death and complex ecological processes.

Opening to Death

Life dominates planet Earth, shaping its form and processes at every scale. Single-celled organisms link the rocks and the oceans together, with atmospheric processes providing the means for renewing and sustaining life in the biosphere. A living fabric drapes the geological bones of every landscape, even to the depths of the oceans. And it is not just multicellular plants, but wherever there is free water much of this living tissue is in the form of biofilms. We are learning that these complex associations form a thin film over all but the driest or most dynamic exposed surfaces.[6] Biogeochemical cycles supply the chemical building blocks for life. These complex elemental and molecular exchanges are mediated by a myriad of microbial species. Single-celled organisms are so pervasive that the fingerprint of living processes is virtually everywhere. There is evidence for a biogenic graphite signature in rocks dating back

John R. Wood, *PhD (University of California, Berkeley) is professor of biology and environmental studies and dean of the Faculty of Natural Sciences, The King's University, Edmonton, Alberta, Canada. John is an ASA Fellow. His current research is on food insects, global food security, and animal behavior and population dynamics with white-tailed jackrabbits.*

3.7 billion years.[7] And with new remote sensing tools we can identify the light back-scatter from photosynthetic microbes on Earth. This is also a promising way to search for a biosignature in deep space.[8] In the ecological sciences, a newly integrated view of life is linking the smallest organisms to planetary ecological processes. Yet, surprisingly, this emerging new view of life is based squarely upon death and dying. Death is a pervasive phenomenon in ecological relationships. The ecological services of living systems are animated at every level by mortality, cessation, and bodily or physical endings.[9] Our challenge is to find a comprehensive theory of death to encompass these observations.

It is surprisingly difficult to find the word "death" in the index of ecology or conservation biology books. It is seldom listed separately, perhaps because the effects of death are pervasive, present in nearly every other subject. One finds detailed coverage of physical disturbances and other mortality mechanisms (e.g., predation, trophic cascades, and population regulation). But there is little coverage of any attendant definitional issues for death. The brute fact of a physical ending is seemingly self-evident. James Carey, a pioneer in the field of biodemography, and specializing on insect models for aging, comments "that [although] death is one of the most mysterious and inexorable problems in biology. There is little direct coverage in basic biological science and textbooks seldom contain any reference to death or dying."[10]

In the source book *Keywords in Evolutionary Biology*, for instance, "predation" and "extinction" are listed, but not "mortality" or "death."[11] This lack of detailed attention to death means that it remains undertheorized in biology.[12] Life scientists may simply be reflecting a more generalized societal discomfort with death.[13] But environmental ethicist Holmes Rolston III suggests that at least part of the reason may lie in the simple avoidance of the challenging philosophical questions raised by evolutionary theory and the associated mechanisms of biotic death. As he says,

> Biology in the last half-century has not been particularly comfortable with the word "struggle" which has largely disappeared from biology texts, being replaced by the notions of "adaptedness" and "fittedness." Still, plenty of "struggle" remains in biology (although the switch in emphasis is revealing), and when philosophical participants find that they themselves have ascended via this struggle, they are confronted with the question whether such a struggle can be meaningful.[14]

The advent of evolutionary theory and its putative mechanisms of natural selection and sexual selection confront us with the challenge of physical death and the meaning of life. The hypothetico-deductive approach of the Darwinian method, as Michael Ghiselin points out, has been a robust success.[15] And as such, it is a challenge to many-received ideas across a wide range of social, philosophical, geological, and, we can add, theological domains. The mechanism of struggle, loss, and death that is so vital to evolutionary theory, Keith Miller says, serves "as an unnecessary stumbling block to a productive engagement of both science and faith."[16]

Rolston, in his chapter "The Life Struggle," shows that questions in evolutionary theory can actually enhance our understanding of God's good earth.[17] We could gain much by applying these new findings on the ecological functionality of death to the stewardship of the earth. The emerging creation-care discourse has necessarily invoked the negative aspects of human actions as a destructive agent of ecosystem change or loss.[18] But it has also taken Job's view of awe and wonder at the dangerous behemoth.[19] In contrast to the traditional view, this literature has also emphasized the fundamental goodness of God's creation in all of its operations, even those involving pain and death.[20] We circle the questions of biotic death, pain, and life in a troubling dance, looking for clarity. The range of answers that we have available through the traditional view of death[21] seems to me theoretically unsatisfactory and is increasingly polarizing.[22] Perhaps a closer look at the phenomenology of biotic mortality through an ecological lens will give us some new insight.

To appreciate the pervasiveness of death in ecology let us start by considering how the end of life animates the entire range of ecological relationships. Population ecologists, trying to understand the regulatory mechanisms in the ebb and flow of populations and communities, mathematically model death in what are called "loss processes."[23] The famous Snowshoe Hare-Canadian Lynx (SSH-CL) predator-prey cycles have been described with linked population equations.[24] The customary view of this species pair is that a proficient predator will regulate the prey in a cyclically balanced fashion.[25]

Yet close analysis shows that more than simple predation is going on. Numerous biotic (competitive) and abiotic (physical) factors are interacting to regulate these populations. We typically think of predator-prey interactions resulting in the demise of prey in a dramatic chase that ends in a cloud of dust, blood, and gore. Predation on this view is a winner-take-all exchange in which the prey species is the loser. But the ecological action of death is considerably more complex.[26] In the classic SSH-CL cycle, the synchronizing mechanism remains elusive. Grouse are an alternate prey item. And the buds, seeds, and twigs of understory shrubs are browsed by both the hares and birds. This nonanimal death also has a regulatory influence. Plants can be predators too: carnivorous plants dominate in nitrogen-poor habitats such as acid bogs in the Boreal Forest or high on the table-like "Tepuis" of Venezuela in South America.[27] Ecologists conclude that death shapes ecosystem processes in a much wider array of feeding (trophic) relationships than that typically imagined as one animal eating another.

In the broadest sense, plant-feeding herbivores (such as bison, elk, antelope, and elephants), fish grazing on phytoplankton, or parasites invading hosts are all forms of predation.[28] But the predator does not need to kill outright in order to have an impact. The mere threat of death is also a population-regulating mechanism. Described colorfully as "landscapes of fear," the indirect or nonconsumptive effects of the threat of predation are increasingly recognized as important determinants of ecosystem structuring.[29] The prey item is not consumed, but simply alters its behavior in the presence of the perceived risk of predation. A classic case of predator-induced stress is the reintroduction of wolves into Yellowstone National Park. The activities of this top-level predator influence species at multiple levels in what is called a "trophic cascade" throughout the food web. The fear that wolves engender is sufficient to prevent elk from freely browsing on aspen trees as they once did near streams. Reduced browsing by the elk releases aspen growth, which in turn has an influence on beaver populations, and so on.[30] In the end, as ecologist Paul Colinvaux pointed out bluntly in his text, "all population control is by death," either by outright mortality or starvation, or by the failure to reproduce.[31]

Ecologists describe the significant biological features in the life cycle of an organism as its life history.[32] Detailed life history studies have shown that there is an energetic cost to these prey responses. The measurable effect of predator presence on reproductive output is one influence on Darwinian fitness.[33] The fear of death response happens in aquatic systems as well as terrestrial ones. Small minnows, or "bait fish," will bulk up around the pectoral fins if they detect the odor plume of a predator.[34] The energy cost of doing so is measurable for vertebrates and invertebrates alike. Water fleas (Daphnia), a common zooplankton in lakes, go through a seasonal cycle of body forms called "cyclomorphosis." In the presence of chemicals released by predators, each generation grows energetically expensive spines called "helmets."[35] Back on the land, entomologists have noticed that tree leaves will toughen, becoming distasteful after the plant has been fed upon by herbivorous insects.[36] And trees are said to "talk" to one another via the volatile chemical signals released when a herbivorous insect begins feeding. So a variety of ecological life history strategies, from outgrowing a predator to becoming distasteful, are deployed in the face of death. Population regulation by predation and stress are not the only death-mediated mechanisms that are structuring the biodiversity of ecosystems.

