The Meaning of Life

John Crooks

Writer's Comment: *While I was re-reading my essay—trying to understand why someone might think it's prized (I'm profoundly grateful, by the way, for the guidance and encouragement of Prof. Davis, whose editing showed me the rewards of a finished product), I caught myself debating the pointlessness of studying any subject at all. And in doing so, I perhaps struck upon the appeal of the essay. For some reason people are compelled to try to answer questions that have no answer. We brazenly attempt to figure out what the hell Mother Nature was thinking. Psychology, philosophy, history, religion, science, and so on, seem ultimately to be different paths towards reconciling nature's chaotic puzzle. But with such a volume of intellectuals in this world, the pieces of this puzzle have become so small that it's easy to lose sight of the greater picture. A biology snob might scoff at some of the concepts in this essay, but this paper isn't meant to be a rigorous investigation. The science in this essay may quickly become antiquated, so I can rely only on the spirit of the paper remaining intact. I hope the casual reader walks away with some small appreciation for a biologist's perspective on life's absurdity, and that others will contemplate the absurdities within their own fields. And perhaps when I'm thirty, still living off cold cereal and studying a small chunk of the puzzle in a window-less lab somewhere, I can be comforted and invigorated by the starry-eyed ideas I foolishly slapped into this essay. Who knows, really?*

—John Crooks

Instructor's Comment: *For me, John's essay is about Beauty—the coherence of Nature, the marvel of life. The essay evolved from a UWP 101 (Writing Across the Disciplines) course assignment to explain, in front of the class, an esoteric concept or definition from the writer's field of study—in a way that listeners outside the field could understand. The class could not help but be surprised and delighted by John's gutsy choice of topic—"The Meaning of Life" . . . are you kidding?—and by his entertaining approach. At the moment of* *this writing (July 2007), John is doing medical/diagnostic research in Dublin on a gadget which he says he needs a cocktail napkin and pen to explain. Until he writes up that project,* Prized Writing *readers will have this essay to marvel at. I warn you: If you're not a scientist, you'll want to be, after reading this remarkable essay.*

—Elizabeth Davis, University Writing Program

I'VE FOUND THAT THERE ARE FEW BETTER WAYS to ruin a stroll through a lush forest than to exclaim, "What a lovely assembly of stardust." The one time I tried this it was received with blank—slightly menacing—stares and that warm feeling of embarrassment. But while the idea of life evolving from space debris may be a socially awkward topic, in the eyes of science it is wonderfully harmonious. The laws of physics, chemistry, and biology intertwine into an unexpectedly coherent image of life's history.

So what is life? Anyone presented with an Emperor penguin and a lump of coal can easily identify the living versus the nonliving object. We have an innate sense of empathy for things that move and breathe like us. Rationalizing this innate response, however, is quite complicated.

Most dictionaries define life with circular logic, using words like *organism* or *being* within the definition. What, then, is an organism—something marked by life? Even biologists struggle to find consensus when defining life. In a famous essay titled *The Seven Pillars of Life*, author Daniel Koshland—a luminary in the biological field—playfully describes a conference he attended where many elite scientists gathered to discuss and establish a firm definition for life:

> After many hours of launching promising balloons that defined life in a sentence, followed by equally conclusive punctures of these balloons, a solution seemed at hand: "The ability to reproduce—that is the essential characteristic of life," said one statesman of science. Everyone nodded in agreement…until one small voice was heard. "Then one rabbit is dead. Two rabbits—a male and a female—are alive, but either one alone is dead" (Koshland 2215).

Life seems tantalizingly simple. As living beings we find the concept of life and death so palpable—why can't I simply brood in a chair and tease a definition out of life? Instead of parsimonious one-liners, we find ourselves defining life with disjointed and lengthy lists that include all of life's various elements. Such lists usually call for an ordered, environmentally responsive entity that's capable of metabolism, reproduction/replication, evolution, et cetera. And each of these vague rules requires further clarity.

But rules, by their very nature, are meant to be broken. Just as *i* doesn't always come before *e*—especially after *c*—our omnisc*ie*nt Mother Nature has crammed w*ei*rdos into her rather b*ei*ge soc*ie*ty of Earthbound spec*ie*s. Our manmade conceptions of life encompass all but a rare fraction of species, but the mere existence of these rule-breaking vagabonds spells doom for the tidy definition of life.

One of life's weirdoes is the sterile mule. Mules violate the fundamental rule of reproduction, so are they alive? Well, let's find out: If you have an especially cold heart and you shoot a mule there is an obvious shift in the mule's demeanor. A trickle of blood, a lump of flesh splayed in the dirt, the body runs cold, and the steady heartbeat skids to a halt—this animal is dead. So what was the mule before it was shot? Empathy and intuition seem to tell us that mules are alive despite their violation of our prescribed definition of life. But mules only violate one rule, how about two or three violations?

