On Teilhard, Entropy, and Love: A Unifying Vision

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> *The labor of seaweed as it concentrates in its tissues the substances scattered, in infinitessimal quantities, throughout the vast layers of the ocean; the industry of the bees as they make honey from the juices broadcast in so many flowers–these are but pale images of the ceaseless working-over that all the forces of the universe undergo in us in order to reach the level of the spirit.* **Teilhard de Chardin**

1 Teilhard: His Life and Legacy

These poetic and insightful words were penned by Teilhard de Chardin in his seminal work *The Divine Milieu*. Buried within them, I believe, is one of the secrets of our universe. Laying bare that secret, to some degree, is the subject of this paper.

Not everyone is familiar with Pierre Teilhard de Chardin. Who was he, and why should we pay attention to his thought and vision? Teilhard died, as was his fervent wish, on an Easter Sunday. The year was 1955. He died in New York City, in exile from his native France, and lies buried beneath a simple headstone in the graveyard of the Jesuit Fathers at Saint Andrews-on-Hudson. His funeral was attended by just a handful of faithful friends. And yet, in 2005, 50 years following his death, conferences were convened around the world to celebrate Teilhard's life and legacy. Some 500 people attended each of the four plenary sessions of "Rediscovering Fire," a conference commemorating Teilhard in November 2005 at Chestnut Hill College near Philadelphia. Why such interest and why now?

First and foremost, Teilhard was a scientist, a paleontologist of the first rank. During an expedition to China's Inner Mongolia in the early 1920s, Jesuit coworkers Emile Licent and Teilhard found the first incontrovertible evidence of paleolithic humans in that remote corner of the world. Although not the discoverer of *Sinanthropus*, commonly known as Peking Man and unearthed a few years later in 1929, Teilhard performed a central role in the interpretive work that dated *Sinanthropus* at 500,000 years and determined him to be the earliest known hominid to use fire, a record that apparently still stands. As a scientist, Teilhard was prolific. In 1930 alone, he published 18 scientific papers. His collected works fill 11 volumes. The caliber and quantity of his scientific work earned him induction into both of France's premier scientific bodies and entry into several prestigious British societies as well (King, 1996).

Second, Teilhard was a Jesuit priest, so devout in his faith that he wished to die on Easter Sunday, a wish granted by a massive heart attack at 3 p.m. in the afternoon of April 10, 1955. And yet, as a scientist who studied human origins and religiously carried a geology hammer and magnifying glass on every outing, he fully embraced evolutionary theory. "Is evolution a theory, a system, or a hypothesis?" Teilhard asked, and then answered:

> It [evolution] is much more: it is a general condition to which all theories, all hypotheses, all systems must bow and which they must satisfy henceforward if they are to be thinkable and true. Evolution is a light illuminating all facts, a curve that all lines must follow. (Teilhard de Chardin, 1959.)

How did a man of such faith arrive at so bold a view of evolution? Keenly aware of 20th-Century developments in cosmology, among them that the universe is expanding, having originated in a primeval atom (to use fellow scientist-priest George LeMaitre's original term for the Big Bang), Teilhard grasped what others had failed: that evolution applies not only to biological processes but to the universe as a whole. From this recognition emerged his beautiful notion of *cosmogenesis*, which signifies a universe in continual creation. When was the moment of creation? Now! Such radical views ran afoul of the religious orthodoxy. Forbidden to publish his theological thought, Teilhard dutifully acquiesced to his superiors and was banished to China for much of his life and to the United States at the end of his life (King, 1996). All his significant non-scientific works were published posthumously, including *The Divine Milieu*, *The Phenomenon of Man*, and the autobiographical *Heart of Matter*.

