Did God Create Viruses?

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By James L. Hayward

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We had just completed a delightful tour of six ancient cities of the Decapolis and were settling into our hotel in Madaba, Jordan. Our highly anticipated archaeological dig would begin in a couple days. But something was wrong. I didn't feel quite right.

Someone found a test kit. After twirling the foam-tipped applicator deep inside both nostrils, I inserted the tip into the slot at the base of the moistened test strip, and waited fifteen minutes.

Alas, the dreaded second line appeared. Despite all the vaccinations and masking, I'd caught COVID. After losing my appetite, I then endured a succession of aches, fever, chills, sweats, and coughs.

Mercifully, after a week of quarantined isolation and discomfort, I and three other members of our group who had tested positive were back on task. Trowel in hand, I began my dig into Tel Hesbon's history. Thanks to antivirals, I was one of the fortunate ones.

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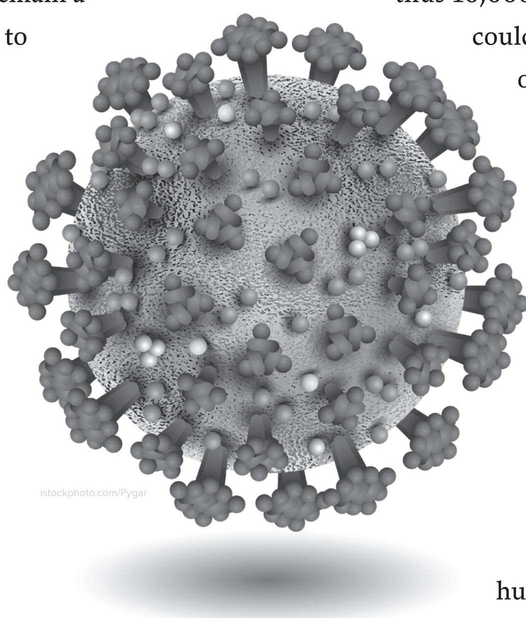
Since December 2019, around 772 million individuals—nearly one in every ten humans on the planet—have contracted COVID-19. Some seven million of those infected have died.[1] Many survivors live with "long COVID" and experience such symptoms as shortness of breath, chest pain, headache, dizziness, depression, stomach pain, rash, and joint or muscle pain.[2] In addition to the human death and misery, the pandemic drained trillions of dollars from the world's economy in the largest economic downturn since the Great Depression.[3]

The COVID-19 pandemic is only the most recent viral disaster to plague humans. The Spanish flu, polio, Asian flu, SARS, swine flu, MERS, Ebola, Zika, and other devastating diseases have taken a massive toll during the past century or so. Viral plagues remain a constant threat and will continue to afflict humankind in the future. And less deadly viruses inflict intermittent, thankfully temporary, miseries upon us—the common cold, influenza, food poisoning, and the like.



Welcome to the world of viruses. Here I will provide a brief overview of this strange, all-encompassing, fast-evolving world. I will explain both the negative and positive (yes!) impact of viruses on human and environmental health. And finally, I will address the question: Did God create viruses?

But first we need to understand what viruses are and how they work.

What Are Viruses?

Back in 1977, Sir Peter Medawar famously defined a virus as "a piece of bad news wrapped in a protein."[4] But we now know that for humans, his colorful definition applies only to a tiny fraction of those microbes. Out of hundreds of thousands of types of viruses, only two hundred and nineteen are known to cause human illness.[5] Most viruses are either harmless or beneficial to humans.[6]

Viruses are intracellular parasites. They inject their nucleic acid (DNA or RNA) directly into living cells. The protein capsule that initially enclosed the nucleic acid remains outside the cell like a spent syringe. Inside, the nucleic acid forces the cell machinery to make more copies of the virus.[7]

Viruses are tiny. Most have diameters of only twenty to four hundred nanometers. (One millimeter, or about 0.0394 inches, equals one million nanometers.) To put this in perspective, the COVID-19 virus is approximately one hundred nanometers in diameter; thus 10,000 COVID-19 virions (virus particles) could fit side-to-side within a space of one millimeter.[8] Because they are so small, viruses could not be visualized until the invention of electron microscopes in the 1930s. Before that time, scientists could only infer their existence.[9]

Viruses occur in and on the bodies of all fungi, plants, and animals, including humans. As an adult human male, I have approximately 36 trillion human cells.[10] But I also contain some 39 trillion bacterial cells,[11] unnumbered fungi and archaea, and perhaps as many as 380 trillion virions.[12] It would be the height of hubris to call myself an individual—I'm a microbe-dominated ecosystem!

