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BEYOND REDUCTIONISM

*Batter my heart, three-person'd God; for you
As yet but knock, breathe, shine, and seek to mend;
That I may rise, and stand, o'erthrow me and bend
Your force, to break, blow, burn and make me new.
I, like an usurpt town, to another due,
Labour to admit you, but Oh, to no end,
Reason your viceroy in me, me should defend,
But is captiv'd, and proves weak or untrue.
Yet dearly I love you, and would be loved fain,
But am betroth'd unto your enemy:
Divorce me, untie, or break that knot again,
Take me to you, imprison me, for I
Except you enthrall me, never shall be free,
Nor ever chaste, except you ravish me.*

John Donne's exquisite "Holy Sonnet XIV: Batter My Heart," written in about 1615, when he was a High Anglican churchman, speaks to one of

the most poignant schisms in Western society, and more broadly in the world: that between faith and reason. Donne wrote in the time of Kepler. Within a hundred years Newton had given us his three laws of motion and universal gravitation, uniting rest and motion, earth and the heavens: the foundations of modern science. With Descartes, Galileo, Newton, and Laplace, reductionism began and continued its 350-year reign. Over the ensuing centuries, science and the Enlightenment have given birth to secular society. Reductionistic physics has emerged for many as the gold standard for learning about the world. In turn, the growth of science has driven a wedge between faith and reason. It was not so much Galileo's geocentric theory (derived from Copernicus) that underlay his clash with the church but his claim that only science, not revelation, is the path to knowledge.

Today the schism between faith and reason finds voice in the sometimes vehement disagreements between Christian or Islamic fundamentalists, who believe in a transcendent Creator God, and agnostic and atheist "secular humanists" who do not believe in a transcendent God. These divergent beliefs are profoundly held. Our senses of the sacred have been with us for thousands of years, at least from the presumptive earth goddess of Europe ten thousand years ago, through the Egyptian, Greek, Abrahamic, Aztec, Mayan, Incan, and Hindu gods, Buddhism, Taoism, and other traditions. Neanderthals buried their dead. Perhaps they also worshiped gods. Recently an aboriginal tribe was unwilling to allow its DNA to be sampled as part of a worldwide study on the origins and evolution of humanity for fear that science would challenge its view of its own sacred origins. Ways of life hang in the balance. This book hopes to address this schism in a new way.

Part of my goal is to discuss newly discovered limitations to the reductionism that has dominated Western science at least since Galileo and Newton but leaves us in a meaningless world of facts devoid of values. In its place I will propose a worldview beyond reductionism, in which we are members of a universe of ceaseless creativity in which life, agency, meaning, value, consciousness, and the full richness of human action have emerged. But even beyond this emergence, we will find grounds to radically alter our understanding of what science itself appears able to tell us.

Science cannot foretell the evolution of the biosphere, of human technologies, or of human culture or history. A central implication of this new worldview is that we are co-creators of a universe, biosphere, and culture of endlessly novel creativity.

The reductionism derived from Galileo and his successors ultimately views reality as particles (or strings) in motion in space. Contemporary physics has two broad theories. The first is Einstein's general relativity, which concerns spacetime and matter and how the two interact such that matter curves space, and curved space "tells" matter how to move. The second is the standard model of particle physics, based on fundamental subatomic particles such as quarks, which are bound to one another by gluons and which make up the complex subatomic particles that then comprise such familiar particles as protons and neutrons, atoms, molecules, and so on. Reductionism in its strongest form holds that all the rest of reality, from organisms to a couple in love on the banks of the Seine, is ultimately nothing but particles or strings in motion. It also holds that, in the end, when the science is done, the explanations for higher-order entities are to be found in lower-order entities. Societies are to be explained by laws about people, they in turn by laws about organs, then about cells, then about biochemistry, chemistry, and finally physics and particle physics.

This worldview has dominated our thinking since Newton's time. I will try to show that reductionism alone is not adequate, either as a way of doing science or as a way of understanding reality. It turns out that biological evolution by Darwin's heritable variation and natural selection cannot be "reduced" to physics alone. It is emergent in two senses. The first is epistemological, meaning that we cannot from physics deduce upwards to the evolution of the biosphere. The second is ontological, concerning what entities are real in the universe. For the reductionist, only particles in motion are ontologically real entities. Everything else is to be explained by different complexities of particles in motion, hence are not real in their own ontological right. But organisms, whose evolution of organization of structures and processes, such as the human heart, cannot be deduced from physics, have causal powers of their own, and therefore are emergent real entities in the universe. So, too, are the biosphere, the human economy, human culture, human action.

We often turn to a Creator God to explain the existence of life. I will spend several chapters discussing current work on the natural origin of life, where rapid progress is being made. Self-reproducing molecules have already been demonstrated in experiments. A Creator God is not needed for the origin of life. More, you and I are agents; we act on our own behalf; we do things. In physics, there are only happenings, no doings. Agency has emerged in evolution and cannot be deduced by physics. With agency come meaning and value. We are beyond reductionist nihilism with respect to values in a world of fact. Values exist for organisms, certainly for human organisms and higher animals, and perhaps far lower on the evolutionary scale. So the new scientific view of emergence brings with it a place for meaning, doing, and value.