Third, Teilhard was an extraordinary human being, a man of shining intelligence, integrity, warmth, and uncommon courage. When Europe erupted into flames in WWI, Teilhard was conscripted and sent to the front as a stretcher-bearer for the 8th regiment of Moroccan Tirailleurs (King, 1996). As the unit had no chaplain, Teilhard found himself consoling the dead and dying. The Muslim men and boys of his unit soon regarded him as a saint, protected by God, and they bestowed on him a title of utmost esteem, "Sidi Marabout," which means "closely bound to God." (Godwin, 2002.) Although he saw action in many great battles of the First World War, Teilhard survived miraculously unscathed, with not the slightest wound. Decorated for valor time and again, he declined promotions in order to remain at the front, of service to those who most needed him (King, 1996). Paradoxically, despite the devastation and unspeakable horror of life at the front, Teilhard found there a strange exhilaration. "The man at the front is no longer the same man," Teilhard observed (Teilhard de Chardin, 1960, preface by Leroy), as his calling came into sharper focus. And it was there on the front, on a moonlight night, that Teilhard had the epiphany that would form the solid core of his life's work. In that suspended moment, Teilhard's deep spirituality and his scientific understanding fused into something new: although the cosmic evolutionary processes are random at one level, they are not directionless. However haltingly, evolution marches forward to create beings of greater biological complexity and concomitantly higher consciousness. Teilhard termed this process *complexification* (or *complexity-consciousness*) and envisioned a distant goal of evolution, the *Omega Point*, toward which creation advances. Consciousness (or spirit), is not the by-product of evolution, it is indeed the purpose of evolution (Teilhard de Chardin, 1959).

Finally, Teilhard was a mystic. The unique struggle of the mystic is sensitively captured in the words by John Yungblut (1979):

> The mystic is under greater constraint than others. He must not merely perceive connections between apparently disparate things and ideas, but make one of two or more worlds, which he experiences as in deadly conflict within him. For the mystic ... the struggle for identity and integrity assumes epic, even cosmic proportions ... because it presents itself existentially as an intensely personal life-and-death struggle.

Teilhard's mystical experiences began early. Recounting a mystical encounter with iron as a child, he reflected, "In all my childish experience, there was nothing in the world harder, tougher, or more durable than this wonderful substance." Throughout his life, Teilhard maintained a great affinity for matter and for the durable, an affinity that led him ultimately to geology and from there to paleontology. Still, as a child, he was plunged into despair to learn that iron can be scratched and will rust. Ironically, Teilhard found the durability he sought in the most insubstantial of all substances. "The felicity that I had sought in iron," he discovered, "I can now find only in Spirit." (Teilhard de Chardin, 1960, preface by Leroy.)

Enamored of both, Teilhard came to see spirit and matter as but two sides of a coin, which he termed the *Within* and the *Without*; both are primary. Again, in his words:

> Co-extensive with the Without, there is a Within to things ... We have recognized the existence of a conscious inner face that everywhere duplicates the 'material' external face, which alone is commonly considered by science ... In a coherent perspective of the world: life inevitably assumes 'pre-life' for as far back as the eye can see ... Refracted rearwards along the course of evolution, consciousness displays itself qualitatively as a spectrum of shifting shades whose lower terms are lost in the night (Teilhard de Chardin, 1959).

From the tension between his scientific career and his Christian faith, Teilhard ultimately forged a remarkable synthesis of matter and spirit, thereby providing us with a new paradigm: "There is neither spirit nor matter in the world; the stuff of the universe is spirit-matter. No other substance but this could produce the human molecule." (Teilhard de Chardin, 1959.) Teilhard's synthetic vision serves as a model to those today who seek wholeness in the integrity of mind and heart.

2 Entropy

> The labor of seaweed as it concentrates in its tissues the substances scattered, in infinitessimal quantities, throughout the vast layers of the ocean; the industry of the bees as they make honey from the juices broadcast in so many flowers–these are but pale images of the ceaseless working-over that all the forces of the universe undergo in us in order to reach the level of the spirit.