Viruses lurk everywhere. One milliliter (about one-fifth teaspoon) of ocean water has up to 250 million virus particles;[13] one gram (about one-third ounce) of fertile soil contains up to 5.8 billion virus particles;[14] and one cubic meter (about one and one-third cubic yards) of indoor air possesses around 470 thousand virus particles. Every day we breathe in approximately six million virus particles.[15] Not only do we contain viral multitudes, but we live and move within a viral blizzard.

Because viruses are so abundant and immersive with living things, scientists suspect they have shaped broad aspects of life from its very beginning.

Are Viruses Alive?

For many years I taught general biology, a university-level course that introduces first-year science majors to the main features of living things. During the initial lecture I always raised the question, "What defines something as living?" I then described the characteristics shared by all living things: growth, metabolism, responsiveness to stimuli, reproduction, and adaptation of populations to changing circumstances.

How well do viruses fit within this definition? Not well. Viruses cannot grow, cannot metabolize, and cannot respond to stimuli. They *can* reproduce, but *only* with the help of the host cells they invade. Like the organisms they infect, however, viruses are champions at adapting to changing environments, never giving vaccine designers a rest. Based on this one characteristic, should we call them alive?

In the year 2000, the International Committee on Taxonomy of Viruses officially declared, "Viruses are not living organisms." Advances in knowledge, however, often falsify our simplistic attempts at categorization. The recent discovery of "giant viruses" (see below), which exhibit cell-like features, is now calling into question the committee's declaration, and today scientists are increasingly considering viruses to be living.[16]

I remain on the conservative side of the question and simply say that viruses exist between the world of the living and the non-living. Thus, I prefer to define viruses as complexes of large biological molecules.

How Were Viruses Discovered?

Around 1890, Dmitri Ivanovsky, a Russian microbiologist, began the task of identifying a disease that affected the leaves of tobacco plants grown in Ukraine and Crimea. Ivanovsky passed fluid from the leaves and stems through a fine, porcelain filter to exclude any bacteria but soon discovered that the filtered fluid remained infective when smeared on the plants. He decided the infective agent must be a tiny bacterium.[17]

(Public Domain)

A 1964 postage stamp featuring Dmitri Ivanovsky (1864-1920), one of the founders of virology.

In 1898, the Dutch microbiologist Martinus Beijerinck confronted the same problem—diseased tobacco plants. Like Ivanovsky, Beijerinck forced fluid from the plants through a fine filter to exclude bacteria. And like Ivanovsky he found that the filtered fluid remained infective. Unlike Ivanovsky, however, Beijerinck was able to rule out the presence of bacteria, even tiny ones. He did not know the nature of the infective agent, but he called it a "virus," a word from Latin meaning "poison." Unwittingly, he and Ivanovsky had discovered the tobacco-mosaic virus, which today continues to serve as a research workhorse in virology labs.[18]

As mentioned above, viruses were too small for Ivanovsky and Beijerinck to observe using the light microscope, which at the time was the best magnifying instrument available. It wasn't until the German physicist Ernst Ruska invented the electron microscope that viruses could be visualized. In about 1938, Ruska's brother, the physician Helmut Ruska, made the first images of viruses using his brother's invention. Now viruses could be seen and not just inferred.[19]

How Diverse Are Viruses?

In the past several decades, researchers have identified hundreds of thousands of kinds of viruses through a technique called metagenomic analysis.[20] In this process, an environmental sample of, say, soil, seawater, or feces is collected and filtered to eliminate everything except cells and viruses. All the DNA molecules are removed from the sample and sequenced (meaning the order of the A, T, G, C bases that constitutes the genetic code). Viral DNA can be identified because it contains unique coding sequences that distinguish it from other sources.[21]

Metagenomics is a powerful technique. A single paper published in 2019, for example, reported the discovery of 195,728 new marine viruses from 145 marine sampling sites.[22] Science discovers new viruses every day.

