THE SACRED DEPTHS OF NATURE: EXCERPTS

by Ursula Goodenough

Abstract. This article is composed of excerpts from the author's 1998 book, *The Sacred Depths of Nature*. The aim of the book is to present an accessible account of our scientific understanding of nature and then suggest ways that this account can call forth appealing and abiding religious responses—an approach that can be called *religious naturalism*. If religious emotions can be elicited by natural reality, then the story of nature has the potential to serve as the cosmos for the global ethos that we need to articulate. The author recalls the religious journey that has enabled her to enter into the authentic religious faith that lives in the context of the ancient premises and symbols, and has led her to ask whether religion can emerge in the context of a fully modern, up-to-the-minute understanding of nature. The book demonstrates how this can happen. The discussion in these excerpts focuses on sex and sexuality, in biological description of mechanisms and function and how these are related to multicellularity, death, and immortality. Beyond the biological descriptions, the author includes reflections that point to the religious significance of the biological phenomena.

Keywords: cosmology; death; immortality; multicellularity; planetary ethic; religion; religious naturalism; sex; sexuality.

PERSONAL

No question about it: I'm writing this book because of my father. He started out as a Methodist preacher but became absorbed—no, obsessed—with a need to understand why people are religious. As Professor of the History of Religion, he poured out book after book on the ancient Jews and early

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Christians: their art, their texts, their motivations. And then he brought it all home, to me sitting there after dessert trying to look inconspicuous while he and the other Yale scholars drank a great deal of wine and held forth on Plato and Paul and Freud and Sartre. Dad began his famous undergraduate course, The Psychology of Religion, by announcing, "I do not believe in God." He ended one of his last books by admitting, "I still pray devoutly, and when I do I forget my qualifications and quibbles and call upon Jesus—and he comes to me." He was a larger-than-life father, passionate and outrageous and adored. When he died of cancer when I was 22, it was almost more than any of us could bear.

I went to college with 1950s expectations: find a husband, raise two children, and continue to read novels. But everything changed when I took Zoology I as a distribution requirement. Nothing in my girls'-school training had led me to understand that creatures are made up of cells and genes and enzymes, that life evolves, that kidneys control blood electrolytes. I was astonished. Better still, I was good at it. And Dad was quite as excited about my unexpected calling as I was. "Ursula a scientist! How splendid!" What a father.

For the next twenty-five years or so I played it straight: biology professorships, research projects, federal grants, undergraduate teaching. I still do all those things, and with as much pleasure and satisfaction as ever. But as my five children grew and there was more time for myself, my father's question returned. Why are people religious? And then: Why am I not religious?

But was that true? What is being religious, anyhow? What about the way I feel when I think about how cells work or creatures evolve? Doesn't that feel the same as when I'm listening to the Saint Matthew Passion or standing in the nave of the Notre Dame Cathedral?

So I joined Trinity Presbyterian Church and have spent the past twelve years singing in the choir, reciting the liturgy and prayers, hearing the sermons, participating in the ritual. I came to understand how this tradition, as played out in a middle-class mostly white congregation, is able to elicit states of serious reflection, reverence, gratitude, and penance. But all of it was happening in the context of ancient premises and a deep belief in the supernatural. What about the natural? Was it possible to feel such religious emotions in the context of a fully modern, up-to-the-minute understanding of Nature?

And so I started reading and talking and listening and reflecting, and out of it has emerged this book. Certainly the most important dialogue has been with Loyal Rue, who has explained to me most of what I understand about theology and philosophy and who has insisted that we scientists speak of what we know and feel.[1] Early on I happened onto an improbable collection of people comprising the Institute on Religion in an Age of Science, and while the support and input of everyone in IRAS has

been seminal, this is particularly true for Gene d'Aquili, Connie Barlow, Michael Cavanaugh, Tom Gilbert, Ward Goodenough, Phil Hefner, Bill Irons, Sol Katz, Ted Laurenson, Karl Peters, Bob Schaible, and Barbara Whitaker-Johns. Kirk Jensen of Oxford University Press has provided generous and unwavering support; Carl Smith has helped me understand and experience the religious impulse; John Heuser has continuously infused his perspective and wisdom; Sine Berhanu and Jeanne Heuser have nurtured my spirituality; Pam Burroughs, Elizabeth Marincola, Sharon Olds, and Betsy Weinstock have nurtured my courage; my children—Jason, Mathea, Jessica, Thomas, and James—bless my life in countless ways; and no one can emerge from a consideration of religion without thanking William James.[2]

Introduction

When people talk about religion, most soon mention the major religious traditions of our times. But then, thinking further, most mention as well the religions of indigenous peoples and of such vanished civilizations as ancient Greece and Egypt and Persia. That is, we have come to understand that there are—and have been—many different religions; anthropologists estimate the total in the thousands. They also estimate that there have been thousands of human cultures, which is to say that the making of a culture and the making of its religion go together: every religion is embedded in its cultural history. True, certain religions have attempted, and variously succeeded, in crossing cultural boundaries and "converting the heathens," but even here the invaded cultures put their unmistakable stamp on what they import, as evinced by the pulsating percussive Catholic masses sung in Africa.