A World Shaped by Dying

Today there is an abundance of new research in ecological studies on death, senescence, and the process of dying. Yet biological death remains a profound mystery to us. Through long and personal association, it is difficult for us to see death as anything but evil—so much so that we might easily pass over the ways that physical mortality has been shaping the form and functioning of the biosphere. It would be difficult for an ecologist to imagine the overall appearance of a prairie landscape, for instance, without death operating in that ecosystem. The influence begins at the lowest structural levels. Cell mortality is a normal developmental component of life-forming processes, eliminating abnormal cells, deleting structures, and shaping tissues.[37]

These processes then scale upward. Ultimately death is expressed in the maintenance of every biotic community, providing structural integrity and vital ecosystem services.[38] The vascular systems of plants, for example, are composed primarily of nonliving

tissues. These dead cells are essential for conducting water and nutrients to the heights of redwood trees. The points and incised margins of leaves are complex functional surfaces shaped by death. These finely divided forms develop from undifferentiated lobes when embryological cells die leaving a gap between the outwardly growing outer surfaces. Likewise programmed-cell demise is at work with flower formation and the fall of deciduous leaves.[39] On the plant surface, protective bark layers form from dead or dying cells, analogous to the keratin-filled cells of our own skin. In the fall of the year, wonderful displays of color and leaf-drop are mediated in a genetically regulated process called programmed cell death (PCD).[40] PCD is expressed through a variety of biochemical pathways defined generally as either regulated cell death (apoptosis) or unregulated (necrosis). And the force of programmed mortality is at work at the community and ecosystem levels too.[41] Yet our cultural ambivalence with death can lead us to overlook the vital functional and structural roles that disturbance-mediated death plays in the biosphere.[42]

On land, physical disturbances, such as fire, shape forest ecosystems. But, for over half a century, best management practices effectively suppressed wildfires and other ecological disturbance agents, such as floods, whenever possible. But excluding all death-dealing ecosystem disturbance agents is widely recognized as poor management practice. We are now beginning to learn how to live adaptively with fire by accepting this necessary mortality as a sign of ecosystem health.[43]

In the ocean, the riot of color and swirling behavior among species in a coral reef community is mediated by complex interactions of physical, chemical, and behavioral processes shaped by death. Among the web of trophic relationships are the interesting coral-feeders (e.g., parrot-fish, filefish, and puffers).[44] These herbivores consume coral in copious amounts extracting the algal and coral polyp nutrients. Their finely divided feces rains down a white cloud forming sand grains that accumulate in many places, including the tropical white sand beaches we find so attractive.[45] Without this constant cropping, the algae would overgrow the reef, dramatically altering its structure and community composition. In every kingdom and domain of life, we find that the genetic program of death operates.

Contemporary views of living systems from cells to ecosystems are increasingly focusing on death and death-like processes. Seemingly every taxonomic level is represented in our emerging understanding of PCD.[46] Ecologists have discovered that PCD has regulatory influence on carbon flow through food webs, and in overall ecosystem structure, particularly in marine ecosystems. Cyanobacteria, better known as blue-green algae, are some of the smallest photosynthetic organisms in the ocean. They make up the base of the food pyramid, converting carbon dioxide into plant tissue and playing key roles in biogeochemical cycles and, ultimately, in regulating Earth's climate. Over the last three decades, we have gained deep insights into the detail of how death, mediated through PCD and the associated genetic pathways, is central to the function and structure of the entire biosphere.[47]

Then, at an entirely different scale, we find another kind of death study giving insight into the colony dynamics and behavior of social insects. Ant and honey bee workers can detect the "sweet smell of death" on a dead or moribund nest mate. At death, the suite of chemical signals associated with life begin to dissipate. This triggers the living to engage in life-conserving housekeeping actions, removing the dead to the refuse heap. And painting a live nest mate with a coat of specific fatty acids elicits a quick ride outside.[48]

Finally, there has been a surge of research on death assemblages in conservation biology that are just now beginning to emerge.[49] It is as if to advance the study of life it is necessary to look carefully at death. In an imaginary world without death there would be few of the many biological distinctions that we take for granted as fundamental to living systems. D'Arcy Thompson's classic study *On Growth and Form* delightfully details the physical rules of shape and form.[50] In an imaginary world without death, all that he describes and all that we observe simply disappear, to be replaced by mineral mechanics. There would be no cell shape, no tissue or texture to living systems. The shape of trees and forest stands, the mix of grassland species on the prairie, the shimmering blue depths of the open ocean, and the riot of color in a coral reef would not be the same. Without the formative mechanism of mortality through which ecological processes occur, we cannot describe the shape, or the behavior, or the system functioning of

the biosphere. Nothing in ecology makes sense apart from the operations of physical death.

What Is Death?

Ecological textbooks, as we said, show little awareness of death per se and seldom address the definitional issues associated with the term that crop up in the medical sciences. But biological mortality, even in ecology, is not so simple; there are varieties of death. In simplest terms, biological death is the act of being killed and the end of life for an organism. More technically, we speak of death as the ceasing to be a self-organized entity.[51] The body may remain, but the capacity for change is missing. Death is sometimes described as the loss of life. And medically, it has been marked by the irreversible cessation or stoppage of the heart, brain activity, or respiration. In science, physical or biological death is a normal process of the contingent, material world.

In some settings, death is characterized as a fundamental force or agent of change. Thus, ending is thought to be necessary for change and renewal to occur.[52] There are many kinds of endings that occur in nature. Biotic life is constituted of events and ends through a myriad of contingent processes.[53] Atoms end in the light-matter quantum exchange of radioactive decay. Molecules end in metabolic respiratory pathways. Cells end with necrosis and PCD, both vital homeostatic processes that ensure the good health of organisms and of ecosystems. Tissues end by replacement, most interestingly in a complex program of dissolution and regrowth called "metamorphosis."[54] Ecologically, species and biotic communities come to an end point in extinction and successional change over time. The arrow of time mediates these endings we commonly label "death."

However, death itself does not have agency. Physical death is not a force like gravity. Rather, it is a condition that results from the power, action, or change mediated by some agent during the course of life. Or put another way, death is an outcome of the lack of life. In these definitions, it is already clear that death is less a discrete event and more a process. And this insight presents life scientists a problem in specifying precisely when death has occurred for a biotic entity.[55]

This complexity arises in ecology too, from our inability to unequivocally identify organisms as individuals with a distinct end point. Without this precision, we cannot say when, or if, an organism has died. The discrete, unitary organisms we encounter every day (e.g., a dog, a cat, or a bird) are only one of two fundamental body forms in nature.[56] Many species, including plants, fungi, and social organisms, live as modular units of a collective, sometimes designated a "superorganism." This presents a challenge for population ecologists tracking the mortality of living units. For example, the typical cluster of aspen trees is a "clone." The founding unit that develops from seed is designated a "genet." The genetically identical shoots that grow to form the stand of trees are called "ramets." But what is the age of this group and when does this clone die? Is it the death of the genet or of the several offshoots that count? And symbiotic relationships push the boundaries of the individual into even fuzzier conceptual and terminological territory.[57] On close examination, we are finding that there is a relational character to living systems that does not sit easily within commonsense platonic categories of discrete individuals.[58]

Careful observers had known from antiquity that there were inherent mechanisms operating to limit the growth and development of plants and animals. The beginnings for a theoretical framing of death came in the eighteenth century with experiments by Linnaeus and his students on the potential consequences of uninterrupted plant growth. "A single plant," he wrote, "if left unchecked by animals, could cover and envelop our entire globe."[59] And Malthus and Darwin, following him, both knew that death was the necessary twin of life. This is perhaps best illustrated by the famous last paragraph of *The Origin of Species*. In it, Darwin explicitly names the agency of death operating as part of a complex system that is naturally selected to sustain life.

> Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.[60]

With Darwin, ecologists have a useful theory explaining new species development. It provides a

mechanism for competitive exclusion and physical or reproductive death.[61]

Death then is axiomatic in the theoretical underpinnings of evolutionary theory, framing key questions in ecology. The so-called "Copernicization" of death is not rejecting Darwin, but suggesting that a more comprehensive theory of death is needed.[62] To better understand death, it may be necessary to examine what is living versus what is merely material and, hence, dead. At the outset of the modern discipline of biology, organisms were defined by their intentionality, their telos. Kant delimited living organisms from mere machine "tools," using the term "self-organized" to indicate their intentionality.

However, as Evelyn Fox Keller shows, since the advent of cybernetics in the 1940s this definition has become problematic. She proposes that we "drop the question of intentionality for living entities and focus instead on agency."[63] Making this move changes the focus for the definition of life to power, action, or change. And now we have a clear link between life and death, in which the lack of agency is defining.

Biology is centered entirely on the study of life and life-like processes; therefore, biologists have defined life by a series of functional properties that we all memorized in high school biology. For most biologists, these functional definitions of living systems seem adequate for our work. But this approach is problematic for philosophers. In a detailed and highly personal accounting, analytical philosopher Fred Feldman undertakes a search for robust definitions both of life and of death. He concludes that "in spite of its magnificent pedigree and its popularity, the life-functional approach to the analysis of life is unsuccessful."[64] In the end he says that "life is a mystery." Nor is he sanguine that we can do any better in precisely defining death.[65] Life and death circle one another in an endless cycle as Steven Peck and the wise Preacher (*Koheleth*) in Ecclesiastes both claim.[66]

From a different disciplinary direction, organic chemist Addy Pross claims greater certainty about his theory of the origin of life, but he also alludes to some mystery, or at least ignorance, as life emerges from lifeless matter. He proposes that a unification of Darwinian theory and the chemical theory of evolution must take place for an "integration that forms the basis of the theory of life."[67] Unfortunately, Pross says little specifically about death. But any integrated theoretical framing of life linking chemistry with evolutionary theory will need a complementary theory of death. We are left then, from both philosophical and biochemical directions, with the theoretical mystery of biotic life and death. We currently lack a means of effectively connecting these two phenomena into a satisfactory theoretical framework. The call by André Klarsfeld and Frédéric Revah for a comprehensive theoretical reframing of death is important to biologists.[68] A deeper insight into the theoretical place of death in ecology may open new avenues for investigating the course of life on Earth than that currently available in the neo-Darwinian synthesis.

From Definition to Meaning

Two aphorisms from Claude Bernard, a founder of modern physiology, sum up a paradox of biotic existence. "Life is creation," he said, and in challenge to the vitalism of the day, "Life is death."[69] Mechanistic theory is conclusive, and we no longer assert a vital force or élan for life. In our attempts to understand life, we are closing in on the goal of producing it artificially and/or identifying it in deep space.[70] But the challenging question is, how will we know it should life appear on the lab bench or even in deep space?[71] Research in ecology, biochemistry, and astrobiology is testing the adequacy of our theoretical understanding of both life and death. Is there an essence to life that links to death? In the end, we simply cannot say that there is one thing that unequivocally defines either end of this wonderful continuum of life that we find ourselves within. How interesting! So I am simply going to continue using each term as if we all understood exactly what is meant by them. And, if Feldman is correct, life and death do form identifiable ontological categories.[72] But it all depends upon how the question is approached.

This illustrates what I take to be the central challenge in speaking about the place of death in ecology. We often take hold of the wrong end of such questions. Asking "when were you born?" or "when did she die?" are relatively straightforward questions to answer. But actually these questions lack the necessary precision for all but the most ordinary examination. If we go further and try to exert the full force of our analytical methods to bring precision to our understanding, the questions escape our empirical grasp. The answer that we actually want cannot

be found in the empirical-theoretical facts of the matter. No amount of scientific exactitude will explain the meaning of human death, the necessity of suffering among creatures, and the putative silence of God in the face of relentless human interrogation. The Creator will not be justified to the creature; and as George Murphy details, the triune God remains wonderfully hidden in plain sight, having become a creature and submitting to these same creaturely limits, including death on the cross.[73] Here is where we must begin our humble inquiry of faith in order to understand death. For as Job discovered in his day, it is in the silence of faith before the Creator that, after all, the answer lies.[74]

The approach to meaning in death that recommends itself to me is much like that found in Robert Farrar Capon's description of how everything was created in his short essay "Let Me Tell You Why."[75] He starts by describing a fanciful party where God decides to make the world. The scene is closer to what might happen by a gathering of artists, rather than by a sovereign royal ruler.[76] And he ends saying,

> It is, I grant you, a crass analogy; but crass analogies are the safest. Everybody knows that God is not three old men throwing olives at each other. Not everyone, I'm afraid, is equally clear that God is not a cosmic force or a principle of being … Accordingly, I give you the central truth that creation is the result of a Trinitarian bash, and leave the details of the analogy to sort themselves out as best they can.[77]

We can scarcely do better in talking about the meaning of death.

Ecologists sometimes say the first rule of ecology is "eat and be eaten," and the aphorism is affirmed in numerous biblical texts. This observation and its ambiguity are captured wonderfully by Annie Dillard in an incident with a mosquito feeding on a copperhead snake.

> Is this what it's like, I thought then, and think now: a little blood here, a chomp there, and still we live, trampling the grass? Must everything whole be nibbled? Here was a new light on the intricate texture of things in the world, the actual plot of the present moment in time after the fall: the way we the living are nibbled and nibbling—not held aloft on a cloud in the air but bumbling pitted and scarred and broken through a frayed and beautiful land.[78]

That food is derived by the consumption of living tissue is our descriptive position. The Bible places eating into the economy of God saying, "He provides food for the cattle and for the young ravens when they call" (Ps. 147:9). And the wonder of God's hand in predation is acknowledged in Psalm 104:14, "The lions roar for their prey and seek their food from God." So death in biotic systems has always been seen as a normal part of nutrition and life in God's kingdom.