Viruses exhibit many shapes. Some, like the Ebola virus, are long and thin. Others, called bacteriophages, look like tiny lunar landers. Still others, such as the common cold virus, are spherically shaped and covered with spike-like processes. In addition, viruses exhibit a large size variation. As already noted, most range between twenty and four hundred nanometers in diameter. But some of the so-called "giant viruses" are larger than bacterial cells and can be viewed using a simple light microscope.[23]

The genetic material of viruses also differs. Some viruses, like most cells, contain double-stranded DNA. But others have single-stranded DNA, double-stranded RNA, or single-stranded RNA. Moreover, the strands can be positive (coding) strands, or they can be negative (non-coding) strands. Without going into detail, different types of strands use somewhat different routes to direct the formation of viral proteins and genetic material.[24]

What Are Giant Viruses and Bacteriophages?

Given their theoretical and numerical significance, I will briefly highlight two interesting groups of viruses. Giant viruses were first isolated in 1992 from a hospital cooling tower in Bradford, England,[25] but they were not characterized until 2003.[26] More than one hundred types of giant viruses have now been discovered in everything from sewage ponds to Amazon River water and forest soils. Aside from their large size, which distinguishes them from other viruses, some giant viruses contain more than one thousand genes (compared, for example, to just twelve functional genes in the COVID-19 virus), including genes that code for enzymes that control glycolysis, Krebs cycle, fermentation, and cytoskeleton formation—cellular enzymes.[27] Even more bizarre is the fact that giant viruses, like cells, are sometimes parasitized by smaller viruses called "virophages"—parasites within parasites.[28] The cell-like features of giant viruses have caused some biologists to suggest that they are either simple cells that lost some of the functions of ordinary cells, or that they originated from the combination of genes from smaller viruses via a process called "horizontal transfer."[29]

The second group of viruses I'll highlight are the bacteriophages, or simply "phages." They are by far the most numerous of all. As the name suggests, bacteriophages parasitize bacteria which also are very abundant. Most bacteriophages consist of a protein capsule shaped as an x (a twenty-sided polyhedron), a protein tail beneath the capsule, and tail fibers. The phage DNA is wound tightly inside the capsule. Once a phage attaches itself to a bacterium, the phage tail injects DNA from the capsule into the cell, functioning very much like a hypodermic needle. Once inside, the phage DNA converts the bacterial cell into a bacteriophage factory, churning out scores of new phages.[30] I have more to say about bacteriophages below.

How Do Viruses Reproduce?

Broadly speaking, viruses reproduce in two ways. The first involves the lytic cycle. In this process, the virus injects its nucleic acid (DNA or RNA) into the host cell. Once inside, the viral nucleic acid causes host organelles and enzymes to produce more viral proteins, some of which cut up the host's DNA, and more viral nucleic acids from host molecules. The proteins self-assemble via molecular attraction into new viral capsules and other structures, which then enclose new strands of viral nucleic acids. The newly assembled viral particles exit the cell, often in large numbers, lysing (breaking apart) the host cell in the process. The new viral particles find other host cells to infect, repeating the lytic cycle. The process is remarkably complex and involves a battery of interacting molecules.[31]

The second form of reproduction involves the lysogenic cycle. In it, the virus injects its DNA or RNA just as in the lytic cycle. But once inside the cell, instead of forcing the cell to make more viral particles, the viral DNA (or RNA translated into DNA) inserts itself into the DNA of the host cell. There it may reside for a long time—even permanently, as in the case of "HERVs" that I mention below. When the cell divides, the viral DNA gets replicated along with the host DNA and passed along to the daughter cells. Under certain conditions, the viral DNA may excise itself from the cellular genome and enter the lytic cycle.[32]

As should be obvious at this point, there is nothing simple about the biology of viruses.

How Are Viruses Transmitted?

Viruses move from host to host in a couple ways. During horizontal transmission, the virus passes from one organism to another through the air, as with the virus that causes the common cold; or through the water, as with the virus that causes cholera; or through direct contact or bodily fluids, as with the AIDS virus. Horizontal transmission can occur both within and between species. Often, human pandemics occur when a virus that has long resided in a wild animal population mutates and becomes capable of infecting humans (a "zoonotic" disease). Once it enters the human population, the virus spreads from human to human. It is what happened with the human immunodeficiency virus (HIV), which originated within African non-human primates, and what may have occurred with the SARS-CoV-2 virus that causes COVID-19.[33]

The second mode of transmission is called vertical transmission. Vertical transmission occurs when a virus goes from parent to offspring through the blood, milk, or other bodily fluid. HIV/AIDS, rubella, Zika, and herpes viruses can all get passed along in this way.[34]

What Viruses Are Beneficial for Humans?