In Teilhard's sweeping views of cosmogenesis and complexification, and in the beautiful passage above with which this paper began, evolution is seen as the quintessential counter-entropic process out of which spirit is distilled from the cosmos. In order to understand the significance of counter-entropic processes, it is first necessary to visit the notion of *entropy.* Entropy is a difficult concept;

each time that one feels that he/she may have fathomed it, one is confounded by some new twist. In a short paper it is impossible to do justice to such a complex idea. So let's simply try to summarize what entropy entails and what it does not, and to make some connections.

In common understanding, entropy is associated with disorder. Low entropy states are characterized by high degrees of order. Conversely, high entropy states are characterized by low order or equivalently by high disorder. The common association of entropy with disorder is problematic, however. First, it suggests that entropy is a loosely defined quantity that lies in the eyes of the (human) beholder. Not so. Entropy, like mass, momentum, and energy, is a physical quantity whose value one can, in principle, evaluate with great precision. Second, in contrast to thermodynamic systems, for gravitating systems in which aggregates of particles of dust and gas accrete and collapse into stars and planets, the tendency is toward greater apparent order, not less, as entropy increases (Penrose, 1989). A more universally valid understanding of entropy, therefore, associates entropy not with disorder but with *probability.* Low entropy states are those that have low probability; high entropy states have high probability. Because the natural tendency of the physical world is for states to transition by degrees from low probability to higher probability, entropy tends to increase over time.

The relationship between entropy and the flow of time in human perception is another deep topic. Stephen Hawking (1988) sums up the situation by saying: "Disorder increases with time because we measure time in the direction in which disorder increases. You can't have a safer bet than that!" The classic illustration is the wine glass that falls off the table and shatters into hundreds of shards. Unfortunate as such an event might seem, it is one nearly all have experienced. On the other hand, were the fragments of the broken glass to spontaneously gather themselves, the spilt wine to flow back into the re-constructed glass, and the glass and its contents to then leap back onto the table, that would be something to behold indeed. It is also highly improbable. Thus, in human perception, time generally flows in the direction that organizes events in a sequence ordered by increasing probabilities.

The notion of entropy arose in a most unromantic context, from the field of thermodynamics that emerged following the invention of the steam engine that propelled the bustling and grimy industrial revolution. In order to make steam engines, in particular, and heat engines, in general, as efficient as possible, an understanding of the flow and transformation of energy was needed. Among the international cadre of luminaries who contributed to the creation and formalization of thermodynamic theory in the 19th Century were the Frenchman Carnot, the Englishman Joule, the German Clausius, the Austrian Boltzmann, the Scot Kelvin, and the American Gibbs. Thermodynamics at first seemed counterintuitive to those steeped in classical physics. As a result, the key to its development as a new scientific field lay in successive steps of abstraction, by which the lumbering steam engine was gradually stripped of all its mechanical apparatus to reveal its underlying essence (Atkins, 2003). At the bottom of this process lay a fundamentally new principle, now known as the Second Law of Thermodynamics and first elucidated by Clausius:

Heat does not flow spontaneously from a cooler body to a hotter body.

The second law is far more subtle than it appears at first blush, because, at root, it has to do with probabilities of thermodynamic systems of particles jostling about in excited states, each according to its temperature. The higher its temperature, the more excited the motion of the particle. The second law can be expressed in many equivalent ways. The most common is:

The entropy of an isolated system cannot decrease over time.

When the physicist or engineer first encounters the second law, it is something utterly foreign. The laws governing mass, momentum, and energy are conservation laws. For example, the First Law of Thermodynamics states that energy can neither be created nor destroyed; it can only change form, from potential energy to kinetic, from chemical energy to heat, and so on. But unlike energy, or mass, or momentum, entropy is not conserved; rather, its tendency is to increase. How unusual.

Some re-statements of the second law are humorous, but each captures a facet of its reach (Trefil and Hazen, 2003):

It is easier to scramble an egg than to unscramble it.

Refrigerators don't work, unless plugged in.

The universe is going to hell in a hand basket.