Ecological Applications of Death to Creation Care

The ecological retheorizing of death that I propose may yield insights into creation care. First, this view supports the theological assertion that biotic death was present from the beginning and is inherently part of the goodness of creation.[79] Second, the land, as scripture calls the biosphere, is a gift. And biotic death is a part of that gifting to which we need to open our hands and gratefully receive it. This does not mean that we actively seek out death, but we no longer fear it either. Third, the fruitfulness of creation is necessarily balanced by endings. While this imperative is intuitively obvious, the mechanism of death still troubles us deeply.[80]

Fourth, a flourishing creation, our stewardship charge, depends on better understanding dying.[81] The ecological rethinking of death that I am advocating opens new insights into biotic functionality and shalom—the biblical concept of the flourishing of all creation.[82] Could it be that the groaning of creation is not primarily from physical death, but from the dislocation of relationships caused by human sin? Restoring those ruptures in relationship of humans to God, and of humans to the creatures is, as Middleton says, what we are interceding for and actively working to accomplish.[83] The lesson of creation care is that the redemptive concern for people requires that we also care for the earth.[84] And that this is possible in the presence of death. Mortality is not an optional, embarrassing, or inconvenient truth, but integral to the order of creation. It is as necessary to life as is the law of gravity. Dying is how our bodies—and likewise all those organismal bodies upon whom we depend for human flourishing—work.

Fifth, we know that our traditional view of death has contributed to an "ecological blind spot" for many in

the evangelical church.[85] The linking of missions and creation care at the 2012 *Lausanne Global Consultation on Creation Care and the Gospel* is a welcome and exciting sea change in this thinking.[86] Sixth, lament may be the response that will transcend the evil we perceive and bring us hope. Differing varieties of theodicy, Celia Deane-Drummond says, address evil in three forms—natural, moral, and, she suggests, *anthropogenic* evil.[87] Although the available theodicies may be inadequate, she says that the "*attempt* to consider theodicy" is still worth doing.

I agree that the full answer to the problem of death will not likely lie in a more detailed theodicy. We need to explore other ways forward. The "grief work" that Walter Brueggemann recommends is both a hopeful sign and, as he says, our prophetic task.[88] The human community faces stark choices that are as old as the covenant announced by Moses in Deuteronomy 30:15–18.[89] Brueggemann says that we can have

> Either ideology or realism;
> Either denial or grief;
> Either despair or hope.[90]

And scientific realism, including embracing the reality of biotic death, is required to address "both methodological and substantive challenges to Christian theology," says Arthur Peacocke.[91] Embracing the reality of biotic death is a vital step on the path to reimagining our relationship to the natural world.

Seventh, the concept of biophilia, our innate creaturely affinity for nature, can give us insight into the paradox of love and relationship lying at the heart of creation. I suggest that understanding biophilia helps us understand who we are, biophysically and spiritually.[92] It links us to our calling as stewards made in the image of God. In spite of all our passion for utilitarian efficiency, and the stewardship failings that ensue, we humans deeply love this biodiverse world.[93] As N.T. Wright suggests, we were created in love, in a relational world. And "love freely given creates a context for love to be freely returned."[94] The world, he notes, has been "created good but *incomplete*."[95] Biological dying is a necessary correlate in the story of a free and contingent universe. But physical death is not the only story.

Why Study Death? A Speculative Postscript

Having a clearer understanding of the "telos of death" as it operates in creation is vital. Ecologist Jeff Schloss gives carefully nuanced accounts for the question of death and predation in ecology. "While death is not necessary for life," he says, "the possibility of death is necessary. So constitutive for life is the possibility of not-being that its very being is essentially a hovering over this abyss, a skirting of its brink."[96] In the beginning God's spirit creates life. I wonder if physical death is not simply assumed in the biblical account of life giving, particularly in Genesis 1 where the abundance of life is springing forward. Can we conceive any functioning ecosystem, under any of the range of suggested time frames (days to millennia to billions of years), functioning without organisms dying? Not under any ecological conditions that we have experienced or theorized. Furthermore, throughout the scriptures, physical death is often linked to flourishing. The metaphors of "pruning," of "dying daily," and of saying that "unless a seed dies it abides alone" all seem to point to physical death as a normal end.[97]

What is life? What is death? We still do not know with precision, and we may never. The gift from God of the biosphere in all its complex ecological processing includes death. In *Nature Reborn*, Paul Santmire gives a clear-eyed account of the ambiguities of both gospel and nature with respect to death. We Christians, he says, "are unable to deny death. A religion that has a crucified Messiah as its fulcrum hardly permits that."[98] So can we find a better vision of death in science and in theology? Can we, he wonders rhetorically, embrace the ecology of death? Yes, it is possible, and I believe that we must do so.

The nexus of ecological relationships is part of our spiritual as well as our physical inheritance. Seeing the land as gift and death as integral to that gift is the way forward.[99] We need to regain the sense of land that Moses laid out in Deuteronomy.[100] It is a sense that the prophets and psalmist praised; and that the wisdom writers declared as a good gift from God our Creator, and it included dying.

Ronald Osborn, in his recent account of *Death before the Fall,* challenges the static reading of scripture which fails to account for the dynamics of death in creation.[101] What are we to make of this flourishing

of life so deeply tied to death?[102] There is a Christian path toward the ecology of death that we have not taken. It was embodied by the Celtic saints and also in the thought of Saint Francis of Assisi.[103] Perhaps as the mystic Francis recognized nearly eight hundred years ago, ecologists are right to welcome "sister death" as an integral part of creation's processes. This understanding of life will continue challenging conventional views of Genesis. One implication of this new complementarian view is that if death is the engine of nature, then life is the fuel. ✞

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Notes

[1]Charles Elton, "The Animal Community," *Animal Ecology* (Chicago, IL: University of Chicago Press, 2001), cited by Elton at the start of chapter 5.

[2]The Psalmist is perhaps speaking descriptively rather than normatively here—or perhaps not. See verse 27 in Psalm 104 of Calvin's *Commentaries*, http://www.studylight.org/commentaries/cal/view.cgi?bk=18&ch=104.

> *All these wait upon thee* The prophet here again describes God as acting the part of the master of a household, and a foster-father towards all sorts of living creatures, by providing liberally for them. He had said before, that God made food to grow on the mountains for the support of cattle, and that sustenance is ministered to the very lions by the hand of the same God, although they live upon prey.

And later (verse 29)

> … the Psalmist asserts, that *if God hide his face they are afraid*; and, secondly, *that if he take away their spirit they die, and return to their dust* … The amount of what is stated is, that when we see the world daily decaying, and daily renewed, the life-giving power of God is reflected to us herein as in a mirror. All the deaths which take place among living creatures, are just so many examples of our nothingness, so to speak; and when others are produced and grow up in their room, we have in that presented to us a renewal of the world. Since then the world daily dies, and is daily renewed in its various parts, the manifest conclusion is, that it subsists only by a secret virtue derived from God.

Charles H. Spurgeon, in his commentary on Psalm 104:29, is more direct in saying that this death related to eating is from God.

> Note here that death is caused by the act of God, "thou takest away their breath"; we are immortal till he bids us die, and so are even the little sparrows, who fall not to the ground without our Father.

And a parallel comment regarding scavengers is made in Psalm 147:9 (ESV): "He gives to the beasts their food, and to the young ravens which cry."

[3]Steven L. Peck, "Death and the Ecological Crisis," *Agriculture and Human Values* 27 (2010): 105–109.

[4]H. Paul Santmire, *Nature Reborn: The Ecological and Cosmic Promise of Christian Theology* (Minneapolis, MN: Augsburg Fortress, 2000), 94. Two iconic stories illustrate the range of emotive power Santmire's observation elicits. In a letter to Asa Gray, May 22, 1860, Charles Darwin recounts his consternation "that a beneficent & omnipotent God would have designedly created the Ichneumonidae with the express intention of their feeding within the living bodies of caterpillars."

In the second story, Annie Dillard describes walking along the edge of an island in a stream "mainly to scare frogs" when she notices a small green frog.