Further, the biosphere is a co-constructing emergent whole that evolves persistently. Organisms and the abiotic world create niches for new organisms, in an ongoing open textured exploration of possible organisms. I will discuss the physical basis of this “open texture” in the chapter on the non-ergodic universe.

At a still higher level, the human economy cannot be reduced to physics. The way the diversity of the economy has grown from perhaps a hundred to a thousand goods and services fifty thousand years ago to tens of billions of goods and services today, in what I call an expanding economic web, depends on the very structure of that web, how it creates new economic niches for ever new goods and services that drive economic growth. This growth in turn drives the further expansion of the web itself by the persistent invention of still newer goods and services. Like the biosphere, the global economy is a self-consistently co-constructing, ever evolving, emergent whole. All these phenomena are beyond physics and not reducible to it.

Then there is the brute fact that we humans (at least) are conscious. We have experiences. We do not understand consciousness yet. There is no doubt that it is real in humans and presumably among many animals. No one knows the basis of it. I will advance a scientifically improbable, but possible, and philosophically interesting hypothesis about consciousness that is, ultimately, testable. Whatever its source, consciousness is emergent and a real feature of the universe.

All of the above speaks to an emergence not reducible to physics. Thus our common intuition that the origin of life, agency, meaning, value, doing, economic activity, and consciousness are beyond reduction to physics can be given scientific meaning. We live in a different universe from that envisioned by reductionism. This book describes a scientific worldview that embraces the reality of emergence.

The evolution of the universe, biosphere, the human economy, human culture, and human action is profoundly *creative*. It will take some detailed exploration of what are called Darwinian preadaptations to explain this clearly. The upshot is that we do not know beforehand what adaptations may arise in the evolution of the biosphere. Nor do we know beforehand many of the economic evolutions that will arise. No one foresaw the Internet in 1920. This unpredictability may exist on many levels that we can investigate. For example, we do not know beforehand what will arise even in the evolution of cosmic grains of dust that grow by aggregation and chemical reactions to form planetesimals. The wondrous diversity of life out your window evolved in ways that largely could not be foretold. So, too, has the human economy in the past fifty thousand years, as well as human culture and law. They are not only emergent but radically unpredictable. We cannot even prestate the possibilities that may arise, let alone predict the probabilities of their occurrence.

This incapacity to foresee has profound implications. In the physicist Murray Gell-Mann's definition, a "natural law" is a compact description beforehand of the regularities of a process. But if we cannot even prestate the possibilities, then no compact descriptions of these processes beforehand can exist. *These phenomena, then, appear to be partially beyond natural law itself.* This means something astonishing and powerfully liberating. We live in a universe, biosphere, and human culture that are not only emergent but radically creative. We live in a world whose unfoldings we often cannot prevision, prestate, or predict—a world of explosive creativity on all sides. This is a central part of the new scientific worldview.

Let me pause to explain just how radical this view is. My claim is not simply that we lack sufficient knowledge or wisdom to predict the future evolution of the biosphere, economy, or human culture. It is that these things are *inherently* beyond prediction. Not even the most powerful

computer imaginable can make a compact description in advance of the regularities of these processes. There is no such description beforehand. Thus the very concept of a natural law is inadequate for much of reality. When I first discuss this in detail, in chapter 10, concerning Darwinian preadaptations, I will lay out the grounds for believing that this radical new view is correct. If it is, it challenges what I will call the Galilean spell, the belief that all in the universe unfolds under natural law.

There is a further profound implication: If the biosphere and the global economy are examples of self-consistently co-constructing wholes, and at the same time, parts of these processes are not sufficiently described by natural law, we confront something amazing. Without sufficient law, without central direction, the biosphere literally constructs itself and evolves, using sunlight and other sources of free energy, and remains a coherent whole even as it diversifies, and even as extinction events occur. The same is true of the global economy, as we shall discuss in chapter 10. Such a self-organized, but partially lawless, set of coupled processes stands unrecognized, and thus unseen, right before our eyes. We appear to need a new conceptual framework to see and say this, then to understand and orient ourselves in our ever creative world. We will find ourselves far beyond reductionism, indeed.

Is it, then, more amazing to think that an Abrahamic transcendent, omnipotent, omniscient God created everything around us, all that we participate in, in six days, or that it all arose with no transcendent Creator God, all on its own? I believe the latter is so stunning, so overwhelming, so worthy of awe, gratitude, and respect, that it is God enough for many of us. God, a fully natural God, is the very creativity in the universe. It is this view that I hope can be shared across all our religious traditions, embracing those like myself, who do not believe in a Creator God, as well as those who do. This view of God can be a shared religious and spiritual space for us all.

This view is not as great a departure from Abrahamic thought as we might suppose. Some Jesuit cosmologists look out into the vast universe and reason that God cannot know, from multiple possibilities, where life will arise. This Abrahamic God is neither omniscient nor omnipotent, although outside of space and time. Such a God is a Generator God who

does not know or control what thereafter occurs in the universe. Such a view is not utterly different from one in which God is our honored name for the creativity in the natural universe itself.