In the end, each of these religions addresses two fundamental human concerns: How Things Are and Which Things Matter. How Things Are becomes formulated as a cosmology or cosmos: how the universe came to be, how human beings came to be, what happens after we die, the origins of evil and tragedy and natural disaster. Which Things Matter becomes codified as a morality or ethos: the Judaic Ten Commandments, the Christian Sermon on the Mount, the Five Pillars of Islam, the Buddhist Vinaya, the Confucian Five Relations. The role of religion is to integrate the cosmology and the morality, to render the cosmological narrative so rich and compelling that it elicits our allegiance and our commitment to its emergent moral understandings. As each culture evolves, a unique cosmos and ethos appear in its coevolving religion. For billions of us, back to the first human beings, the stories, ceremonies, and art associated with our religions-of-origin are central to our matrix.

I stand in awe of these religions. I am deeply enmeshed in one of them myself. I have no need to take on the contradictions or immiscibilities

between them, any more than I would quarrel with the fact that Scottish bagpipes coexist with Japanese tea ceremonies. And indeed, the resounding failure of Soviet Marxism to obliterate Russian Orthodoxy, and of Maoism to obliterate Buddhism, Confucianism, or Taoism, reminds us that any project designed to overthrow established cultural traditions is inherently doomed.

My concern is very different. As I witness contemporary efforts to generate global understanding, I see some high-minded and idealistic people attempting to operate within an amalgam of economic, military, and political arrangements, and I find myself crying out, "But wait! Where is the religion? What is really orienting this project besides fear and greed? Where is the shared cosmology and the shared morality?"

That we need a planetary ethic is so obvious that I need but list a few key words: climate, ethnic cleansing, fossil fuels, habitat preservation, human rights, hunger, infectious disease, nuclear weapons, oceans, ozone layer, pollution, population. Our global conversations on these topics are, by definition, cacophonies of national, cultural, and religious self-interest. Without a common religious orientation, we basically don't know where to begin, nor do we know what to say or how to listen, nor are we motivated to respond.

My agenda for this book is to outline the foundations for such a planetary ethic, an ethic that would make no claim to supplant existing traditions but would seek to coexist with them, informing our global concerns while we continue to orient our daily lives in our cultural and religious contexts.

Any global tradition needs to begin with a shared worldview—a culture-independent, globally accepted consensus as to how things are. From my perspective, this part is easy. How things are is, well, how things are: our scientific account of Nature, an account that can be called the epic of evolution.[3] The Big Bang, the formation of stars and planets, the origin and evolution of life on this planet, the advent of human consciousness and the resultant evolution of cultures—this is the story, the one story, that has the potential to unite us, because it happens to be true.

But that potential can be realized under only one condition. A cosmology works as a religious cosmology only if it resonates, only if it makes the listener feel religious. To be sure, the beauty of Nature—sunsets, woodlands, fireflies—has elicited religious emotions throughout the ages. We are moved to awe and wonder at the grandeur, the poetry, the richness of natural beauty; it fills us with joy and thanksgiving. Our response to accounts of the workings of Nature, on the other hand, is decidedly less positive. The scientific version of how things are, and how they came to be, is much more likely, at first encounter, to elicit alienation, anomie, and nihilism, responses that offer little promise for motivating our allegiance or moral orientation.

It is therefore the goal of this book to present an accessible account of our scientific understanding of Nature and then suggest ways that this account can call forth appealing and abiding religious responses—an approach that can be called *religious naturalism*. If religious emotions can be elicited by natural reality—and I believe that they can—then the story of Nature has the potential to serve as the cosmos for the global ethos that we need to articulate. I will not presume to suggest what this ethos might look like. Its articulation must be a global project. But I am convinced that the project can be undertaken only if we all experience a solemn gratitude that we exist at all, share a reverence for how life works, and acknowledge a deep and complex imperative that life continue.

A key component of any religious cosmology is its human focus. Even as we now understand that our advent on the planet was but a moment ago, even as we now gaze into the heavens with new and urgent questions about our significance, the significance and future of humanity remain central to our religious concerns.

Religious naturalism has no problem here. Being at home with our natural selves is the prelude to ecology, both environmental and cultural, and there are many ways to see human beings as noble and distinctive even as we are inexorably part of the whole. A global ethic must be anchored in both an understanding of human nature and an understanding of the rest of Nature. This, I believe, can be achieved if we start out with the same perspective on how Nature is put together, and how human nature flows forth from whence we came.

How This Book Is Put Together

A Lutheran friend who read an early draft of this book remarked that it was set up like a daily devotional booklet. A daily devotional, he explained, contains a collection of short stories, each story followed by a religious meditation on the story's theme. Not being Lutheran, I wasn't familiar with the genre, but that is basically how this book is constructed.

The text is divided into twelve chapters. Each begins with a short story about the dynamics of Nature. Most of these stories are about biology, because this is what I best understand, and most are about biology at the level of molecules and genes and cells, because this is what cries out to be understood. The stories walk through the epic of evolution: the origins of the universe and the planet; the origins of chemistry and life; the workings of cells and organisms; the patterns of biological evolution and the resultant biodiversity; awareness and emotion; sex and sexuality; multicellularity and death; and speciation. Throughout, I have done my best to bridge the two cultures. For readers not versed in scientific concepts and terminology, I have made every effort to render the accounts understandable, accurate, and meaningful. Those who know the terrain will, I hope, find

themselves engaged by the analogies and narratives that are used to explain the familiar.

Then, at the end of each story, I offer a short religious response, the analogue of the Lutheran meditation. In some cases these responses draw on traditional religious concepts, most often from the Judeo-Christian tradition because that is what is most familiar to me. But for the most part each response is personal, describing the particular religious emotion or mental state that is elicited in me when I think about a particular facet of the evolutionary story. For example, the evolution of the cosmos invokes in me a sense of mystery; the increase in biodiversity invokes the response of humility; and an understanding of the evolution of death offers me helpful ways to think about my own death. If religious naturalism is to flourish, it will be because others find themselves called to reflect on the dynamics of Nature from their own cognitive, experiential, and religious perspectives—in which case this book will become one of an emergent series of daily devotionals.