Earlier, I noted that most viruses are harmless to humans, and that some viruses are even beneficial. That comes as a surprise to many people—the term "virus" connotes "disease" for most people.

Some years ago, I attended a seminar by a virologist. I asked if she knew of any beneficial viruses. She thought for a moment and said, no, she didn't know of any beneficial viruses. Her response depicted the general belief of people over the course of many years. Recent

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discoveries, however, have changed the perspective.

Had I not put our speaker on the spot, she might have recalled that some bacteriophages can destroy bacterial pathogens like *Shigella* and *Staphylococcus*. In Russia and Georgia, a person with a bacterial infection can walk into a clinic or pharmacy and receive treatment in the form of a phage solution taken orally or applied topically.[35] The treatment often works and has saved many lives since first tried in 1919.[36] The West has long considered "phage therapy" suspect, in part because of its development in a Stalinist nation.[37] But now that antibiotic resistance has become such a serious problem, phage therapy will likely become more widespread. Many companies in Western Europe and North America are now exploring ways to use phages to treat bacterial infections.[38]

In addition, we now recognize that the billions of bacteriophages in our digestive tract keep the helpful populations of bacteria there in balance, bacteria that help digest cellulose, manufacture vitamin K, bolster the immune system, and outcompete harmful bacteria, among other functions. In short, we would not live long without the positive contributions that both bacteria and phages make within our digestive tract.[39]

Yet another vital role that viral DNA plays in our bodies occurs in the form of human endogenous retroviruses, or HERVs for short. Geneticists estimate that eight percent of our DNA consists of HERVs incorporated long ago by the process of lysogeny. Some HERVs are no longer of any functional significance, and many others cause problems such as cancer. But others are necessary for our very existence. One of them, for example, is responsible for producing syncytin, a protein crucial for the development of the placenta during pregnancy. Another directs the production of amylase, which breaks down starch molecules in our digestive tract. And then an entire series of HERVs directs the production of globin, a primary constituent of hemoglobin and myoglobin, crucially important oxygen carrying and storage molecules.[40]

The upshot of all this is that while some viruses are harmful to humans, others protect us from disease, provide important anatomical structures, and produce enzymes for digestion, oxygen transport, immune responses, and additional crucial activities.

What Other "Good" Viruses Are There?

Here I use the term "good" to refer to situations in which the virus makes life better, or even possible, for organisms.

Consider, for example, the virus that infects a fungus which, in turn, infects panic grass, a plant that lives along the borders of thermal ponds in Yellowstone National Park. The soils along the edges of such ponds reach 55^0 Celsius (131^0 Fahrenheit), temperatures that would kill most plants. But panic grass survives because of its symbiotic relationship with its virus-infected fungus. Take away the fungus or the virus, and the grass will die.[41]

Then consider white clover cryptic virus. White clover, a member of the legume family, is known for its ability to remove free nitrogen from the air and combine it with oxygen to make nitrate. The nitrate serves as a nutrient—the clover's self-made fertilizer. The process of "nitrogen fixation" occurs within bacteria-containing nodules that form along the clover roots. The development of nodules requires energy. If the virus infects a clover plant and the soil contains sufficient nitrogen, the virus suppresses the formation of nodules in the plant's roots. Insufficient nitrogen, however, removes the suppression, and the plant produces nodules. The virus thus benefits the plant by controlling whether or not it produces nodules, maximizing use of the plant's available energy.[42]

My final and favorite example involves the large concentration of viruses in seawater, many of which are bacteriophages. Photosynthetic bacteria called cyanobacteria are also abundant in seawater, and photosynthesis releases oxygen as a byproduct. Curiously, infection of cyanobacteria cells by bacteriophages increases their photosynthetic rate, thus producing more oxygen. It's been estimated that eight percent of the oxygen in the atmosphere comes from this "turbo-boost" to marine cyanobacteria. Such oxygen is what we and all other aerobic, terrestrial organisms on earth depend on.[43]

Many other examples of beneficial viruses could be listed. As we become better acquainted with the virosphere, science will discover more and more examples. Viruses, it turns out, are crucial for the existence of life on earth.