> He didn't jump; I crept closer. At last I knelt on the island's winter killed grass, lost, dumbstruck, staring at the frog in the creek … And just as I looked at him, he crumpled and began to sag … being sucked dry by a giant water bug … I stood up and brushed the knees of my pants. I couldn't catch my breath. (Annie Dillard, *Pilgrim at Tinker Creek* [1974; New York: Harper Collins, 1998], 7–8)

[5]In John 15:1–27, we find a related agricultural metaphor in the vinedresser pruning away moribund or nonproductive branches.

[6]Steven L. Percival et al., "Introduction to Biofilms," in *Biofilms and Veterinary Medicine,* ed. Steven L. Percival, Derek C. Knottenbelt, and Christine A. Cochrane (New York: Springer, 2011): 41–68, doi:10.1007/978-3-642-21289-5_2.

[7]Yoko Ohtomo et al., "Evidence for Biogenic Graphite in Early Archaean Isua Metasedimentary Rocks," *Nature Geoscience* 7, no. 1 (2014): 25–28.

[8]William B. Sparks et al., "Detection of Circular Polarization in Light Scattered from Photosynthetic Microbes," *Proceedings of the National Academy of Sciences of the United States of America* 106, no. 19 (May 12, 2009): 7816–21.

[9]The terminology of death is challenging as we use one word for a complex of meanings. Theologian Gordon J. Spykman has helpfully emphasized that "dualist views of human nature also create insuperable dilemmas, not to mention needless complications" for both end of and beginning of life issues. Gordon J. Spykman, *Reformational Theology: A New Paradigm for Doing Dogmatics* (Grand Rapids, MI: Wm. B. Eerdmans, 1992), 242. In this article, I simply focus on physical or biological death and will not attempt to untangle this theological complex. Getting a better understanding of the biological meaning of death may yield useful insights into what is meant variously by metaphysical death.

[10]James Carey, "Biology of Death," *The Evolution & Medicine Review* (July 4, 2008), https://evmedreview.com/biology-of-death-2/#more-83.

[11]Evelyn Fox Keller and Elisabeth A. Lloyd, ed., *Keywords in Evolutionary Biology* (Cambridge, MA: Harvard University Press, 1992).

[12]André Klarsfeld and Frédéric Revah, *The Biology of Death: Origins of Mortality,* trans. Lydia Brady (Ithaca, NY: Cornell University Press, 2004).

[13]Especially pertinent on this point is Philippe Ariès, "Forbidden Death," chap. 4 in *Western Attitudes toward Death: From the Middle Ages to the Present*, trans. Patricia M. Ranum (Baltimore, MD: The Johns Hopkins University Press, 1974), 85–107.

[14]Holmes Rolston III, *Science and Religion: A Critical Survey*. (Philadelphia, PA: Temple University Press, 1987), 133–34.

[15]Michael T. Ghiselin, *The Triumph of the Darwinian Method* (Berkeley, CA: University of California Press, 1969).

[16]Keith B. Miller, "'And God Saw That It Was Good': Death and Pain in the Created Order," *Perspectives on Science and Christian Faith* 63, no. 2 (2011): 85–94.

[17]Rolston III, "Life: Religion and the Biological Sciences," chap. 3 in *Science and Religion*, 81–150.

[18]There is a richly textured literature of Christian concern for the care of creation, including the classic, and my beginning place, Loren E. Wilkinson et al., *Earthkeeping in the Nineties: Stewardship of Creation* (Grand Rapids, MI: Wm. B. Eerdmans, 1991).

[19]For example, see Calvin DeWitt, *Caring for Creation: Responsible Stewardship of God's Handiwork* (Grand Rapids, MI: Baker Books, 1998); and Fred Van Dyke et al., *Redeeming Creation: The Biblical Basis for Environmental Stewardship* (Downers Grove, IL: InterVarsity Press, 1996), 47–51, 114.

[20]Robert James Berry, ed., *The Care of Creation: Focusing Concern and Action* (Leicester, UK: Inter-Varsity Press, 2000), 177–83. See also the remarkably clear and early linking of ecological death to the goodness of creation by Loren E. Wilkinson, "A Christian Ecology of Death: Biblical Imagery and the Ecologic Crisis," *Christian Scholar's Review* 5 (1976): 319–38. And the equally emphatic early statement made by Wesley Granberg-Michaelson in *Worldly Spirituality: The Call to Take Care of the Earth* (San Francisco, CA: Harper & Row, 1984), "The creation lives, at all levels, through the giving up of life" (p. 203). However, there are authors who remain within the traditional framings. See, for example, Laura Yordy, "Biodiversity and the Kingdom of God," chap. 8 in *Diversity and Dominion: Dialogues in Ecology, Ethics, and Theology*, ed. Kyle S. Van Houtan and Michael S. Northcott (Eugene, OR: Wipf and Stock, 2010), 166–90; especially p. 175.

[21]See, for example, the entry Rupert E. Davies, "Death," in *The Zondervan Pictorial Encyclopedia of the Bible*, vol. 2 (D–G), ed. Merrill C. Tenney and S. Barabas (Grand Rapids, MI: Zondervan, 1975/1976), 70–72.

[22]By traditional, I mean the theological consensus that has emerged from the influence of early twentieth-century fundamentalism. As N.T. Wright, in *Surprised by Hope: Rethinking Heaven, the Resurrection, and the Mission of the Church* (New York: HarperCollins, 2008), has noted, "Christian thought has oscillated between seeing death as a vile enemy and a welcome friend" (p. 15). For an entrance into this extensive literature, see Mark Noll, "Thinking about Science," in *The Scandal of the Evangelical Mind* (Grand Rapids, MI: Wm. B. Eerdmans, 1994), 177–208; and Ronald E. Osborn, *Death before the Fall: Biblical Literalism and the Problem of Animal Suffering* (Downers Grove, IL: InterVarsity Press, 2014). I appreciate Osborn's winsome approach and also that of Richard A. Young, *Healing the Earth: A Theocentric Perspective on Environmental Problems and Their Solutions* (Nashville, TN: Broadman & Holman, 1994), 142–47. Although I agree with much that Young writes, he does have a more traditional discussion of death which he acknowledges most ecologists (including this one) would disagree with.

[23]Biology students are often surprised to learn in the population ecology unit that a primary analytic tool, the life table, is actually keeping track of deaths in the population. It becomes common place to speak of mortality curves, k-value analysis (killing power), and the co-evolution of predator-prey relationships. All of these are mediated by death processes.

[24]This textbook example can be found in Robert L. Smith and Thomas M. Smith, *Ecology and Field Biology*, 6th ed. (San Francisco, CA: Benjamin Cummings, 2001), 188–91.

[25]See Daniel B. Botkin, *The Moon in the Nautilus Shell: Discordant Harmonies Reconsidered* (Oxford: Oxford University Press, 2012).

[26]This typical telling of predator-prey cycling is not a full treatment of the complexities of population regulation by death. For an alternative account of population cycles, see Dennis Chitty, *Do Lemmings Commit Suicide? Beautiful Hypotheses and Ugly Facts* (Oxford: Oxford University Press, 1996). And there are numerous specialty texts on prey response to predation, e.g., Tim Caro, *Antipredator Defenses in Birds and Mammals* (Chicago, IL: University of Chicago Press, 2005).

[27]Botanical carnivory occurs in a mixed group of flowering plants forming a common "ecological niche" with nearly 600 species distributed today on every continent except Antarctica. For details, see Aaron M. Ellison et al., "The Evolutionary Ecology of Carnivorous Plants," *Advances in Ecological Research* 33 (2003): 1–74.