THE FOUR INJURIES

It would be a sufficient task to unravel the implications of this new scientific worldview for our unity with nature and life. But the project before us appears to be even larger. T. S. Eliot once wrote that with Donne and the other metaphysical poets of the Elizabethan age, for the first time in the Western mind, a split arose between reason and our other human sensibilities. The anguish between faith and reason in Donne's "Holy Sonnet XIV" is but one of these emerging schisms. With the growth of science and the Enlightenment, the Western mind placed its faith in reason and subordinated the rest of our humanity, Eliot's "other sensibilities," the fullness of human life.

Almost without our noticing, our secular modern society suffers at least four injuries, which split our humanity down the center. These injuries are larger than the secular-versus-religious split in modern society. What the metaphysical poets began to split asunder—reason and the remaining human sensibilities—we must now attempt to reintegrate. This is also part of reinventing the sacred.

The first injury is the artificial division between science and the humanities. C. P. Snow wrote a famous essay in 1959, "The Two Cultures," in which he noted that the humanities were commonly revered as "high culture" while the sciences were considered second-class knowledge. Now their roles are reversed: on many university campuses, those who study the humanities are often made to feel like second-class citizens. Einstein or Shakespeare, we seem to believe, but not both in the same room. This split is a fracture down the middle of our integrated humanity.

I believe it is important that this view is wrong. Science itself is more limited by the un-prestatable, unpredictable creativity in the universe than we have realized, and, in any case, science is not the only path to knowledge and understanding. I shall show in this book that science cannot

explain the intricate, context-dependent, creative, situated aspects of much of human action and invention, or the historicity that embraces and partially defines us. These, however, are just the domains of the humanities, from art and literature to history and law. Truth abides here, too.

A second injury derives from the reductionistic scientific worldview. Reductionism teaches us that, at its base, the real world we live in is a world of fact without values. Wolfgang Kohler, one of the founders of Gestalt psychology, wrote a mid-twentieth-century book hopefully entitled *The Place of Value in a World of Fact*, in which he struggled unsuccessfully with this issue. His efforts had no effect on reductionism and its claims. The French existentialist philosophers struggled with the same issue, the view that the real universe is devoid of values. Our lives are full of value and meaning, yet no single framework offers a secure place for these facets of our humanity to coexist with fundamental science. We need a worldview in which brute facts yield values, a way to derive ought from is, just the step that Scottish Enlightenment philosopher David Hume warned against. Agency, values, and “doing” did not come into being separately from the rest of existence; they are emergent in the evolution of the biosphere. We are the products of that evolution, and our values are real features of the universe.

A third injury is that agnostic and atheist “secular humanists” have been quietly taught that spirituality is foolish or, at best, questionable. Some secular humanists are spiritual but most are not. We are thus cut off from a deep aspect of our humanity. Humans have led intricate and meaningful spiritual lives for thousands of years, and many secular humanists are bereft of it. Reinventing the sacred as our response to the emergent creativity in the universe can open secular humanists to the legitimacy of their own spirituality.

The fourth injury is that all of us, whether we are secular or of faith, lack a global ethic. In part this is a result of the split, fostered by reductionism, between the world of fact and the world of values. We lack a shared worldwide framework of values that spans our traditions and our responsibilities to all of life, one another, and the planet. Secular humanists believe in fairness and the love of family and friends, and we place our faith in democracy. Our diverse religions have their diverse beliefs. But in the industrialized world all of us are largely reduced to consumers. It is

telling that the Nobel laureate economist Kenneth Arrow, when asked to help evaluate the “value” of the U.S. national parks, was stymied because he could not compute the utility of these parks for U.S. consumers. Even in our lives in nature we are reduced to consumers, and our few remaining wild places, to commodities. But the value of these parks is life itself and our participation in it.

This materialism profoundly dismays many thoughtful believers in both the Islamic world and the West. The industrialized world is seen to be, and is, largely consumer oriented, materialistic, and commodified. How strange this world would seem to medieval Europe. How alien it seems to fundamentalist Muslims. We of the industrialized world forget that our current value system is only one of a range of choices. We desperately need a global ethic that is richer than our mere concern about ourselves as consumers. We need something like a new vision of Eden, not one that humanity has forever left but one we can move toward, knowing full well our propensities for both good and evil. We need a global ethic to undergird the global civilization that is emerging as our traditions evolve together.

Part of reinventing the sacred will be to heal these injuries—injuries that we hardly know we suffer. If we are members of a universe in which emergence and ceaseless creativity abound, if we take that creativity as a sense of God we can share, the resulting sense of the sacredness of all of life and the planet can help orient our lives beyond the consumerism and commodification the industrialized world now lives, heal the split between reason and faith, heal the split between science and the humanities, heal the want of spirituality, heal the wound derived from the false reductionist belief that we live in a world of fact without values, and help us jointly build a global ethic. These are what is at stake in finding a new scientific worldview that enables us to reinvent the sacred.