Where Do Scientists Think Viruses Came From?

Nobody knows the origin of viruses. But that hasn't kept scientists from posing hypotheses.

The "virus-first" hypothesis was an early explanation given for the possible origin of viruses. According to this view, viruses emerged from a pre-cellular, primordial soup of amino acids, lipids, and RNA—RNA because this nucleic acid can function as its own enzyme, and enzymes are required for nucleic acids to form viral proteins. The virus-first hypothesis is no longer popular because, in part, it seems unlikely that a virus could arise before host cells were available.[44]

The "escape" hypothesis suggests that genes developed the capacity to leave and exist outside of cells. As they exited the cells, pieces of cell membrane enclosed them. Such membrane-encapsulated genes became the first viruses. This hypothesis carries a certain degree of plausibility, because so-called "jumping genes" do sometimes excise themselves out of cellular chromosomes. Moreover, some viruses called "envelope viruses" are enclosed in membrane-like structures.[45]

Finally, the "reduction" hypothesis assumes that single-celled organisms lost important functions such as metabolism and self-replication. They then became parasites on fully functioning host cells, as do viruses today. This hypothesis has gained adherents in recent years because of the discovery of giant viruses. Giant viruses, as we've seen, are not only as large as some cells, but they contain large numbers of genes used for many types of cellular processes.[46]

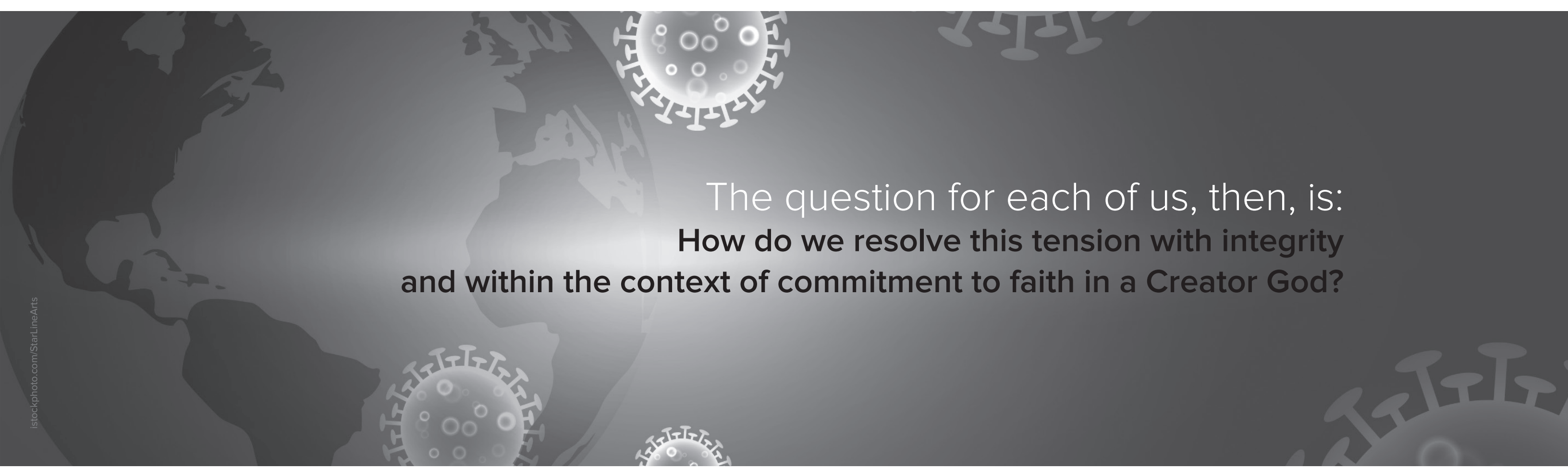
As we learn more about viruses, scientific views about their origins will be continually refined and modified.

Did God Create Viruses?

A very big question, it is one that raises other very big questions, such as: What is God like? When did God create? What did God create? How did God create? Christians believe that God is the Creator but, despite claims by some to the contrary, we do not know what, when, or how God created. Both the origins of life and the God of origins are shrouded in mystery.