[28]A predator typically kills its prey and consumes it whole or in parts. The strategy used is a size dependent and/or social response to the food item. Many plant feeders consume only a portion of the living tissue. They are called "grazers" if feeding on nonwoody tissues of grasses and broad-leaved plants (the forbes), or "browsers" when feeding on woody shrubs or trees. Since they kill the food, these primary consumers are classified broadly as plant predators. In the insects, there is a functional feeding group called "parasitoids" that slowly consume the prey item, ending by killing the host. This is the feeding strategy of the ichneumonid wasp that so troubled Darwin's sensibilities. Close analysis of the various families of microhymenoptera reveals thousands of such species in habitats from mountain tops to jungle canopies and even aquatic ponds and streams. Yet the insects do not have it all their own way. Look up examples of zombie fungi (*Cordyceps,* for example) for a glimpse into the coevolutionary world of predator-prey contests. The entire new field of ecological chemistry, pioneered by the late Thomas Eisner, is filled with complex examples of the signal-response relationships that characterize tropic relationships. See Thomas Eisner, *For Love of Insects* (Cambridge, MA: Belknap Press, 2005). For further details on the definition of predation, see Peter Price et al., *Insect Ecology: Behavior, Populations and Communities* (Cambridge: Cambridge University Press, 2011), 269.

[29]John W. Laundré, Lucina Hernández, and Kelly B. Altendorf, "Wolves, Elk, and Bison: Reestablishing the 'Landscape of Fear' in Yellowstone National Park, USA," *Canadian Journal of Zoology* 79 (2001): 1401–9; Evan L.

Preisser, Daniel I. Bolnick, and Michael F. Benard, "Scared to Death? The Effects of Intimidation and Consumption in Predator-Prey Interactions," *Ecology* 86, no. 2 (2005): 501–9.

[30]Andy P. Dobson, "Yellowstone Wolves and the Forces That Structure Natural Systems," *PLoS Biology* 12, no. 12 (2014), e1002025, doi:10.1371/journal.pbio.1002025.

[31]In addition to predation, he lists six forms of death that regulate population numbers. "Perhaps the commonest form of 'death' is not being born at all because of the stress of competition." The failure to find a mate is an equally effective form of biological death as is that of carnivory or the death which results from starvation, malnutrition, parasitic disease, or accident. P. Colinvaux, *Ecology 2* (New York: John Wiley & Sons, 1993), 201–202.

[32]Roger J. Lincoln, G.A. Boxshall, and P.F. Clark, *A Dictionary of Ecology, Evolution and Systematics* (Cambridge: Cambridge University Press, 1982).

[33]Stephen Stearns, *The Evolution of Life Histories* (Oxford: Oxford University Press, 1992); Barney Luttbeg and Jacob L. Kerby, "Are Scared Prey as Good as Dead?," *Trends in Ecology and Evolution* 20, no. 8 (2005): 416–18.

[34]Stanley Dodson, "Predator-Induced Reaction Norms," *BioScience* 39, no. 7 (1989): 447–52.

[35]Stanley Dodson, *Introduction to Limnology* (Boston, MA: McGraw Hill, 2005), 172–76. Predation is only one of the numerous biotic forces shaping biological communities. Cooperation is another. Theories of community assembly also entail abiotic disturbance and stochastic processes. In the end, as Colinvaux in *Ecology 2* says, population regulation is by some form of biotic death (p. 201).

[36]For a detailed discussion of the chemical defenses of plants (called allelopathy), see Price et al, *Insect Ecology*, 492–501.

[37]Eric H. Baehrecke, "How Death Shapes Life during Development," *Nature Reviews Molecular Cell Biology* 3, no. 10 (2002): 779–87.

[38]Joshua S. Madin et al., "Mechanical Vulnerability Explains Size-Dependent Mortality of Reef Corals," *Ecology Letters* 17 (2014): 1008–15.

[39]Arunika H.L.A.N. Gunawardena, John S. Greenwood, and Nancy G. Dengler, "Programmed Cell Death Remodels Lace Plant Leaf Shape during Development," *The Plant Cell* 16, no. 1 (2004): 60–73; Pyung O. Lim, H.J. Kim, and H.G. Nam, "Leaf Senescence," *Annual Review of Plant Biology* 58, no. 1 (2007):115–36.

[40]The concept of programmed cell death (PCD) is both complex and rapidly developing. First described in the nineteenth century, its significance was not fully appreciated. It emerged again in animal development studies in the 1990s and is vital across molecular, developmental, medical, and ecological fields. For an introduction to the terminology, see Martin Raff, "Cell Suicide for Beginners," *Nature* 396 (1998): 119–22; and Alexei Degterev and Junying Yuan, "Expansion and Evolution of Cell Death Programmes," *Nature Reviews Molecular Cell Biology* 9, no. 5 (2008): 378–90.

[41]For example, Daniel J. Franklin, Corina P.D. Brussaard, and John A. Berges, "What is the Role and Nature of Programmed Cell Death in Phytoplankton Ecology?" *European Journal of Phycology* 41 (2006): 1–14; Jakob Pernthaler, "Predation on Prokaryotes in the Water Column and Its Ecological Implications," *Nature Reviews Microbiology* 3, no. 7 (2005): 537–46; Jerry F. Franklin, H.H. Shugart, and Mark E. Harmon, "Tree Death as an Ecological Process," *BioScience* 37, no. 8 (1987): 550–56.

[42]On this cultural reluctance, see Colin Tudge, *The Engineer in the Garden: Genes and Genetics – From the Idea of Heredity to the Creation of Life* (New York: Hill and Wang, 1993), 347–48. On the economic and ecological benefits of disturbance, see Johan Colding, Thomas Elmqvist, and Per Olsson, "Living with Disturbance: Building Resilience in Social-Ecological Systems," chap. 7 in *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*, ed. Fikret Berkes, Johan Colding, and Carl Folke (New York: Cambridge University Press, 2003), 163–86.

[43]For example, see J. Boone Kauffman, "Death Rides the Forest: Perceptions of Fire, Land Use, and Ecological Restoration in Western Forests," *Conservation Biology* 18, no. 4 (2004): 878–82.

[44]Patrick L. Osborne, *Tropical Ecosystems and Ecological Concepts* (New York: Cambridge University Press, 2000); Maurice Schwartz, "Carbonate Sandy Beaches," chap. 10, in *Encyclopedia of Coastal Science,* ed. Maurice Schwartz (Dordrecht, The Netherlands: Springer Science & Business Media, 2005), 218–20.

[45]Peter W. Glynn, "Bioerosion and Coral-Reef Growth: A Dynamic Balance," in *Life and Death of Coral Reefs*, ed. C. Birkeland (Dordrecht, The Netherlands: Springer Science & Business Media, 1997), 68–95.

[46]On the role of programmed cell death in bacterial biofilm formation and quorum sensing, see Maureen A. O'Malley and John Dupré, "Size Doesn't Matter: Towards a More Inclusive Philosophy of Biology," *Biology and Philosophy* 22, no. 2 (2007): 155–91.

[47]Kay D. Bidle, "The Molecular Ecophysiology of Programmed Cell Death in Marine Phytoplankton," *Annual Review of Marine Science* 7 (2015): 341–75.

[48]Dong-Hwan Choe, Jocelyn G. Millar, and Michael K. Rust, "Chemical Signals Associated with Life Inhibit Necrophoresis in Argentine Ants," *Proceedings of the National Academy of Sciences of the United States of America* 106, no. 20 (2009): 8215–55.