Human memory, they say, is like a coat closet: The most enduring outcome of a formal education is that it creates rows of coat hooks so that later on, when you come upon a new piece of information, you have a hook to hang it on. Without a hook, the new information falls on the floor. Some readers with scanty scientific backgrounds have told me that at the time they were reading one of my stories about Nature, they felt like they understood everything I said, but the next day they couldn't remember a thing about it. No hooks, I explain. Then I remind them that there isn't going to be a test, and that as they were reading the story they were in fact creating hooks for their next encounters with scientific explanation. And then, the most important part: the point of hearing a story for the first time is not to remember it but to experience it.

Sex

Eukaryotic sex is both ancient and ubiquitous: it arose some time prior to the Cambrian explosion and is found in all the phyla that trace back to the Cambrian.[4]

Sex necessitates the coming together of two genomes, and thus it necessitates the finding of a mate. Therefore, the origin of sex marks the onset of biological relationship—as contrasted with the solitary asexual existence of the bacteria and amoebae. Once procreation was handed over to germ cells and embryos and offspring, moreover, their protection assumed vital importance and, in animals, was entrusted to strong emotional instincts.

What does sex entail?

A genome contains all the genetic information needed to make an organism, but in eukaryotes it is not encoded in a single piece of DNA. Instead, it is divided up into a number of lengths

of DNA called chromosomes. A useful analogy here is to an encyclopedia. All the information in an encyclopedia could be printed in a single huge volume that is rolled about in a wheelbarrow, but it is more manageably organized as a set of volumes, the first containing all the A-B information, the second the C information, for a total of, say, nineteen volumes. A chromosome is equivalent to a volume, and the full set of nineteen chromosomes comprises a genome. The genome of each species is apportioned to distinctive numbers of chromosomes: cats happen to have nineteen, while humans have twenty-three, goldfish fifty, flies four, corn ten.

The chromosomes reside in the nucleus of a eukaryotic cell, and we have already considered how their component genes come to give rise to organisms. Now our concern is how they are transmitted sexually from parent to offspring.

Sex entails making two kinds of cells: a haploid cell with a single complete set of chromosomes, and a diploid cell with two complete sets of chromosomes. The diploid cell, not surprisingly, is formed when two haploid cells fuse together. Reciprocally, haploid cells arise when diploid cells engage in a halving of their chromosome number. We can look at each process in turn.

Forming Diploid Cells. The formation of a diploid cell occurs during fertilization: two haploid gametes, a sperm or pollen grain from the male and an egg from the female, fuse to form a single diploid cell called a zygote. Returning to the encyclopedia analogy, if we could color all nineteen volumes from the sperm blue and all nineteen volumes from the egg pink, the zygote would have a complete set of blue volumes and a complete set of pink, thirty-eight in all, such that every entry, every gene, is present twice.

There are important advantages to having two sets of instructions. Let's say that there is a large printer's error in the "calcium ion channel" entry in the blue volume 2. Chances are that the pink volume 2, printed in a different year in a different city by a different typesetter, won't have this same error (although it may well have other errors in other entries). If you have both volumes, you have access to readable information from the pink version and hence can construct a serviceable ion channel. Expressing this in genetic terms, we say that diploid cells, carrying two sets of instructions for making each kind of protein, are less vulnerable to deleterious mutations than haploid cells are.

Forming Haploid Cells. Now we can look at the reciprocal process, the formation of haploid cells from diploids. In Nature this happens in many contexts; we can consider here how it occurs in the testis of a cat. The task is to generate haploid sperm with nineteen chromosomes from diploid precursor cells with thirty-eight chromosomes, nineteen of which

are pink (from mother) and nineteen blue (from father). If this were accomplished by grabbing nineteen chromosomes at random, the result would almost certainly be a disaster: the sperm would wind up carrying, say, a pink and a blue chromosome #1, no chromosome #2, a pink chromosome #3, no chromosome #4. That is, you would almost certainly create a sperm with an incomplete set of instructions for making a cat.

Therefore, the rule is that you have to include a complete set of chromosomes—a complete set of encyclopedia volumes—in every haploid sperm nucleus. But this doesn't mean that they have to all be pink or all be blue. You can have a pink #1 and #2, a blue #3, a pink #4, and a blue #5, so long as you wind up with one of each kind, a complete set.

All this takes place during an elegant cellular process called meiosis, during which the chromosomes are carefully segregated and assorted such that complete sets are generated. And the consequences are profound. Our original diploid male cat had nineteen pink chromosomes and nineteen blue, whereas each sperm he produces will contain a distinctive full collection of nineteen chromosomes, some pink and some blue. When any of his sperm manages to fertilize an egg, the egg nucleus will contain a set of nineteen chromosomes that has also been shuffled by meiosis. Therefore, while the resultant diploid zygote will have thirty-eight chromosomes, two complete sets of genetic information, these will be very different from the sets that were present in the parents.

Another way of stating this is to say that although parents each contribute half of their genetic endowment to a child, they basically end up with a stranger.