The first and last statements reflect the fact that the natural trend of systems, including the universe as a whole, is toward increasing disorder, or more correctly, toward states of higher probability. The second statement dices things more finely. It addresses what the second law does not say. The second law does not say that heat cannot flow from cold bodies to hot bodies or that order cannot be created out of disorder. But doing so requires an input of energy from outside, in which case the system is no longer isolated. A refrigerator transfers heat from colder bodies (the carton of milk) to hotter ones (the room), but it doesn't do so spontaneously. It must first tap into a source of energy via the electrical cord and the outlet.

From the thermodynamic point of view, the existence of life offers a most curious fact to ponder. The second law of thermodynamics requires the universe to run downhill, to degenerate into disorder and heat death. Ultimately the universe is destined to become a cold, formidable place where all energy is imprisoned forever inside black holes scattered about, the gravesites of massive stars. But that is only half the story. In the words of Sir Charles Sherrington, the 1932 Nobel Laureate for medicine (Schroedinger, 1992):

> The universe of energy is we are told running down. It tends fatally towards an equilibrium which shall be final. An equilibrium in which life cannot exist. Yet life is evolved without pause. Our planet in its surround has evolved it and is evolving it. And with it evolves mind.

Similarly, Sir Julian Huxley wrote in the introduction to Teilhard's *The Phemonenon of Man* (Teilhard de Chardin, 1959):

> [Evolution] is an anti-entropic process, running counter to the second law of thermodynamics with its degradation of energy and its tendency to uniformity. With the aid of the sun's energy, biological evolution marches uphill, producing increased variety and higher degrees of organization.

By analogy, evolution is the salmon, valiantly swimming upstream against the raging current of entropy. Thus, there are two counter trends in the observed universe. There is the tendency of the physical world to run downhill according to the second law, and there is the counter-entropic trend of biological systems toward greater complexity and higher consciousness. This begs the question: Are these trends somehow related, and if so, how?

3 What is Life?

In the same year that Sherrington took the Nobel Prize for medicine, the Nobel Prize in physics went to quantum physicist Erwin Schroedinger. In 1943, during the Second World War, in a series of lectures at Trinity College that a year latter became the little gem of a book entitled *What is Life?*, the eminent physicist delved into biology to address the question implied by the book's title: What are the primary characteristics that distinguish life from non-life?

To Schroedinger, above all, life is characterized by its ability to temporarily hold at bay the ravages of entropy. A living organism is defined as "living" precisely because of its ability to avoid decay, to maintain itself temporarily free from the universe's tendencies toward disorder. So-called inanimate matter does not possess this amazing quality. For all their grandeur, mountains are powerless against the forces of erosion: wind, water, and acids. Each grain of sand on each beach testifies to the powerlessness of rocks and mountains in the face of natural forces. Similarly, iron is powerless against rust, and downed wood is powerless against rot.

In *Genesis* 3:19 it is written,"For dust thou art, and unto dust shalt thou return." We come from the substance of the earth, whose origin is itself the cosmic dust, and to the dust of the earth and the cosmos we shall return. But not while living. Life is the interval between the periods of dust. Life in Schroedinger's (1992) words is: "An organisms astonishing gift of concentrating a 'stream of order' on itself and thus escaping the decay into atomic chaos–of 'drinking orderliness' from a suitable environment ... "

How then does the living organism avoid decay? In a word, by *metabolism* (Schroedinger, 1992). The word "metabolism" originates in a Greek root meaning "exchange." Life is fundamentally associated with some sort of exchange. But what is the currency? It is tempting to regard energy as the currency of exchange. But Schroedinger, ever the physicist, catches the common mistake. Life does not thrive on "energy" per se any more than a nation needs an "energy" policy, for as anyone familiar with the laws of thermodynamics or physics knows, energy is conserved! For an adult organism, one no longer growing and whose mass is constant, the net exchange of energy with the environment is zero. That is, the energy consumed by the organism in the form of food is exactly balanced by the energy relinquished to the environment in the form of low-grade heat. The forms of the input and output energies, however, are vastly different. Energy contained in food is highly concentrated, while that in waste heat is highly diffuse. Which brings us back to thermodynamic's second law. In the concise language of physics and the words of Schroedinger: "What an organism feeds on is negative entropy." (Schroedinger, 1992.)