Consider the virus: usually nothing more than a small piece of genetic material that is protected and encapsulated by a protein coat. Viruses are essentially complex chemicals that are capable of an extreme form of parasitism. Unassuming and docile, the virus will spring into action only when it contacts a viable host cell. Once this contact occurs, the virus injects its genetic material into the host, thereby assuming command of the cellular machinery. The resulting cellular zombies are then forced to produce and assemble viral components that will propagate a new generation of virus. And now we face the dilemma: is a virus alive? Unlike the mule, viruses aren't as tangible in our minds—we can't feel guilty about slaughtering a virus. From a scientific perspective, viruses are built from the stuff of life, but they rely on cells for processes of replication, growth, and metabolism. This gross lack of self-sufficiency makes the virus one of several interesting natural phenomena that fall in the gray area between static chemicals and vivacious cells.

The great marvel of life is its immense complexity from such simple origins—from primordial pond scum to Tyrannosaurus Rex. The first traces of cellular life appeared around four billion years ago when the 4.6 billion-year-old Earth was just stepping out of its infancy. Five hundred million years passed after Earth's birth date before solid ground, an atmosphere, and seas were formed. And geologic records suggest that these are the conditions that may have first supported life. These dates are remarkable because they imply that the transformation of simple chemicals to a functional cell occurred within the span of only several hundred million years. Biologists find these dates encouraging, as they show that life established itself almost as quickly as the proper ingredients were available—an observation that points to the spontaneity of life.

Admittedly, a series of remarkable and unlikely events must occur to produce a blob that can be called living. But, similarly, a poker hand with four aces is considered to be an unbelievable statistical feat, unless—of course—you've been playing poker for a hundred million years. A withered and grumpy old poker player will be unimpressed with any hand, simply because he has seen every possibility before. The improbable events that created our blob only had to occur once during a span of time that transforms impossible phenomena into plausible occurrences.

In 1953, the young Stanley Miller—working under Harold Urey at the University of Chicago—created a laboratory version of Earth's early atmosphere and oceans by compiling simple chemicals believed to be present on ancient Earth. Miller then proceeded to heat his assemblage of chemicals and to shock his Frankensteinian mixture with electrical discharges—to simulate lightning. After only a few days the clear "ocean" had turned brown, and Miller's chemical analysis revealed large quantities of important organic compounds. Refinements over the last 50 years to Miller's early experiments have revealed that many of life's building blocks—including some amino acids, carbohydrates, and portions of nucleotides—could have been cooked up by early Earth into a primordial soup. Stranger yet, some of life's building blocks may have simply been handed to Earth by a meteor. When anyone plays the meteor card it usually deserves some skepticism, but in 1969 the famous Murchison meteor crashed into Australia. And analysis of the meteorite exposed some astonishing stowaways. Amino acids, the building blocks of protein, were discovered throughout the fragments at similar concentrations and ratios as the amino acids found in the Miller/Urey experiment. So it's conceivable that the basic units of life were born in an extraterrestrial environment.

The mere presence of organic building blocks, however, does not ensure the synthesis of large biomolecules. And researchers are still grappling with the obdurate mystery behind biomolecular formation. If you wick the moisture from a cell you will typically find that about half of the cell is made of amino acids, and the remainder is largely composed of various carbohydrates, nucleotides, and lipids. So how did nature take these relatively simple building blocks—the amino acids and nucleotides—and produce the utterly complex proteins and gigantic strands of RNA and DNA that reside in cells today? This sort of question has both fascinated and frustrated biologists for years since the answers have remained stubbornly elusive.

A flurry of hypotheses spiral around the problem of biomolecular formation, but the ideas that are most embraced involve *replicators*. Scientists probe the characteristics of biomolecules in search of individuals with the strange ability to replicate themselves. Imagine falling asleep with a delicious Hershey's bar lying on your desk, only to awake and discover that the chocolate has miraculously replicated into two bars. You may ask yourself, "Wow, how did that work?" Biologists are pondering similar questions about primordial chemicals, but research efforts are aimed towards molecules that show much more promise for self-replication than a hunk of chocolate. RNA, for instance, is structurally similar to DNA, and molecular biologists have found that certain RNA strands can act as enzymes. These enzymatic RNAs are, therefore, able to store genetic information and they can perhaps catalyze their own replication—at least that's the theory. Other studies suggest that specific minerals or clays helped create simple proteins, and these early proteins may have been Earth's first organic catalysts. Still others claim that cyclic reactions between very simple chemicals on ancient Earth are capable of evolving into living entities—the so-called *metabolism first* theory. In the end, researchers face the same fundamental problem as Egyptologists—there is just no way to prove the exact technique for lifting those monstrous stone obelisks. Scientists can only speculate about life's early stages, and we may never know the true path of evolution. Yet here we stand, so we can assume that biomolecules must have assembled themselves somehow—that is the ultimate proof.