WHAT DOES SEX ACCOMPLISH? If we look at the female cat who generated the egg just fertilized, her chromosomes (we can call nineteen of them orange and nineteen of them purple) are expected to carry a different spectrum of mutations from the pink/blue set contributed by the male. Specifically, the calcium-channel gene in the orange version of her chromosome #2 might specify a channel that transports ions particularly rapidly, whereas her purple chromosome #2 might carry a slow channel gene. If a fertilized egg winds up with an orange and a pink chromosome #2, this means that the kitten will have two kinds of channels: one rapid (orange) and one normal (pink). A littermate might inherit orange and blue versions of the gene and therefore only transport calcium rapidly—the blue version is dysfunctional. In genetic terminology, we say that each zygote, and hence each kitten, carries two alleles of the channel gene, with allele meaning "a different version."

Now we can go to all cats and look at every calcium channel gene in every chromosome #2 in the entire species. We might in this case find twelve alleles of the gene; we can drop our color-coding analogy and call them C1–C12. Some will encode nonfunctional proteins, like our blue

example, with deleterious mutations at various positions in the gene sequence. Others will carry codon changes that make no difference to the rate of calcium flux—so-called neutral alleles. Others will specify channels that work at various rates. The survey will also reveal that some of the alleles are more abundant than others. 62% of the genes might be C2, 13% C3, 3% C12, and 0.1% C1. But they would all be represented in the cat "gene pool."

If we move along chromosome #2, we come to the next gene—let's say it codes for an enzyme involved in making black fur. Looking at all cats, we find that 44% have the allele B1, which results in jet black hair, 17% have allele B2, which yields charcoal gray, and 39% have B3–B16, all of which encode dysfunctional enzymes so the hair is white. The next gene, I, and its series of alleles, may be involved with implantation of the fetus, the next, P, with purring.

So, virtually every cat chromosome #2 will be different from every other. The first might read C1, B3, I6, P3, the second C1, B7, I6, P1, and so on. The same, of course, will also be true of the other eighteen kinds of chromosomes. Since the cat genome contains perhaps 90,000 genes, each chromosome will on average carry some 4,500 genes, meaning that the cat species harbors a huge chromosome diversity.

Running through these concepts one more time with the encyclopedia analogy, we can imagine thumbing through countless sets of nineteen-volume encyclopedias, with each volume having on average 4,500 entries. The first entry in volume 1 is always Aardvark, but there may be eighteen versions (alleles) of the Aardvark spiel in the worldwide volume-1 pool, some informative, some mediocre, and some unintelligible. The second entry is always Aaron, with twenty-seven versions. If you pick up a volume 1 in one bookstore you might find Aardvark 17 followed by Aaron 3; the next bookstore might have Aardvark 9 followed by Aaron 14.

EVOLUTIONARY STRATEGY. And now, finally, we can put all of this together. There are nineteen different kinds of cat chromosomes, each one of its kind carrying a unique lineup of alleles. If we think of the whole pool of cat chromosomes on the planet as a gigantic collection of playing cards, then in one generation the cards are dealt out as sets of nineteen cards held in countless gamete-nucleus hands. Each fertilization brings two sets together and creates a diploid kitten that, when it matures and makes sperm or eggs, shuffles the two sets together and deals out new haploid hands. Any one of these then combines with a second new hand to make a new diploid kitten, with many such fertilizations creating the next cat generation.

What this means is that each sexual generation is, in effect, a whole new card game, with each cat holding a unique diploid hand and the entire gene pool dealt into countless diploid hands, all subject to natural selec-

tion. The hands—and hence the cards—that survive are shuffled and dealt again, with the next generation of diploid hands again substrates for natural selection.

This strategy is beautifully designed for generating different kinds of organisms. Each diploid hand is in effect a new experiment in making a cat. A given allele is placed in a nucleus with 179,999 other genes, many of which it has probably never coexisted with before, and even subtle differences in the time of appearance, shape, or stability of the resultant protein products may generate subtle differences in the cat's ability to hunt, resist disease, or produce offspring. The next diploid, with a different palette of alleles, will come up with a slightly different version of a cat.

In effect, sexual populations deal all their hands, strut their stuff, at every generation, rather than going out on a limb and specializing in one particular phenotype the way an asexual population tends to do. Specialization can definitely be a good idea over the short haul, when a particular facet of a niche can be exploited by a particular kind of creature. But it is vulnerable to the fact that most niches keep changing.

Overall, then, two reproductive strategies seem to win the evolutionary lottery every time. The first is to be asexual and make as many specialized organisms as you can before the niche changes—the strategy of the bacteria. The second is to be sexual and make enough different kinds of organisms in one generation that at least some survive the vagaries of the niche and make enough different kinds of new organisms that the whole enterprise keeps going.

NURTURE. The advent of sex marks a whole new idea in the history of organisms. While the overall goal—the transmission of genomes from one generation to the next—is the same as with asexual organisms, the genomes are now entrusted to a new class of individuals, the immature offspring. Therefore, the nurture of offspring is fully as important as surviving long enough to produce them.

Nurture is manifested in countless ways. Plants go to great lengths to ensure that their fertilized ovules are surrounded with hardy seed coats and fruity tissues. Butterfly larvae snuggle in cocoons; the social insects stagger out of disturbed nests with larvae in their mouths to carry to the next refuge. And the vertebrates, particularly the mammals and birds, have devised a stunning array of behaviors to assure the survival and maturation of their progeny.

REFLECTIONS

We have considered thus far two ways to think about caring. We have acknowledged our deep genetic homology with all of life and the affinity, the fellowship, that emerges from that acknowledgment. We have also

celebrated our capacity to experience empathy with other creatures and respond to their concerns as our own. And now we encounter our biological imperative to nurture our offspring, sacrificing, if need be, our lives on their behalf.