God's creation has experienced many changes over time. Some of them have led to predation, cannibalism, and parasitism. But other examples have resulted in astounding species diversity, dazzling beauty—and an amazingly complex virosphere.

People of faith believe that God is good, that what God makes is good, and that God is maker of all.[47] But reality suggests that nature at its very core is a mixture of things we like and things we don't like—a combination of "good" and "evil." The existence of both beneficial and harmful viruses is a poignant example of this reality. The question for each of us, then, is: How do we resolve this tension with integrity



and within the context of commitment to faith in a Creator God?

As it turns out, Christians voice a variety of perspectives on the origin and existence of viruses. Some commentators, like Joshua Moritz, a lecturer in philosophical theology at the Graduate Theological Union in Berkeley, view viruses as originating from mysterious dark forces. "Like evil and demonic in the Bible," he writes, "viruses are a form of intelligent non-life that seeks to distort information and truth in order to illegitimately enter in through a host's gates in order to steal and destroy health and life."[48] Erwin Lutzer, former pastor of the Moody Church in Chicago, holds that God uses the COVID-19 virus to teach us a lesson. He sees the COVID-19 virus as "God's judgment" for sins such as divorce and abortion. He believes that viruses and other "judgments . . . come to us from God, not because God does them but . . . [w]e have to learn from what he has allowed."[49]

By contrast, Daniel Harrell, former editor-in-chief of *Christianity Today*, takes an alternate view. "Unless God's creation defies every characteristic of biological reality," he writes, "bacteria and viruses are not bitter fruits of the fall, but among the first fruits of good creation itself. If science is right, there could be no life as we know it without [viruses]. God makes no mistakes . . . and viruses indeed are mirabilis [miraculous] . . . and part of the plan from the start."[50] Harrell's perspective is consistent with the findings of science and the views of Christian theologians and philosophers who hold that God is a God of freedom, a Creator who has given the creation space to freely choose among multiple paths.[51]

I favor Harrell's view because wherever I look in the universe, I see process and the unfolding of new reality—galaxies collide, and new stars form; tectonic plates merge, and new volcanoes erupt; mountains rise, and new species emerge; humans conceive, and new babies are born; viruses mutate, and new hosts get infected. In this view, the God of creation is a God of process, one who not only creates but also allows created things the freedom to make "choices" and participate in the creative process. Some choices lead to "good" outcomes, and others to results that we judge as "natural evil."

Alvin Plantinga, a philosopher at the University of Notre Dame, notes: "A world containing creatures who are significantly free . . . is more valuable, all else being equal, than a world containing no free creatures at all. Now God can create free creatures, but He can't *cause* or *determine* them to do only what is right. For if He does so then they aren't significantly free after all; they do not do what is right *freely*" (italics his).[52] Similarly, Terence Fretheim, an Old Testament scholar at Luther Seminary, states that "God does not create with strings attached or keep creatures on a leash." Fretheim notes that most students of Genesis 1 "agree that such natural events as earthquakes, volcanoes, floods, destructive weather patterns, cell mutations, and even potentially deadly viruses were an integral part" of the original creation, and that "in some sense, such natural events are God-designed in the very creation of things, and they can be destructive."[53]

For those of us who grew up with the notion of a "perfect" creation,[54] an open view of God and creation sounds foreign, if not heretical. I must admit the concept is not completely satisfying to me, but it is an honest attempt to take seriously both the scientific evidence and a sincere faith in the Creator God. The more deeply I delve into the details of the universe—the integrated and indelible processes of galactic, geologic, organismal, and viral systems that lead to both misery and grandeur—the more this interpretation seems to be the most reasonable of available options.

So, did God create viruses? In view of their remarkable diversity, their amazing capabilities, and the crucial functions they carry out for us and for all living things, I would have to say, yes. And as to why some viruses cause so much death and destruction, I would suggest that at times these complex molecular machines follow available pathways that are detrimental to life, nudged along through time by the omnipresent forces of mutation, horizontal gene transfer, natural selection, and other organic processes.

Whatever approach we take regarding the origin and existence of viruses, one thing is clear: we are just beginning to understand the diverse roles that they play in our lives and those of all living things. The wonders of the virosphere are opening before us at an ever-increasing pace. A rapidly growing awareness that both our bodies and the world around us are completely integrated with these microbes is revolutionizing our perception of ourselves, of the biosphere, and of creation itself.

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