To the ordinary person who is not a Nobel laureate, Schroedinger's statement seems at first incomprehensible. It helps to recognize that, as a measure of probability, entropy is also a measure of the quality (availability) of a form of energy, in the sense that the more concentrated (available) the form of energy, the lower its entropy. Conversely, the more diffuse (unavailable) the form of energy, the higher its entropy. Because an organism consumes energy in concentrated form as food (at low entropy) and expels that energy in diffuse form as heat (at high entropy), the net difference (entropy in minus entropy out) is negative. Put in more down-to-earth terms: "Thus the device by which an organism maintains itself stationary at a fairly high level of orderliness really consists in continually sucking orderliness from its environment." (Schroedinger, 1992.) Schroedinger's observation is a 180-degree twist to the existentialist's lament, "Life sucks."

It would seem, however, that the second law of thermodynamics forbids, for isolated systems, the decrease of entropy associated with life. Fortunately, the earth is not an isolated system. Provided there is a concentrated source of energy (low entropy) available that can be tapped, life can proceed to swim upstream. In *Galileo's Finger* (2003), Peter Atkins writes:

> Although elaborate events may occur in the world around us, such as the opening of a leaf, the growth of a tree, the formation of an opinion, and disorder thereby apparently recedes, such events never occur without somehow being driven. That driving results in an even greater proportion of disorder elsewhere.

In other words, entropy must increase somewhere else for it to decrease on earth through the evolution of life, and, by the second law, the overall increase is greater than or equal to the local decrease.

Thus, crucial to life and evolution is the existence of a well of low entropy somewhere nearby from which life can draw. For life on earth, that well is the sun. Radiant energy from the sun is the ultimate source of all life on earth. The sun's light fuels photosynthesis for the metabolic processes of plants. Plants in turn concentrate energy into sugars for herbivores, and in the tissues of herbivores are the further concentrated energies necessary for carnivores. At the top of the food chain are warm-blooded animals. Warm bloodedness is yet another marvelous adaptation of evolution, for as Schroedinger (1992) observes: "The higher temperature of warm-blooded animals includes the advantage of enabling it to [expel heat and] get rid of its entropy at a quicker rate."

What then is the relationship between these two universal counter-currents: physical entropy and biological complexification? Buried inconspicuously in the endnotes of *God, Mystery, Diversity* by Harvard Theologian Gordon Kaufman (1996) and attributed to Arthur Peacock (1984), is one of the most profound connections ever made by human beings: "It has recently begun to appear possible, even likely, that the continuous increase in entropy over time in the universe may itself, in the natural course of events, give rise–through the development of so-called dissipative systems–to complex forms of organization, eventually including living systems." The counter-currents therefore are intimately related. The former propels the latter. Once again, in the words of Peter Atkins (2003):

> The ceaseless decline in the quality of energy expressed by the second law is a spring that has driven the emergence of all components of the biosphere. In a very direct way, all the kingdoms of creation have been hoisted out of organic matter as the universe has sunk ever more into chaos.

But as Sherrington noted, "With life evolves mind." Life is the carrier of consciousness. Or, as implied in the poetry of Teilhard, life is the distillery of consciousness, gathering spirit from the proto-consciousness scattered about the cosmos as bees gather nectar for honey. We are drawn inexorably, like moths to a flame, to the synthesis of ordained scientist Arthur Peacocke (1984), which continues:

> The picture that is emerging in ... recent thermodynamic analyses ... [suggests that] the movement of the [entropic] stream itself inevitably generates, as it were, very large eddies within itself in which far from there being a decrease of order, there is an increase first in complexity and then in something more subtle: functional organization. ... There could be no self-consciousness and human creativity without living organization, and there could be no living dissipative systems unless the entropic stream followed its general,

irreversible course in time. Thus does the apparently decaying, randomizing tendency of the universe provide the necessary and essential matrix (*mot juste!*) for the birth of new forms–new life through death and decay of the old.