My own experience with this imperative came when, alone on a beach with my youngest son, I saw him being dragged out to sea. I jumped in, fully clothed, and as I swam out I realized that I was taking in huge amounts of water as I navigated the strangely turbulent surf. My brain displayed the headline: This Is How People Drown in Rip Tides. I looked ahead at James's terrified face bobbing above the waves, and the next realization came to me not as a headline but as an understanding: Either both of us survive or both of us drown. I reached him and pulled him to shore with a calm conviction that was somehow outside myself, and as we stood together on the empty beach, I absorbed my new self-knowledge: I am endowed with an inherent maternal altruism, unrehearsed, that is poised to flood my being whenever my children are in danger. There is no way to describe the joy that attends this kind of knowledge.

It seems likely that the emotional circuits invoked when we contemplate our deep evolutionary affinity with other creatures, and when we are infused with compassion, will turn out to map closely onto the circuits that drive our parental instincts, emotions that generate such feelings as tenderness and warmth and protectiveness. These same emotions extend to our understanding that the Earth must be nurtured, an understanding embedded in many religious traditions.

> There are creatures whose children float away
> at birth, and those who throat-feed their young
> for weeks and never see them again. My daughter is
> free and she is in me—no, my love
> of her is in me, moving in my heart,
> changing chambers, like something poured
> from hand to hand, to be weighed and then reweighed.[5]
>
> —Sharon Olds, 1996

We nurture our children selflessly. But we also recognize them as our most tangible sources of renewal—for a child, the world is always new. Renewal has been a religious theme throughout the ages, be it the Jews exhorted by Isaiah to return to Jerusalem after their exile in Babylon or the disciples exhorted by Jesus to seek the redemption of the spirit. Theists find that they can renew their personal sense of worth through petitions to God for atonement and grace. All of us see in children—our own and all children—the hope and promise of what human beings can become. As the forebears of our children we are called to transmit to them a joyous and sustainable vision of their future—meaning that we are each called to develop such a vision.

Sexuality

Sex, as we have seen, has everything to do with the adaptive strategy of eukaryotic organisms, and it generates the seminal necessity to nurture offspring. But sex generates another important consequence as well: gametes carrying haploid genomes must, at each generation, fertilize other gametes to create new diploid organisms.

Bacteria and amoebae have no such burden; their sole obligation is to go through a cell cycle, divide in two, go through another cell cycle, divide in two again, ad infinitum. Whereas sexual creatures, at a minimum, must produce gametes that find, recognize, and then fuse with gametes of the same species and opposite gender, a far more ambitious proposition. Still more ambitious are the animals that keep their gametes inside their bodies rather than spewing them out into the water or the air. In these cases, it becomes necessary to first identify the animal of the correct species and opposite gender, and then engage in copulation with that animal such that the gametes can fuse.

These strategies entail relationship, if only brief and reflexive, between sexually mature males and females, and they are, of course, antecedent to the elaborate emotional networks that govern human sexual relationships.

ATTRACTION. All organisms locate their mates, or the gametes of their mates, by some form of sexual attraction. Attraction can entail a simple receptor-mediated interaction, like the binding of the alpha pheromone to its receptor on the yeast A cell, or the binding of a protein on the surface of a starfish sperm to its receptor on the surface of a starfish egg. But even such simplicity can become complex, as when higher plants produce elaborate flowers so that insects or birds will brush against their anthers and transport their pollen to the stigmas of other flowers. And then, once the pollen binds to its correct receptor, it is programmed to send a long pollen tube down into the ovary where it locates and fuses with a receptive ovule.

Animals with nervous systems take the behavioral possibilities for sexual attraction to every possible limit. Fireflies pulse, houseflies beat their wings, moths send out musk, fish dance, frogs croon, birds display feathers and song, mammals strut and preen. If this is a planet shimmering with awareness, then a great deal of that awareness is focused on the sexual signals that creatures send to one another.

If we look to our closest relatives, the bonobos and the chimpanzees, we find quite different approaches to sexuality. The bonobos have sex with one another—male with male, male with female, and female with female—about ten times a day, often to reduce levels of conflict or solidify alliances, but often just because they seem to enjoy it. The chimps, in contrast, have only heterosexual sex, and only when the female is in heat. Neither group

is monogamous, and although dominant chimp males attempt to monopolize one or several females, "dalliances" occur frequently.

The range of human sexual behavior includes all of the above. In addition, human beings profess allegiance to the concept, if not always the practice, of committed marriage. This commitment feeds into the second facet of sexuality, the need for other.

THE NEED FOR OTHER. All sexual organisms need to attract a mate if they are to transmit their genes to the next generation. Whether this need for sexual relationship is experienced consciously takes us back to the issue of which creatures are conscious, an issue we can bypass by agreeing that, whether or not human beings are unique in experiencing this need, what we experience is an awareness of emotional pathways that have deep evolutionary roots.

Human beings also rely on one another for the nurture and care of their dependent offspring. Much of this has come to be accomplished by larger social groups—clusters of males hunting for game and defending against predators, clusters of females gathering fruits and tending the hearth. But human pair-bonding is encountered in all cultures and appears to be instinctive, at least while the children are young.

The instinct to engage a mate to help with child-rearing is accompanied by the reciprocal instinct in children (and in all young mammals and birds) to form strong relationships with their all-important parents. Again, we do not know whether the need for parenting penetrates conscious awareness in other young animals, but it seems probable that our affection for our parents flows through emotional networks that establish parent-offspring bonds in other mammals.