[49]Susan M. Kidwell and Adam Tomasovych, "Implications of Time-Averaged Death Assemblages for Ecology and Conservation Biology," *Annual Review of Ecology, Evolution, and Systematics* 44 (2013): 539–63.

[50]D'Arcy Thompson, *On Growth and Form*, an abridged edition, ed. J. T. Bonner (Cambridge: Cambridge University Press, 1961).

[51]The term "self-organization" is first applied in relation to living beings by Kant. Evelyn Fox Keller, "Ecosystems, Organisms, and Machines," *BioScience* 55, no. 12 (2005): 1069–74.

[52]Klarsfeld and Revah, *The Biology of Death*.

[53]"Every form of life we know or can imagine is sustained by this fountain of energy; remove death, and the fountain dries up" (Wilkinson, *Christian Ecology of Death*, 321).

[54]Michael Buszczak and William A. Segraves, "Insect Metamorphosis: Out with the Old, In with the New," *Current Biology* 10, no. 22 (2000): R830–33, doi:10.1016/S0960-9822(00)00792-2.

[55]For a popular exposition of the fuzzy line between life and death, and the processes leading to death, see Dick Teresi, *The Undead: Organ Harvesting, the Ice-Water Test, Beating-Heart Cadavers – How Medicine Is Blurring the Line between Life and Death* (New York: Pantheon Books, 2012).

[56]There is no single definition for a biological organism. See John W. Pepper and Matthew D. Herron, "Does Biology Need an Organism Concept?," *Biological Reviews* 83 (2008): 621–27, Table 1 "Terms referring to variants of the organ-

ism concept" in which as many as twelve terms have been proposed, each a distinct organism concept.

[57]For an extended discussion of this challenge, see Stephen Jay Gould, "The Meaning of Individuality and the Expansion of the Darwinian Research Program," in *The Structure of Evolutionary Theory* (Cambridge: Harvard University Press, 2002), 597–612.

[58]This raises the foundational question of the best way to characterize organisms. Should they be thought of as autonomous individual entities, the most common concept in models of evolution—just an individual? Or as communities of being, ensembles of interacting species suggested by new research on biofilms, the human microbiome, or the evolution of mitochondria and other cell organelles from once free-living organisms? For entry into this literature, see John Dupré and Maureen A. O'Malley, "Varieties of Living Things: Life at the Intersection of Lineage and Metabolism," *Philosophy and Theory in Biology* 1 (2009): e003, doi:10.3998/ptb.6959004.0001.003; Betsey Dexter Dyer, "Symbiosis and Organismal Boundaries," *American Zoologist* 29, no. 3 (1989): 1085–93.

[59]Klarsfeld and Revah, *The Biology of Death,* 5.

[60]Charles Darwin, *On the Origin of Species*, 1st edition, accessed via The Project Gutenberg EBook of *On the Origin of Species* by Charles Darwin (1859), 459.

[61]Evolutionary theory also explains cooperation and altruism, especially in social species. The effective "death" here is mediated through and compensated for in mating systems such as haplo-diploidy, in which forgoing reproduction has a clear advantage for sister workers, or in the act of near-kin adoption. See, for example, Edward O. Wilson, *Sociobiology: The New Synthesis* (Cambridge, MA: Harvard University Press, 1980).

[62]Klarsfeld and Revah, *The Biology of Death,* 1, 3, 6.

[63]Fox Keller, *Ecosystems, Organisms, and Machines*, 1073.

[64]Fred Feldman, *Confrontations with the Reaper: A Philosophical Study of the Nature and Value of Death* (New York: Oxford University Press, 1992), 71.

[65]Ibid. On death Feldman says,

> So, though death looms large in our emotional lives, though we hate it, and fear it, and are dismayed by the thought that it will someday overtake us and those we love, we really don't know precisely what death is. The Reaper remains mysterious. (p. 69)

[66]Peck, "Death and the Ecological Crisis," 108; e.g., Ecclesiastes 1:4, 11; 3:18–21; and 12:1–7 (ESV).

[67]Addy Pross, *What is Life? How Chemistry Becomes Biology* (Oxford: Oxford University Press, 2012), 161–62.

[68]Klarsfeld and Revah, *The Biology of Death.*

[69]Quoted in ibid., 10. However, Bernard's views on human-induced animal death and suffering are not helpful. See Brian Klug, "Can We See a Moral Question about Animals?," chap. 17 in *Animals on the Agenda: Questions about Animals for Theology and Ethics,* ed. Andrew Linzey and Dorothy Yamamoto (Urbana, IL: University of Illinois Press, 1998), 206–15.

[70]In addition to the theory by Pross, *What is Life?*, we have the empirical work of synthetic genomics by Craig Venter, for example, as discussed in Daniel G. Gibson et al., "Creation of a Bacterial Cell Controlled by a Chemically Synthesized Genome," *Science* 329, no. 5987 (2010): 52–56.

[71]Andrew Wilson, ed., *Exobiology in the Solar System and the Search for Life on Mars: Report from the ESA Exobiology Team Study 1997–1998* (Noordwijk, The Netherlands: European Space Agency, 1999).

[72]The challenge also appears in defining ecosystems and communities. Trying to specify the difference between living and nonliving material is challenging in any but the simplest of pathways as nutrients cycle in and out of biotic and abiotic compartments. See Timothy F.H. Allen and Thomas W. Hoekstra, *Toward a Unified Ecology* (New York: Columbia University Press, 1992), 45–47.

[73]George L. Murphy, *The Cosmos in the Light of the Cross* (Harrisburg, PA: Trinity Press International, 2003).

[74]See the delightful new commentary on the Book of Job by Lindsay Wilson, *Job* (Grand Rapids, MI: Wm. B. Eerdmans, 2015). The central issue, she says, "is not suffering but rather faith" (p. 352).

[75]Robert Farrar Capon, *The Romance of the Word: One Man's Love Affair with Theology* (Grand Rapids, MI: Wm. B. Eerdmans, 1995), 176–77.

[76]See J. Richard Middleton, "Imaging God's Primal Generosity," chap. 7 in *The Liberating Image: The* Imago Dei *in Genesis 1* (Grand Rapids, MI: Brazos Press, 2005), 271–98. Middleton provides a more typical academic account of these contrasting metaphors that nevertheless illustrates a fresh hermeneutical approach to the creation story.

[77]Capon, *The Romance of the Word*, 177.

[78]Dillard, *Pilgrim at Tinker Creek*, 230.

[79]The death that entered with the sin of Adam and Eve was relational separation from God and consequently from the creation. Robert J. Berry explores this thesis in detail in "Did Darwin Dethrone Humankind?," in *Darwin, Creation and the Fall: Theological Challenges,* ed. Robert J. Berry and T.A. Noble (Nottingham, UK: Inter-Varsity Press, 2009), 63–69. For an early use of the term "creation care" and the presence of physical death in the Garden of Eden, see Ron Elsdon, *Bent World: A Christian Response to the Environmental Crisis* (Downers Grove, IL: InterVarsity Press, 1981), 104.

[80]This deep ambiguity is perhaps best and elegantly articulated by Dillard in "Fecundity," chap. 10 in *Pilgrim at Tinker Creek,* 161–83.

[81]Wilkinson, *Christian Ecology of Death*, 320. The role of death in our care for creation is explored in part by Denis Edwards in *How God Acts: Creation, Redemption, and Special Divine Action* (Minneapolis, MN: Fortress Press, 2010).