4 Love

Let us leave the broad universe for a moment and re-focus, each of us, on our little corner of the planet: our home, our yard, our family. What counter-entropic events can we find on a daily basis in our small neck of the woods? For those who own homes, home maintenance is counter-entropic. Left alone, the roof will leak, the paint will flake, and the wood will succumb to termites. Unattended, the home will disintegrate around us. Expenditures of energy are necessary to reverse the decay: repairs to the roof, painting of the siding, and chemical barriers to keep the termites temporarily at bay. For those who garden, gardening is also counter-entropic. Left to its own, a plot of untended earth rapidly degenerates into a chaotic tangle of vines and weeds. Pulling weeds, mulching, planting flowers, and sculpting plots: these are counter-entropic inputs of energy from the tender. Finally, consider the act of parenting. The young of humans are so helpless that it is many years before they can successfully fend for themselves. During the first two years especially, the parent feeds, bathes, and changes the helpless infant, who otherwise would quickly succumb, to hunger and in filth.

And so, what name do we humans give to the counter-entropic processes of our daily experience? We call these "labors of love," or simply love for short.

In summary, under the mantle of cosmogenesis, Teilhard's term for cosmic evolution, there are two counter tendencies. There is the relentless tug of entropy on the material universe, by which iron rusts, bodies wither, aged stars collapse into black holes, and disorder ultimately prevails. Against this, there is Teilhard's counter-entropic trend of complexification, in which life swims upstream against entropy, becoming ever more ordered and biologically complex, and ever more self-aware. What then is the connection between the running down of the physical world and the running up of the biological world? The former enables and drives the latter. Indeed, it is the very running down of the physical world that propels the biological and conscious world upward! Thus, in anthropomorphic terms we might say that entropy is the labor of love of the material universe for the sake of the conscious (or spiritual) universe.

To close in an unusually succinct summary of our unveiled secret of the universe, let us quote not from a scientist nor from a theologian, but from a poet and minstrel. In a song entitled "The Wherefore and the Why," Canada's songwriter and *de facto* poet laureate, Gordon Lightfoot, pens:

Then all at once it came to me; I saw the wherefore
And you can see it if you try
It's in the sun above; it's in the one you love
You'll never know the reason why

References

[1] Peter Atkins, *Galileo's Finger*, Oxford University Press, 2003.

[2] Gail Godwin, *Heart: A Natural History of the Heart-Filled Life*, Reprint Edition, Harper Perennial, 2002.

[3] Stephen Hawking, *A Brief History of Time: From the Big Bang to Black Holes*, Bantam Dell, 1988.

[4] Gordon D. Kaufman, *God, Mystery, Diversity: Christian Theology in a Pluralistic World*, Augsburg Fortress Publishers, 1996.

[5] Ursula King, *Spirit of Fire: The Life and Vision of Teilhard de Chardin*, Orbis Books, 1996.

[6] Arthur Peacocke, "Thermodynamics and Life," *Zygon* 19 (1984), p. 430.

[7] Roger Penrose, *The Emperor's New Mind*, Oxford University Press, 1989.

[8] Erwin Schroedinger, *What is Life? with Mind and Matter*, Reprint Edition, Cambridge University Press, 1992.

[9] Teilhard de Chardin, *The Phenomenon of Man*, Harper & Row, New York, 1959.

[10] Teilhard de Chardin, *The Divine Milieu*, Harper & Row, New York, 1960.

[11] James Trefil and Robert M. Hazen, *The Sciences: An Integrated Approach*, 4th Ed., Wiley, 2003.

[12] John R. Yungblut, *Discovering God Within*, The Westminster Press, Philadelphia, 1979.