Psychologists have long posited that our love/need for our parents emanates from the same impulses as those that drive our love/need for our mates, even though they are expressed at different stages of maturity and experienced as very different sets of feelings. Certainly they have in common an extraordinary intensity. At least at the outset, our emotional responses to our parents and to our mates are thoroughly wondrous, thoroughly compelling, and deeply joyous.

Alas, of course, intimate relationship is inherently fraught with conflict. We confront, often clumsily, the imperative that we separate from our parents while retaining affection for them. We struggle to accommodate our love for our mates, and our need for their reliability and trust, with the experience of temptation and lust. When we find ourselves estranged from our mates, we are torn apart by jealousy, loneliness, desolation, and anger. We fear disapproval and abandonment. We can become deeply confused about our sexuality. It is all very complicated.

Reflections

Given the complexities of human relationship, an enormous attraction of the monotheistic religions—Judaism, Christianity, and Islam—is that they offer the opportunity for intimate relationship with a deity. Indeed, they suggest that the most stable and fruitful outlet for passion and dependency is in relationships with the divine.

Judaism initiated such a path with its concept of a Father God—a stern and judgmental father, to be sure, but one who can also offer protection and even affection, as in Psalm 23:

> The Lord is my shepherd; I shall not want.
> He maketh me to lie down in green pastures.
> He leadeth me beside the still waters.
> He restoreth my soul.
> He leadeth me in the paths of righteousness for his name's sake.
> Yea, though I walk through the valley of the shadow of death,
> I will fear no evil, for thou art with me;
> Thy rod and thy staff, they comfort me.
> Thou preparest a table before me in the presence of mine enemies.
> Thou anointest my head with oil; my cup runneth over.
> Surely goodness and mercy shall follow me all the days of my life,
> And I will dwell in the house of the Lord for ever. (Psalm 23)

And then Christianity (and Islam) took this all the way. Christian doctrine certainly implores us to feel compassion for others, but it speaks with particular poignancy to our longing for relationship. The reward of Christian faith, we learn, is the inexhaustible, unconditional love that flows from God the Father and Mary the Mother and Christ the Redeemer. They are there for us, they listen and respond, they will never abandon us, and they seek only our love in return—as in these hymns and prayers:

> Jesus, the very thought of thee with sweetness fills the breast;
> But sweeter far thy face to see, and in thy presence rest.
> O hope of every contrite heart, O joy of all the meek,
> To those who fall, how kind thou art! How good to those who seek!
> But what to those who find? Ah, this nor tongue nor pen can show;
> The love of Jesus what it is, none but his loved ones know.
>
> —Bernard of Clairvaux, 1153

> Jesus, priceless treasure, source of purest pleasure,
> Truest friend to me,
> Long my heart hath panted, till it well-nigh fainted,
> Thirsting after thee.
> Thine I am, O spotless Lamb, I will suffer naught to hide thee,
> Ask for naught beside thee.
>
> —Johann Frank, 1653

> Jesus, lover of my soul, let me to thy bosom fly,
> While the nearer waters roll, while the tempest still is high.
> Hide me, O my Savior, hide, till the storm of life is past;
> Other refuge I have none, hangs my helpless soul on thee;

Leave, ah! leave me not alone, still support and comfort me.
All my trust on thee is stayed, all my help from thee I bring.
—Charles Wesley, 1740

Softly and tenderly Jesus is calling,
Calling for you and for me;
See, on the portals he's waiting and watching,
Watching for you and for me.
Come home, come home;
You who are weary, come home;
Earnestly, tenderly, Jesus is calling,
Calling, O sinner, come home.
—Will L. Thompson, 1880

So we arrive here at what is, for many, the heart of it all. If there is a major tension between an approach like religious naturalism and the monotheistic traditions, it centers on the question of whether or not one believes in a personal god. Most people raised in the context of theistic traditions would probably say that "being religious" means "believing in God." Indeed, when reminded that personal gods are not inherent in such systems as Buddhism or Taoism, they would likely question whether these traditions are really religions and not something else, like philosophies.

The concept of a personal, interested god can be appealing, often deeply so. In times of sorrow or despair, I often wonder what it would be like to be able to pray to God or Allah or Jehovah or Mary and believe that I was heard, believe that my petition might be answered. When I sing the hymns of faith in Jesus' love, I am drawn by their intimacy, their allure, their poetry. But in the end, such faith is simply not available to me. I can't do it. I lack the resources to render my capacity for love and my need to be loved to supernatural beings. And so I have no choice but to pour these capacities and needs into earthly relationships, fragile and mortal and difficult as they often are.

Theism versus Non-Theism. The choice has been presented to us as saved *versus* damned, holy *versus* heathen. But when I talk to thoughtful theists, I encounter not a polarity but a spectrum. Belief and faith in supernatural being(s), when deeply wrought, are as intensely personal and individual and dynamic as our earthly relationships are. They add another dimension, another opportunity for relationship, to be sure. But those of us incapable of embracing that dimension remain flooded with opportunities to open ourselves to human relationship and hence to fill our lives with the religious experience of love.

What the monotheistic traditions offer to all of us, theists and nontheists alike, are challenging and enchanting images and evocations for how to best love. Michelangelo, unsurpassed in his ability to render in visual art the spirit of Christian love, writes of his earthly passions with the same imperative.