[82]Humans have power and agency for good or ill. See, for example, Middleton's description of the flood as a restorative measure for shalom, to inhibit human violence to each other and the earth in *Liberating Image*, 220–21.

[83]He speaks of it as our human vocation as the *imago Dei* in God's world (Middleton, *Liberating Image*, 90).

[84]In John R. Wood and S.C. Bouma-Prediger, "Seeking Shalom," chap. 10 in *Living the Good Life on God's Good Earth*, ed. David S. Koetje (Grand Rapids, MI: Faith Alive, 2006), 79–83, we said, "The vision of all things in right relationship [shalom] is itself rooted in our understanding that God is a God of relationship." We are beginning to appreciate that biotic death is a necessary part of that flourishing.

[85]According to Davis, we have had an ecological blind spot in recent systematic theology. He argues that "deficiencies in the doctrines of creation and the atonement in evangelical theological systematic theology textbooks" help explain the uneven response to environmental issues. John J. Davis, "Ecological 'Blind Spots' in the Structure and Content of Recent Evangelical Systematic Theologies," *Journal of the Evangelical Theological Society* 43, no. 2 (2000): 273–86.

[86]Lowell Bliss, *Environmental Missions: Planting Churches and Trees* (Pasadena, CA: William Carey Library, 2013).

[87]Celia Deane-Drummond, *Eco-Theology* (London: Darton, Longman & Todd, 2008), 114–29.

[88]Walter Brueggemann, *Reality, Grief, Hope: Three Urgent Prophetic Tasks* (Grand Rapids, MI: Wm. B. Eerdmans, 2014). Although there is much to lament, collectively we do not seem to feel much sense of loss even in the face of the ongoing mass extinction of species. See Richard Bauckham, *Living with Other Creatures: Green Exegesis and Theology* (Waco, TX: Baylor University Press, 2011), 213–17. Here he affirms the charge by Edward O. Wilson, in *The Future of Life* (New York: Alfred A. Knopf, 2002), that humanity has become a "serial killer of the biosphere" (p. 94).

[89]Deuteronomy 30:15–20 (ESV): "See, I have set before you today life and good, death and evil. If you obey the commandments of the Lord your God that I command you today, by loving the Lord your God, by walking in his ways, and by keeping his commandments and his statutes and his rules, then you shall live and multiply, and the Lord your God will bless you in the land that you are entering to take possession of it. But if your heart turns away, and you will not hear, but are drawn away to worship other gods and serve them, I declare to you today, that you shall surely perish. You shall not live long in the land that you are going over the Jordan to enter and possess. I call heaven and earth to witness against you today, that I have set before you life and death, blessing and curse. Therefore choose life, that you and your offspring may live, loving the Lord your God, obeying his voice and holding fast to him, for he is your life and length of days, that you may dwell in the land that the Lord swore to your fathers, to Abraham, to Isaac, and to Jacob, to give them."

[90]Brueggemann, *Reality, Grief, Hope*, 161.

[91]Arthur Peacocke, *Evolution: The Disguised Friend of Faith?* (Philadelphia, PA: Templeton Foundation Press, 2004).

[92]John R. Wood, "Biophilia and the Gospel: Loving Nature or Worshipping God?," chap. 8 in *Living in the LambLight: Christianity and Contemporary Challenges to the Gospel,* ed. Hans Boersma (Vancouver, BC: Regent College Publishing, 2001), 153–76.

[93]For more on the problem of human independence, death, and creation care, see the entries for these terms in Wesley Granberg-Michaelson, *Ecology and Life: Accepting Our Environmental Responsibility* (Waco, TX: Word Books, 1988).

[94]Wright, *Surprised by Hope,* 102.

[95]Ibid., italics added.

[96]Jeffrey P. Schloss, "From Evolution to Eschatology," in *Resurrection: Theological and Scientific Assessments*, ed. Michael Welker, Ted Peters, and Robert J. Russell (Grand Rapids, MI: Wm. B. Eerdmans, 2002), 61. Also see Schloss's three-part contribution "Evolution, Creation, and The Sting of Death: A Response to John Laing," Parts 1, 2, and 3, blog entry, *The BioLogos Forum: Science and Faith in Dialogue*, August 10–12, 2012, http://biologos.org/blogs/archive/evolution-creation-and-the-sting-of-death-a-response-to-john-laing-part-1, http://biologos.org/blogs/archive/evolution-creation-and-the-sting-of-death-part-2, and http://biologos.org/blogs/archive/evolution-creation-and-the-sting-of-death-part-3.

[97]John 15:1–2, Luke 9:23, and John 12:24.

[98]Santmire, *Nature Reborn*, p. 95. He also asks,

> Is it really possible for us to embrace the ecology of death? Is it spiritually realistic to aspire to encounter nature untamed, unpacified, and unromanticized, with all its ambiguities and its death-driven violence, as a gift from the giver of every good and perfect gift, as a tabernacle of the most high, and thereby to be able to embrace nature spiritually, as a world charged with the glory of God, overflowing with blessings, beauty and goodness? (p. 95)
>
> That is what the classical Celtic saints did. And that is why we need them as our mentors today: so that, having confronted the stark reality of death in nature, our spirituality will sustain, not undermine, our theology of nature. (p. 96)

[99]Walter Brueggemann, *The Land: Place as Gift, Promise, and Challenge in Biblical Faith*, 2nd ed. (Minneapolis, MN: Augsburg Fortress, 2002).

[100]With respect to our wanton destruction of the biosphere, few have noticed the significance of the setting of Deuteronomy 30 cited above. Moses explicitly calls on "heaven and earth to witness against you today." The entire creation is portrayed as standing within the royal court as witnesses against one species, humanity, the only species gifted with the *imago Dei*. We might have formerly read these words as a mere metaphorical flourish, a quaint cultural turn of phrase perhaps. But I wonder. Today we are living in what has been called the Anthropocene Age. Thus, invoking the agency of creation in testimony as Moses does here seems eerily prescient. See Richard Monastersky, "Anthropocene: The Human Age," *Nature* 519, no. 7542 (2015): 144–47.

[101]While his main focus is on the consequences of a "plain reading" or "literalism" and on biblical interpretation, Osborn also lays out a positive case for reading scripture in light of evolutionary accounts of death. Whether he is entirely successful or not is less important than that he clearly points out that the old wineskins of interpretation will not hold up to what has been called "the Copernicization of death." Osborn, *Death before the Fall*.

[102]Animal welfare is a closely related topic. There have been attempts to explain animal death and suffering that rely on the Cartesian mind-body dualism and Descartes's theory that animals are mere machines, and that their death or pain is no more significant than breaking a rock or a machine. Snoke takes this approach to maintain the significant difference between humans and animals. I agree that a robust theory of death will necessarily incorporate human uniqueness. David Snoke, "Why Were Dangerous Animals Created?," *Perspectives on Science and Christian Faith* 56, no. 2 (2004): 117–25. But this approach to predation is not the same as an ecological theory of death. It is based on a stark human-animal dualism that was contested by philosophers even as it was being proposed, and it seems to undercut the motivation of animal care embodied in antivivisection legislation. For the history and a theological review of human-induced animal pain, suffering, and death, see Donna Yarri, *The Ethics of Animal Experimentation: A Critical Analysis and Constructive Christian Proposal* (Oxford: Oxford University Press, 2005).

[103]H. Paul Santmire, *The Travail of Nature: The Ambiguous Ecological Promise of Christian Theology* (Philadelphia, PA: Fortress Press, 1985); and Wright, *Surprised by Hope*, 16–17.