One classic image of a cell that we all hold in our minds is that writhing, amorphous amoeboid. And the membrane that defines this distinctive figure remains unappreciated. But all of the wondrous complexities and sophisticated metabolic ballets occurring within the cell might never have evolved without the concentration of biomolecules within this dynamic shield. For this reason, membranes are crucial for life's existence and origin—for partitioning the living cell from a non-living environment. But how would a membrane spontaneously assemble itself in a primordial ocean? Well, every time you do the dishes tiny chemical structures are formed that resemble cellular membranes. Soap consists of long, chain-like molecules that have different affinities for water at either end. Imagine that one end of the chain is attached to a cat, while the other end has been tied to a fish. If such an assembly were tossed into a vat of water, an epic tug-of-war would ensue with the cat struggling to escape, while the fish is completely satisfied in its watery milieu. If thousands of such soap molecules are placed in a solution together, microscopic spheres will spontaneously form with the cat-ends on the interior, trying to avoid the surrounding water molecules, and fish-ends on the exterior. The reason why soap is such an effective cleanser is that dirt and oil hate water as much as cats do, so they will join the feline alliance on the interior of the sphere. A splash of water from the faucet washes the whole assembly of soap and grime away, leaving your dishes squeaky clean. The framework of a cellular membrane is slightly more complex than that of soap, but the governing principles are nearly identical. Mere proximity of individual membrane molecules in a solution causes them to coalesce and create structure. So it is easy to imagine how membranes can spontaneously form around biomolecules if luck is given enough time. Evolution can quickly sort through these early cellular prototypes until a very basic, but functional, cell is achieved.

Cellular diversity today is seemingly limitless, as a multitude of cellular archetypes compete to fill the vast array of environmental niches on Earth. Despite this smear of cellular diversity, there were singular events in evolution's history that clearly mark the boundary between simple and complex cells. Predation—the mode of killing other species for sustenance—is a common way to make a living in the cellular world. One cell will completely engulf and digest another. But imagine what might happen if digestion fails and the captive cell is imprisoned within its captor. Like the woeful Geppetto—Pinocchio's father—trapped within the belly of Monstro, the whale, the imprisoned cell laments. Now suppose the story of Pinocchio is changed into an anticlimactic version where Geppetto develops Stockholm syndrome and aligns himself with

Monstro the acrimonious whale. This creative woodworker may use his talents to clean up the place, and help Monstro increase his gruesome killing efficiency. The familiar chloroplast and mitochondria evolved from such undigested prey and reshaped the basic architecture of the cell. Each cell in the human body, in trees, even in sea cucumbers and bread mold, is a Siamese relationship between ancient cells—a mutual friendship and reliance formed through millions of years. This dichotomous association opened new environmental niches and ushered in a wave of new cells that leapt past their counterparts. With a slight stretch of the imagination cells begin to aggregate, form colonies, and specialize in specific tasks. Soon multicellular creatures emerge, and millions of years down the road *Homo sapiens* develop a mind that dares to question our enigmatic world.

The problem with studying life is that most things that have lived are now dead. Scientists can only glimpse life's inner workings using cells that are alive today. From this modern snapshot of a cell, the long road of life's molecular history and evolution must be cleverly extrapolated.

Evolution does not create sharp edges, and this only adds to the difficulty of extrapolating the cell's history. If we witness a criminal lineup with an ancient hominid and a modern human, plus the thousands of proto-humans in between, is it possible to point to the perpetrator—the sole individual that represents the boundary between the ancient and modern human? We'd be hard pressed to single out an individual from the crowd, and there would certainly be conflicting opinions. Vast time scales and evolution's endless imagination leave long trails of intermediate forms and there is no easy way to bisect such a smooth continuum. Now imagine that the criminal lineup were replaced with a long line of proto-cells and we were asked to identify the simplest individual that is alive. The task is impossible, for there would be far too many variations, and any choice would be plagued with ambiguity. According to the modern definition of life, we must choose a cell, or proto-cell, that encompasses a laundry list of characteristics like metabolism, replication, growth, and so on. But what is *metabolism* at its simplest level? How do you quantify *order* in a primordial context? Our modern conceptions of everyday processes lose their clarity at life's inception, and even our most rigorous definitions of life seem to unravel.

So what is life? Life is meaningless, for it defies definition. Just as everything else is spun from absurdity, biology is no exception. We are just a silly curiosity, dynamic lumps of coal, on a speck of a planet in a seemingly infinite universe—we are stardust.

Works Cited

Koshland, D. E. Jr. "The Seven Pillars of Life." *Science* 295. (2002): 2215–16.