With your beautiful eyes, I see a gentle light
my blind ones could never see;
On your feet, I bear a burden
my lame ones could never bear.
With your wings, I fly though featherless;
By your mind I'm lifted ever upward;
At your whim, I pale or blush,
cold in the sun, warm in the cold of winter.
In your desire alone is my desire;
my thoughts are forged in your heart,
my works are breathed in your breath.
Alone, I am like the moon, itself alone;
our eyes see it in the heavens
only as the sun enlightens it.[6]

—Michelangelo, 1534

Multicellularity and Death

THE GERM/SOMA DICHOTOMY.[7] Many kinds of sexual algae and fungi are single-celled. Each cell/organism is either a haploid male or a haploid female, and each has two options: it can replicate and divide and replicate and divide to generate millions of identical copies (a mitotic clone) of itself, or else it can recognize and fuse with a cell of the opposite sex to produce a diploid zygote. The zygote switches on genetic programs that allow it to form a protective spore coat around itself and go into dormancy. And then, when circumstances are favorable, the spore undergoes meiosis and releases haploid male and female organisms that are pink/blue mixtures of their parents, and these again either cycle mitotically or else mate with one another.

Multicellular eukaryotes evolved from such single-celled creatures at the time of the Cambrian. We have already considered how multicellular organisms produce all manner of specializations by expressing different sets of genes in different sets of cells. Omitted from that account was the important fact that all multicellular organisms are sexual. Indeed, the invention of sex was necessary for multicellularity to evolve.

To understand what this means, we can consider the diploid zygote—the fertilized egg—of a multicellular animal. Whereas the algal zygote has but modest potential—it can form a spore coat and it can undergo meiosis—the animal zygote proceeds to cleave into two cells, and then four and then eight, with each cleavage generating daughter cells that remain together as a developing embryo. And then all of them start to specialize.

As we have said, each cell expresses only a subset of the genes it possesses, a differential that plays itself out in space and time. Let's focus on one of the cells in an 8-cell embryo, a cell programmed to switch on a certain set of genes. In the 16-cell embryo this cell has given rise to two daughter cells, both containing the protein products of these genes, and the products cause a second subset of genes to switch on. In the 32-cell

embryo, the products of the second subset initiate a signal-transduction cascade that induces the now four daughter cells in the lineage to move together to a new location and, several cleavages later, to move into the interior of the embryo in a process called gastrulation. Following gastrulation, the lineage (now 512 daughter cells) is subject to several fates: 64 of the cells at one end of the embryo activate a set of genes that allow their daughters to differentiate into gut cells; another 8 near the midline activate the program that ultimately generates the heart; and so on.

Early in this process of embryogenesis, certain cells switch on sets of genes that commit them to become germ-line cells—precursors of the egg or sperm cells that are uniquely capable of undergoing meiosis. These migrate into what will become the animal's gonads, where they remain dormant until sexual maturity and then begin undergoing meiosis to produce haploid gametes.

We can now appreciate the beauty of this arrangement. The dichotomy between the germ-line cells and the remaining somatic cells effectively parcels out the job of being alive. Transmission of the genome to the next generation is entrusted to the germ line, while negotiating the niche so that the germ cells are successfully transmitted is entrusted to the soma. The germ line is safely sequestered in gonads, nurtured by surrounding tissues, its genomes released only at appropriate times; the somatic cells are the ones that perceive and move and sprout feathers and pump blood and make love.

MORTALITY AND IMMORTALITY. One of the fates that is often programmed into a cell lineage during the course of embryogenesis is that those cells should die. Thus, the limbs of a human embryo initially terminate as blunt stubs, after which sets of cells die in order to create separate fingers and toes. And every autumn, in every deciduous tree, the cells at the base of each leaf stem are programmed to die such that the flow of nutrients is cut off and the leaves themselves die.

The more general fate of the soma is that the whole soma dies. If this death is premature, before the germ line has had time to be successfully transmitted to the next generation, we say that that organism was either unfit (an insect incapable of flight) or unlucky (an insect eaten by a bird). But if it happens after the germ line has successfully participated in the production of sons and daughters, then we say that the organism has served its biological purpose. Natural death may occur after only a few days of life, as with some kinds of adult insects, or it may be postponed for hundreds of years and hundreds of attempted procreation cycles, as is the case for some kinds of trees.

Eventually, though, the sequoias die just like the dragonflies do. If we don't die by accident or infection or because of the failure of a particular organ, we die because we just get old. A friend describes her husband's last

two years before his death at the age of 91: "It just got slower and slower, and less and less, and then he stopped being interested in eating, and then in drinking, and then he stopped breathing."

So is there such a thing as an immortal organism? The answer is yes, but immortal organisms are by definition very limited in complexity. For example, there is no death programmed into the life cycle of a bacterium or an amoeba. Certainly, the cells can be killed by boiling or starvation—the individuals are fully mortal—but they don't have to die. The same is true for the sexual single-celled algae that we grow in my laboratory. The cells need to have sex when they are in the wild—they must form heavy-walled zygotic spores to protect their genomes from freezing and desiccation—but under our care they will keep on dividing indefinitely by mitosis as long as we provide them with light and nitrogen salts. By the same token, tumor cells, in scientific terminology, are said to be "immortalized." They carry somatic mutations in key cell-cycle genes such that they don't know when to stop dividing, either in our bodies or in the laboratory.

But once you have a life cycle with a germ line and a soma, then immortality is handed over to the germ line. This liberates the soma from any obligation to generate gametes and allows it to focus instead on strategies for getting the gametes transmitted. And because morphogenesis is the key niche-negotiating strategy of eukaryotes, multicellular eukaryotes, freed of constraints, have generated every complex morphological structure imaginable: wings, gills, eyes, leaves, glands, claws, bark, nostrils, tentacles. All of these parts are highly specialized, and although each cell in each part retains two full copies of the genome, transmission of these somatic genomes to the next generation is not included in the arrangement. The arrangement is that the parts will do their utmost to ensure the transmission, and often the nurture, of the germ line, and then they die.

One of these "parts" is my brain, the locus of my self-awareness. My brain developed with nary a backward look at gene transmission or immortality. The whole point was to make synapses, strengthen them, modulate them, and reconfigure them, with countless neurons dying in the process and countless more dying during my lifetime, many as I sit here typing. It is because these cells were not committed to the future that they could specialize and cooperate in the construction of this most extraordinary, and most here-and-now, center of my perception and feelings.

So our brains, and hence our minds, are destined to die with the rest of the soma. And it is here that we arrive at one of the central ironies of human existence, which is that our sentient brains are uniquely capable of experiencing deep regret and sorrow and fear at the prospect of our own death, yet it was the invention of death, the invention of the germ/soma dichotomy, that made possible the existence of our brains.

Reflections

All religions offer us a way to think about death, usually in the context of some form of immortality. We know about the heaven and hell of Western traditions and the reincarnation cycles of Asian traditions, but in fact the concept of immortality is global. The Bwende, in the Congo, carved icons to the Four Moments of the Sun: Dawn (the beginning of life), Noon (life at its fullest), Sunset (the end of life's journey), and a Second Dawn (for those who have lived an exemplary life). The Egyptians developed an elaborate afterlife ruled by King Osiris and inhabited by numerous gods. The Taoists look to Fei-sheng, the ascension to heaven in daylight. The Muslims anticipate resurrection (*yaum al-qiyama*) and final judgment (*yaum al-din*).

Religious naturalism offers two responses to human death. The first is the response to the death of someone loved, or a death that is premature or senseless. These directly ravage our personal fabric of relationship, or activate our empathy and compassion, and we experience unmitigated loss and grief. I was told of a school-age child whose mother was killed in an automobile accident—how weeks later he would go into her clothes closet and bury his face in her dresses so he could smell her smell. I am undone by his savage loss, and outraged by her death, even though these people are strangers to me. Our sorrow at the death of others is a universal human emotion that transcends cultural and religious particularities. Indeed, ape mothers have been observed carrying their dead babies around for several days, suggesting that this form of grieving far antedates our humanness.

And then there is the response to the fact of death itself, and, in particular, to the fact of my own inevitable death. When I wonder what it will feel like to be dead, I tell myself that it will be like before I was born, an understanding that has helped me to cope with my fear of being dead. But what about the fact that I will die? Does death have any meaning?

Well, yes, it does. Sex without death gets you single-celled algae and fungi; sex with a mortal soma gets you the rest of the eukaryotic creatures. Death is the price paid to have trees and clams and birds and grasshoppers, and death is the price paid to have human consciousness, to be aware of all that shimmering awareness and all that love.

My somatic life is the wondrous gift wrought by my forthcoming death.

Notes

1. My understanding of the nature of religion has been particularly influenced by Loyal Rue; see, for example, his *Amythia: Crisis in the Natural History of Western Culture* (Tuscaloosa: Univ. of Alabama Press, 1989), *By the Grace of Guile: The Role of Deception in Natural History and Human Affairs* (New York: Oxford Univ. Press, 1994), and *Everybody's Story* (Ithaca: State Univ. of New York Press, 2000).

2. Two other key influences have been Erwin R. Goodenough (see Eleanor B. Mattes, *Myth for Moderns: Erwin Ramsdell Goodenough and Religious Studies in America, 1938–1955* [Lanham, MD: Scarecrow Press, 1997] and E. R. Goodenough, "A Historian of Religion Tries to Define

Religion," *Zygon: Journal of Religion and Science* 2:7–22 [1967]) and William James (*Varieties of Religious Experience: A Study in Human Nature* [New York: Longmans, Green & Co., 1903], a book quoted several times in the text).

3. The term "Epic of Evolution" is invoked by Edward O. Wilson in *On Human Nature* (Cambridge: Harvard Univ. Press, 1978). The term "religious naturalism" appears in *Science and Religion: A Critical Survey* by Holmes Rolston, III (New York: Random House, 1987). Connie Barlow explores the religion-science interface in *Green Space, Green Time: The Way of Science* (New York: Copernicus, 1997).

4. George C. Williams has written a classic book, *Sex and Evolution* (Princeton, N.J.: Princeton Univ. Press, 1975), and more recent reviews are found in *The Evolution of Sex: An Examination of Current Ideas* (Sunderland, Mass.: Sinauer, 1988), ed. Richard Michod and Bruce Levin. An evolutionary perspective on human sexuality is offered by Helen Fisher in *Anatomy of Love: A Natural History of Mating, Marriage, and Why We Stray* (New York: Fawcett Columbine, 1992).

5. "High School Senior," from *The Wellspring* by Sharon Olds, ©1996 by Sharon Olds, reprinted by permission of Alfred A. Knopf, Inc.

6. Michelangelo Buonarroti (1475–1564), "Veggio co' be' vostr' occhi," 1564. Sonnet for Tommaso de' Cavalieri from *Set My Heart Aright: A Michelangelo Portrait*, translations and music © Carl F. Smith, 1996.

7. A collection of essays on death, edited by J. D. Roslansky, is found in *The End of Life* (Amsterdam: North-Holland Publishing, 1973), one of which, "The Origin of Death" by George Wald, also considers the importance of the germ/soma dichotomy. William R. Clark has developed this idea as well in *Sex and the Origins of Death* (New York: Oxford Univ. Press, 1996).